DEVELOPMENT OF LANJAK ENTIMAU WILDLIFE SANCTUARY AS A TOTALLY PROTECTED AREA, PHASE II

[Project 15/95 REV .3(F)]

Final Report

BY
Paul P.K. Chai

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First Published April 2000

Printed by
Lee Ming Press Co.
Lot 147 & 148, 1st Floor, Abell Road
93100 Kuching, Sarawak, Malaysia

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EXECUTIVE SUMMARY

The Lanjak Entimau Wildlife Sanctuary Project was initiated as a result of the visit by the ITTO Mission to Sarawak in 1989-1990 at the invitation of the Sarawak Government.

Lanjak Entimau, the largest of the Totally Protected Area in Sarawak, will be increased to 191,568 ha when an extension of 22,810 ha is completed before the end of the year. The Sanctuary lies in an area of mountainous and rugged topography and is an important watershed serving the people of central Sarawak.

Studies during Phase I and Phase II have confirmed the Sanctuary to be extremely rich and diverse in plant and animal species. A wide range of eight major forest types provide the habitats for their existence. The structure and species composition of these eight forest types were studied during Phase I.

The Sanctuary has for many generations served as an important resource base for more than 12,000 Iban people living in the periphery. Although out-migration is becoming a common phenomenon among the young people, many are still dependent on the Sanctuary's resources for their livelihood support. Hunting, fishing and collecting of jungle produce by the local people and outsiders are problems faced in the management of the Sanctuary.

The outputs and achievements in Phase II are significant considering that the information and data for each of the studies were obtained within a period of six months. The Sanctuary is now known to contain eight forest types with 2,807 species of vascular plants, 500 species of fungi, 42 species of lichens, over 1,000 species of insects, 48 species of small mammals, 235 species of birds, 75 species of reptiles and amphibians and 82 species of fish.

In the preparation of management guidelines for the Sanctuary, a review of the Management Plan is made on conservation of biodiversity, research and education, community involvement and socio-economic benefits, protection, infrastructure and training.

The Management guidelines cover a number of specific areas namely, priorities for strengthening ecological studies, priorities for strengthening biodiversity inventories and identification of areas in the buffer zone for community-based resource development and training. Recommended actions for each of the areas are given.

Zoning of the Sanctuary has been modified and a number of special protection zones are established to ensure more effective protection of habitats and resources.

Another significant achievement for Phase II is the establishment of the Trans-boundary Conservation Area of Betung Kerihun National Park and Lanjak Entimau Wildlife Sancutary. This was followed by the ITTO Borneo Biodiversity Expedition to the Trans-boundary Conservation Area in 1997.

ACKNOWLEDGEMENTS

We are grateful to the past Executive Director of the ITTO, Dr. B.C.Y. Freezailah, the present Executive Director, Dr. Manoel Sobral Filho, and the Projects Manager, Dr. Efransjah for their support in the Lanjak Entimau Wildlife Sanctuary project.

Our sincere thanks also go to the Director of Forests, Mr Cheong Ek Choon, the past Projects Coordiantor, Mr James Dawos Mamit, the present Projects Co-ordinator, Mr Penguang Manggil, and the project's co-leader Mr Sapuan Ahmad for their valuable advice and encouragement.

The work and analysis were done by Dr. Paul P.K. Chai, Mr Kueh Hong Siong, Dr Charles Leh, Dr. Chey Vun Khen, Dr Katharine G. Pearce, Mr Chin Fook Hon, Mr Han Kwai Hin, Mr Stephen Sungan and Mr Jiram Sidu.

Contributions were also made by local scientists/counterparts Mr Oswald Braken Tisen, Mr Engkamat Lading, Mr Mohd. Shahbudin Sabky, Miss Sim Lee Kheng, Miss Runi Sylvester, Mr Julaihi Lai, Mr Stephen Teo and Miss Mohizah Mohamad, and many other officers and staff of the National Parks and Wildlife Division and Forest Research Division.

Our sincere thanks also go to the following ITTO staff : Mr Kho Seng Yaw (who helped to check the final draft), Miss Chiang Moi Sien (who painstakingly typed the report), Mr Johnny Poh, Miss Fauziah Hassan, Miss Angelia Muri, Miss Jong Pei Yung; Mr Francis Dihom, Mr Voon Voo Joo and Mr Azman Hipni.

District Forest officer, Song : Mr Yip Heng Wah
Administrative Assistant : Mr Kon Chiang Fatt
Senior Accounting Officer : Mr Abang Alias
Mapping Division : Mr Jong Tze Hiong
Storekeeper : Mr Kenny Chew

and many other officers and staff of the Forest Department HQ

Lastly, our sincere thanks go to the local communities who extended to us their warm welcome and hospitality whenever we visited them, and for their active participation and co-operation in field work.

FINAL REPORT FOR ITTO PROJECT PD.15/95 REV.3(F)

DEVELOPMENT OF LANJAK ENTIMAU WILDLIFE SANCTUARY AS A TOTALLY PROTECTED AREA, PHASE II

PART 1 - INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

As the world's tropical rain forest is disappearing at an alarming rate, the conservation of biodiversity becomes a critical problem. To be effective, tropical biodiversity conservation requires the preservation of natural forests areas large enough to include a complete series of representative habitats for flora and fauna. In Sarawak, thirteen national parks and three wildlife sanctuaries with a combined area of approximately 546,900 hectares have been established. Further efforts are being made to establish another 29 national parks (including eleven extensions to existing parks) and five wildlife sanctuaries (including three extensions) with a combined total area of about 916,000 hectares. In addition, a number of nature reserves that are small in size but with various conservation values are also in the process of being constituted totalling 86,000 hectares. When fully constituted all these national parks, wildlife sanctuaries and nature reserves will altogether meet the target of the State Government to set aside 10% of its forested land as Totally Protected Areas (TPAs).

When the Lanjak Entimau Wildlife Sanctuary (LEWS) with an area of 168,758 ha was established in 1983, it was, and still is, the largest TPA in Sarawak. Although the primary objective of the TPA was to protect the orangutan, it has become home and refuge to thousands of species of plants and animals including those that are rare and threatened with habitat destruction.

The development of LEWS as a Totally Protected Area for the *in situ* preservation of the State's natural heritage fitted the recommendation of the ITTO Commission which visited Sarawak in 1989-1990. Phase I and II activities were consistent with the Mission's recommendations as they set out to:-

- survey, identify and describe a complete series of representative forest types relative to different soil types and altitudes;

- study the floristic diversity and distribution in the different forest types and identify species of economic potential;

- establish gene bank plots for timber tree species;

- identify rare and endangered plant and animal species and their habitats for protection;

- study populations of mammals, birds, fish and insects to determine their species diversity, distribution and habitat ranges.

These activities are encompassed in the following Project objectives for Phase II:-

- **Development Objective**
  Formulation of policies, strategies and procedures for the development of Lanjak Entimau Wildlife Sanctuary to serve as a model in the conservation, protection and scientific utilisation of other Totally Protected Areas in Sarawak and Malaysia.

- **Specific Objective 1**
  To conserve the Lanjak Entimau Wildlife Sanctuary through a locally based programme of research into its biological diversity and other aspects of its living resources.

- **Specific Objective 2**
  Establish protection programmes for the Sanctuary through community consultation and community-oriented biodiversity resource development in the surrounding Buffer Zone.

The strategies to achieve these objectives involved continuing scientific inventories, establishment of gene bank plots for timber tree species, and community development activities to assist the local communities to seek alternative livelihood using the Sanctuary's rich non-timber resources. The inventory was necessary to build up a database that was not available before the Project was implemented.

For ITTO and the Governments of Sarawak and Indonesia, a significant achievement of Phase II was the establishment of the Trans-boundary Biodiversity Conservation Area (TBCA) comprising Lanjak Entimau Wildlife Sanctuary on the Sarawak side and Betung Kerihun National Park in West Kalimantan. This Trans-boundary Conservation Area of nearly one million ha launched in October 1994, is the largest in the humid tropics. Following this, an important activity was undertaken to initiate international co-operation and collaborative scientific research between Malaysia and Indonesia. Thus the

ITTO-sponsored Biodiversity Expedition to the Trans-boundary Conservation Area (IBBE, 1997) was successfully organised for a duration of six weeks between September and November 1997. The formation of a Task Force for the TBCA by Indonesia and Sarawak will further enhance the collaboration and exchange of information between the two parties.

1.2 HISTORY OF THE LANJAK ENTIMAU WILDLIFE SANCTUARY

1.2.1 Location and Status

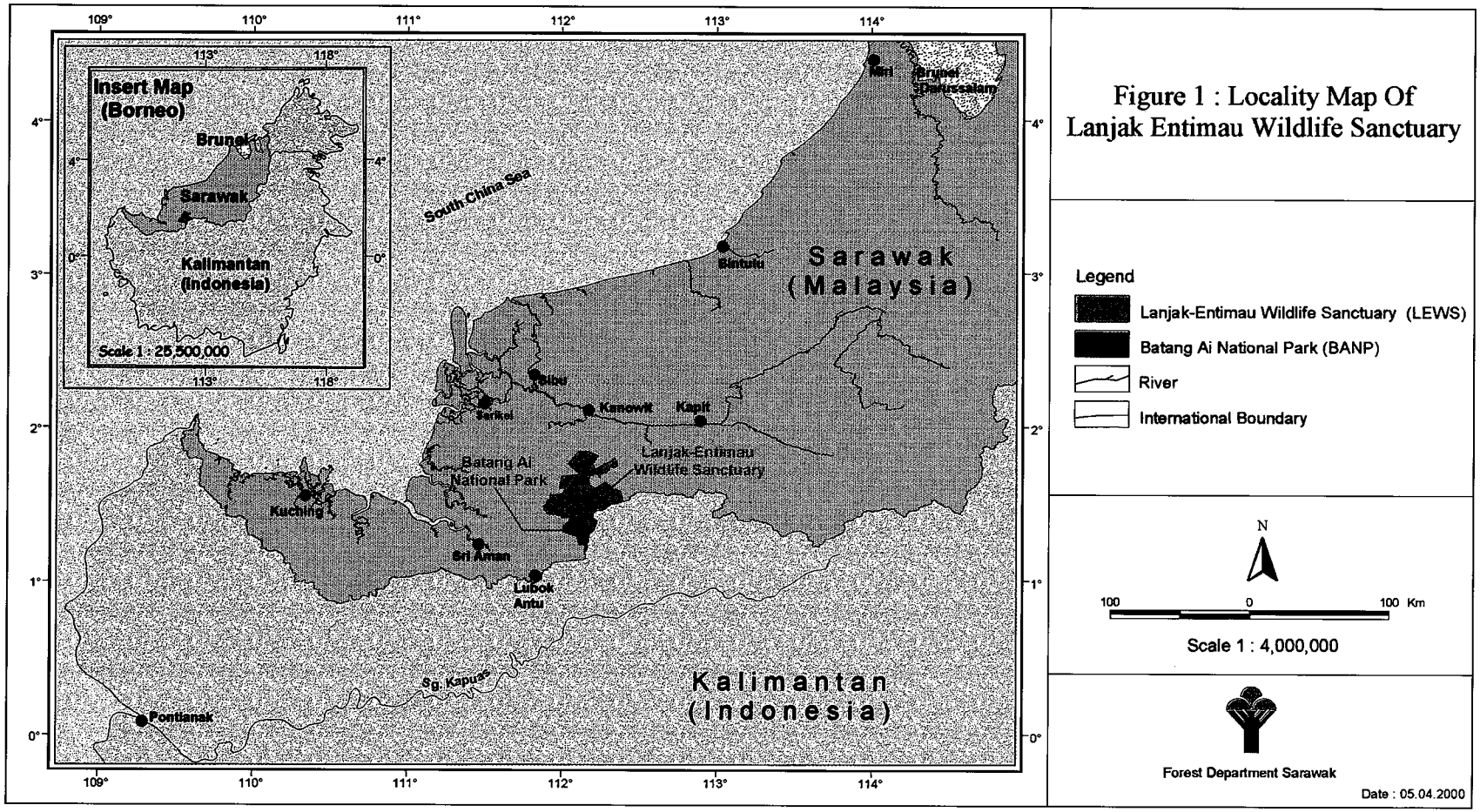
Lanjak Entimau Wildlife Sanctuary is located in south-western Sarawak between 111° 53' E to 112° 28 ½' E and 1° 19' N to 1° 51' N. (Fig. 1). It encompasses portions of the Kapit, Sarikei, Sibu and Sri Aman Divisions. The area of the Sanctuary, as constituted in 1983, is 168,758 ha. Since then, extensions have been proposed to include three areas in the north-east and eastern regions with an additional area of about 22,810 ha. This would increase the Sanctuary to 191,568 ha.

The Sanctuary is contiguous with the Batang Ai National Park (in Sarawak) to its south and the Betung Kerihun National Park in West Kalimantan, Indonesia to its south-east (see Fig. 1). Cutting of the 160 km long boundary of LEWS to a width of 5 m was completed by the Forest Department in 1999. This will ensure more effective control of illegal activities inside the Sanctuary.

Existing facilities include a Ranger Station at Nanga Ju in Ulu Mujok, a Base Camp and field station laboratory in Nanga Segera in Ulu Engkari and a temporary headquarters at Nanga Bloh in Ulu Katibas. These facilities are manned by wildlife rangers from Kuching and local employees recruited from nearby longhouses. The Sanctuary's headquarters building in Nanga Bloh is expected to be completed in September, 2000.

1.2.2 Topography, Geology and Soils

Lanjak Entimau is characterised by a deeply dissected, rugged and hilly terrain ranging from 60 to nearly 1,300 m above sea level. The highest peak of Bukit Lanjak (1,285 m), is located in the south-western region. The mountain ranges between 700 and 1,000 m are marked by a series of sharp ridges characterised by shallow soils.


Insert Map
(Borneo)
Brunei
Sarawak
Kalimantan
(Indonesia)
Scale 1 : 25,500,000
South China Sea
Miri
Bintulu
Sarawak
(Malaysia)
Kanowit
Kapit
Batang Ai
National Park
Lanjak-Entimau
Wildlife Sanctuary
Kuching
Sri Aman
Lubok
Antu
Sg. Kapuas
Pontianak
Kalimantan
(Indonesia)
Figure 1 : Locality Map Of
Lanjak Entimau Wildlife Sanctuary
Legend
Lanjak-Entimau Wildlife Sanctuary (LEWS)
Batang Ai National Park (BANP)
River
International Boundary
N
100 0 100 Km
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Forest Department Sarawak
Date : 05.04.2000

The sedimentary rocks covering the entire Sanctuary area were laid down between 75 and 60 million years ago (Upper Cretaceous to Lower Eocene). The soils are generally very shallow overlying weathered rocks, and have little profile development. They are classified as Skeletal soils or shallow Red-Yellow Podzolic soils which are very common in central Sarawak.

Parts of the Batang Rajang and Batang Lupar drainage basins are included inside Lanjak Entimau. The Rajang watershed is the largest in Sarawak. The rivers and their tributaries inside the Sanctuary flow swiftly over gravel banks. Numerous rapids are caused by the presence of rocky outcrops and boulder beds. Alluvial deposits are common along the lower stretches of the rivers.

Uniform high rainfall and temperature throughout the year are responsible for the formation of the luxuriant rain forest. Rainfall records from nearby stations indicate an annual range of 2,000 to 4,000 mm, although monthly distributions may vary considerably. It is possible that greater rainfall may occur at higher altitudes in the interior although no record is available.

1.2.3 Flora

Lanjak Entimau is known to possess most of Sarawak's inland major habitats or forest types except forests on limestone and igneous rocks. Based on soil types, altitude and species composition, eight forest types have been classified. These include secondary forests of different ages from 30 to over 100 years old occupying extensive areas along the major rivers. They have evolved from shifting cultivation plots abandoned by the local communities when they moved out of the Sanctuary. Ecological surveys to classify the forest recorded to total of 1,075 species of trees with diameters equal to or above 10 cm at breast height (dbh). There were also 719 tree species below 10 cm dbh, and 177 species of non-tree flora. The Sancutary also contains no less than 218 species of medicinal plants, 158 species of jungle fruits and 108 species of all types of jungle vegetables. Floristic inventories of vascular plants have so far collected a total of 3,500 herbarium specimens representing more than 1,114 species of trees, shrubs, herbs, climbers, palms and orchids. From the two studies, Lanjak Entimau is now known to possess 2,807 species of vascular plant comprising 1,826 tree species and 911 non-tree species. Over 500 species of fungi and 42 species of lichens are also known.

1.2.4 Fauna

With the exception of the herpetofauna and fish fauna, faunal inventories were conducted in different forest types to cover an altitude range from 60 m to over 1,200 m. Lanjak Entimau is now known to contain 6 species of primates, 48 species of small mammals, 235 species of birds, 75 species of reptiles and amphibians, 82 species of fish and 1,053 species of insects. The studies on birds, small mammals and insects show the lowland forests to be a much more important wildlife habitat than the highland forests.

1.2.5 Socio-economic aspects

The periphery of the Sanctuary is occupied by numerous Iban communities with an estimated population of 12,400 people. They live in 102 longhouses mostly located along the major rivers that originate from inside the Sanctuary.

Out-migration is common among the young educated people who look for employment and education in the towns. Those who stay behind are still very dependent on the Sanctuary's resources for their livelihood support. One way to reduce the conflicts between protection and use of the resources is to look into their needs and encourage the local people to participate in economic activities that will help them to develop alternative livelihood.

1.3 ITTO MISSION IN SARAWAK AND ITS SIGNFICANCE

The ITTO sent a Mission to Sarawak in 1989-1990 at the invitation of the State Government. One of the conclusions made by the Mission in its report to the International Tropical Timber Council (Anon, 1990b) was that the conservation of the biological diversity of Sarawak was best served through the *in situ* preservation of the State's natural heritage. Measures recommended towards the accomplishment of this goal included preservation of:-

- a complete series of representative widespread habitats (various forest types, for example) to be accomplished by insuring that a full range of soil types and altitudes is included;

- examples of all unusual habitats or areas with rare or endemic species;

- viable populations of animals (especially large mammals and birds) which require large home ranges;

- species which are naturally rare or endangered, or subject to intensive cropping, such as orchids.

These recommendations are consistent with the policy of the Sarawak Forest Department whose central goal is "to preserve areas of significant geological, biological or historical value for the benefit, education and enjoyment of present and future generations".

The ITTO Mission made a significant impact in making the LEWS Project as a model for biodiversity conservation and sustainable resource management. It also successfully led to the formation of the Betung Kerihun–Lanjak Entimau Trans-boundary Conservation Area in 1994. In 1997, ITTO financed a joint six-week Borneo Biodiversity Expedition (IBBE, 1997) to the Trans-boundary Conservation Area participated by 42 scientists from Malaysia and Indonesia. The Expedition represented the first initiative in collaborative research between the two neighbours.

The trans-boundary concept is being taken up by other ITTO member countries including Peru and Ecuador, and Cambodia and Thailand. This augurs well for the conservation of biodiversity in the humid tropics.

1.4 MANAGEMENT PROBLEMS

The local Iban communities lived and farmed inside the reserve long before Lanjak Entimau became a wildlife sanctuary in 1983. Today, many of them still occupy and farm much of the land in the periphery. In Sarawak, the rural communities are traditionally recognized as an integral part of the forest ecosystems that have provided them with their needs for many generations. Recognising this, the people of Lanjak Entimau have been granted the priviledge to hunt, fish and collect jungle produce in the Sanctuary for their own subsistence.

The Sanctuary is situated in a very remote and inaccessible part of interior Sarawak where the terrain is extremely mountainous and rugged. To the Iban communities, the rivers are the only means of access to the nearest towns usually no less than three hours away by motorised longboats.

Protection became increasingly difficult when logging roads began to penetrate into the area during the last ten years. Human interference came in the form of illegal logging, farming, hunting and fishing. Commercial hunters who use both

the logging roads and rivers for access have created a significant impact on the game animals such as deers and wild boar. Until recently, the lack of a clearly marked boundary on the ground made it difficult to control encroachment by the timber contractors and other encroachers.

These problems that threaten the survival of the complex biodiversity of the Sanctuary need to be addressed and overcome. The importance of the Sanctuary was further recognised when it became a part of the Trans-boundary Conservation Area with Betung Kerihun National Park in West Kalimantan. This joint protected area initiates calls for a collaborative management effort between Malaysia and Indonesia.

PART 2 : OUTPUTS AND ACHIEVEMENTS

2.1 RESEARCH AND DEVELOPMENT

2.1.1 Inventory of Vascular Plants

(a) Collections

To-date the total number of herbarium specimens collected from LEWS including the present inventory and IBBE (1997) stands at 3,500 representing 125 families and 1,114 different species. The five most commonly collected families are Rubiaceae (91 species), Euphorbiaceae (85 species), Palmae (68 species), Melastomataceae (42 species) and Zingiberaceae (41 species). The flora of the major forest types are highlighted below.

(i) Lowland Mixed Dipterocarp Forest

This forest has a dominance of dipterocarps comprising up to 30% of the total number of species recorded. Up to 56 species of the Dipterocarpaceae were recorded from the present inventory with species of *Shorea* forming the bulk. Members of *Dipterocarpus* and *Vatica* are less common while only one species of *Aniosptera (A. costata)* was encountered. Non-dipterocarp emergents include *Sindora* sp., *Diospyros laevigata*, *Gironniera subaequalis*, *Polyathia hypoleuca*, *Ochanostachys amentacea* and *Neoscortechinia kingii*.

Trees and shrubs of the lower storeys belong mainly to members of the Euphorbiaceae, Melastomataceae, Myrsinaceae, Ochnaceae and Rubiaceae. Palms and climbers (including rattan) are common (Table 1).

Table 1 Common palms of Lowland MDF

Areca minuta	*Ceratolobus* sp.
Arenga undulatifolia	*Korthalsia* sp. nova
Calamus caesius	*Licuala pygmaea*
Calamus javensis	*Pinanga mooreana*
Calamus laevigatus var. *mucronatus*	*Pinanga sessilifolia*
Calamus paspalanthus	*Salacca vermicularis*
Calamus tenompokensis	*Salacca affinis* var. *borneensis*

Good collection was made of the herbs belonging to the families of Begoniaceae, Gesneriaceae and Melastomataceae. A wide variety of *Begonia* species differing in habit, leaf shape, leaf coloration and flower features, was particularly remarkable. Owing to the lack of reference material in the herbarium, the identification of many species particularly *Begonia,* would take sometime.

Where thick accumulation of leaf litter occurs, saprophytic plants such as *Sciaphila* (Triuridaceae) are found. This has so far been known to occur in the primary forest only. Among the gymnosperms were *Agathis borneensis* and *Gnetum* spp. The former was collected at a low altitude.

(ii) Old Secondary Forest

This forest is concentrated on low undulating hills near rivers. The Iban people first cleared the forests when they migrated from the Ulu Batang Ai to the Katibas about 300 years ago. Older secondary forests between 30 and 150 years old are common.

Old secondary forest of up to 100 years or more is similar in appearance to the primary mixed dipterocarp forest. Ecological surveys have revealed a significantly low number of dipterocarp species compared to the primary forest. Both forests share a similar group of the dominant families although the species and frequencies differ. Some species are good indicators of former disturbance such as *Cratoxylum arborescens* and *Tristaniopsis sumatrana* which are common in the older secondary forest.

A much larger selection of climbers was collected compared with the lowland dipterocarp forest. As climbers thrive well in the canopy gaps and edges of the forest, they naturally become more abundant in the secondary forest where tree densities are much lower (see Table 2).

One notable feature of the old secondary forest was the abundance of tree species that produce edible fruits. The presence of such trees might be due to seeds of fruit trees having been discarded in areas once used for shifting cultivation by the Ibans migrating through the area in the past (Table 3).

In the old secondary forest, most of the collections were shrubs and herbs belong to the families of Acanthaceae, Euphorbiaceae, Rubiaceae, Saurauiaceae, Amaryllidaceae, palms, ferns, Hypoxidaceae, Marantaceae, Myrsinaceae and Piperaceae. Species such as *Ixora*, *Pavetta*, *Psychotria* spp. (Rubiaceae) and *Papualthia*, *Popowia* and *Pseudouvaria* spp. (Annonaceae) were commonly

encountered. The secondary forest has better developed undergrowth than primary forest due to the lower tree density and more open canopies allowing more light to reach the forest floor. A number of secondary species have taken advantage of the conditions of higher light intensity to colonise the new niches.

Table 2 Some common climber species in old secondary forest

Apocynaceae	*Willughbeia* spp. *Kopsia* sp.
Gnetaceae	*Derris* spp.
Gramineae	*Dinochloa* sp.
Leguminosae	*Bauhinia* sp. *Derris* spp.
Rubiaceae	*Uvaria* sp. *Psychotria* sp.
Symphoremataceae	*Sphenodesma* sp
Vitidaceae	*Pterisanthes* sp.

Table 3 Common wild fruit trees found in the old secondary forest

Mangiaceae	*Alangium* sp.
Bombacaceae	*Durio lanceolatus*
Clusiaceae	*Garcinia bancana*
Euphorbiaceae	*Baccaurea macrocarpa*
Fagaceae	*Castanopsis* sp.
Gnetaceae	*Gnetum gnemon*
Leguminosae	*Dialium maingayi*
Moraceae	*Artocarpus elasticus* *Artocarpus integer*
Polygalaceae	*Xanthophyllum amoenum*
Sapindaceae	*Dimocarpus longan*
Saurauiaceae	*Saurauia* sp.

(iii) Alluvial and riparian forests

These forests on the flat ground in the flood zone of rivers are subject to periodic disturbance due to flash floods. They are characterised by high light intensities at waterway margins, high relative humidities and the intermittent action of fast-flowing currents. Many herbs, climbers and epiphytes are adapted to these conditions. Mossy condition has also developed.

Some of the common tree species are *Dimocarpus longan*, *Dipterocarpus oblongifolius*, *Pometia pinnata* and *Parashorea macrophylla*. A dipterocarp of alluvial forest (which also occurred on hill slopes further away from the river) was *Shorea macrophylla*. Some individuals of *S. macrophylla* have reached giant size and the species was found to be regenerating well in the area as many seedlings were encountered. Many members of the Euphorbiaceae (*Baccaurea, Aporusa* spp.) and Myrtaceae (*Eugenia* spp.) also occur in this forest type.

Palms characteristic of alluvial and riparian forests are *Areca jugahpunya*, *Pinanga mooreana*, *Plectocomiopsis geminiflora*, *Salacca dransfieldiana* and *Salacca vermicularis*. Climbing palms include *Calamus* spp., *Daemonorops* spp., *Korthalsia rostrata*, *Korthalsia rigida* and *Korthalsia robusta*. Herbaceous flora are very well-represented by the families Begoniaceae, Gesneriaceae, Rubiaceae and Zingiberaceae (Table 4). The alluvial and riparian forests are particularly rich in epiphytes, including many orchids. As many as 1/3 of the orchid specimens were collected from these forests.

Table 4 Herbs of alluvial and riparian forests

Genus	No. of species	Genus	No. of species
Acranthera (Rubiaceae)	5	*Cyrtandra* (Gesneriaceae)	15
Begonia (Begoniaceae)	10	*Globba* (Zingiberaceae)	6

Other plants of the undergrowth consist of *Donax canniformis* and *Phrynium capitatum* (Marantaceae), *Bhesa pinnata* (Celastraceae), *Elatostemma* (Urticaceae), *Argostemma* (Rubiaceae) and *Homalomena* spp. (Araceae).

(b) Habits of plants

The specimens represented a wide range of vascular plant types. The majority of the specimens so far collected from LEWS are trees but the non-tree flora, including herbs, shrubs, climbers and epiphytes, is also extremely rich and has been well sampled. Hemi-parasites (with more than 10 species of Loranthaceae) and saphrophytes (two species of *Burmannia* [Burmanniaceae]) have been collected.

(c) New species

Korthalsia rostratioides Mogea (Palmae) collected in Katibas, has been recognised as new (Mogea, pers. comm.). A species of *Microtropis* (Celastraceae) collected twice during this project, appears new as it is not described in the recent revision of this family. It is very likely that new species of *Acranthera* (Rubiaceae), *Agrostistachys* (Euphorbiaceae), *Begonia* (Begoniaceae, *Cyrtandra* (Gesneriaceae), *Eugenia* (Myrtaceae), *Garcinia* (Clusiaceae), *Helicia* (Proteaceae), and *Psychotria* and *Urophyllum* (Rubiaceae) can be described after further taxonomic work.

(d) New records for Sarawak and Borneo

Seven new records were noted (Table 5). This number is likely to increase as more such records are detected on further examination of relevant literature. It is significant that all but two of the newly recorded taxa were collected in lowland forest and of these, *Calophyllum mukunense* was collected from secondary forest. *Garcinia bancana* var. *curtisii* and *G. dumosa* were collected in hill dipterocarp forest.

Table 5 Taxa collected from Lanjak Entimau Wildlife Sanctuary which represent new records for Sarawak and Borneo

Family	Species	Status (N.R. = New Record)	Habitat (forest type)
Anacardiaceae	*Semecarpus sandakanus*	N.R. Sarawak	Lowland D.F.
Clusiaceae	*Calophyllum mukunense*	N.R. Sarawak	Secondary F.
	Garcinia bancana var. *curtisii*	N.R. Sarawak	Hill D.F.
	Garcinia dumosa	N.R. Sarawak	Hill D.F.
Myrtaceae	*Eugenia burkilliana*	N.R. Sarawak	Lowland D.F.
Polygalaceae	*Xanthophyllum monticolum*	N.R. Sarawak	Lowland D.F.
Rubiaceae	*Urophyllum sessiliflorum*	N.R. Borneo	Lowland D.F.

(e) Rare species

Rarity of a species was stringently defined for the purpose of this project. Only species represented by at the most two specimens in SAR, or reference to two specimens in the literature, were taken to be rare. This totalled 29 species in 19 families. Interestingly nearly all of these occur in lowland or hill forest. *Iguanura chaiana* (Palmae) is the one rare species that was found limited to hill and submontane forests. *Medinilla allantocalyx* (Melastomataceae) occurs in montane

forest but is not limited to this habitat. *Knema mucosa* (Myristicaceae) occurs in the summit ridge forest.

(f) Endemic species

Endemism can only be determined for groups where an up-to-date taxonomic revision is available. Endemism of the species occurring in the TPA has been ascertained for 25 families so far revised under the Tree Flora of Sabah and Sarawak Project : (Alangiaceae, Anacardiaceae, Anisophyllaeaceae, Burseraceae, Capparidaceae, Celastraceae, Chloranthaceae, Crypteroniaceae, Ixonanthaceae, Juglandaceae, Leeaceae, Loganiaceae, Ochnaceae, Olacaceae, Oxalidaceae, Pittosporaceae, Rhamnaceae, Rhizophoraceae, Rutaceae, Sapindaceae, Scyphostegiaceae, Simaroubaceae, Styracaceae, Ulmaceae and Winteraceae). Endemism in the Dipterocarpaceae, ferns, rattans, Meliaceae and Euphorbiaceae has also been determined. The TPA has been found to be the home to at least 61 endemic species including 17 rattans, 15 Euphorbiaceae species and 13 dipterocarps, chiefly *Shorea* species, with *Shorea flava* and *Shorea iliasii* being endemic to Sarawak and the remainder endemic to Borneo.

(g) Plants of significance to wildlife

As Lanjak Entimau is a wildlife sanctuary, plants of significance to wildlife ought to be highlighted. The abundance of *Aristolochia* and *Thottea* (Aristolochiaceae) is of significance as it is the food plant of the caterpillars of the Rajah Brooke's birdwing (*Troides brookiana brookiana*). Food plants of other caterpillars are also found in abundance *viz*, Moraceae and Convolvulaceae. Wild fruit trees such as *Aglaia*, *Litsea* and *Ficus* spp. are also abundant. These fruit trees serve as a dependable source of food for wild animals like hornbills, orang utans and other primates.

Numerous plants also serve as shelter for the wild animals. The tall emergent *Koompassia malaccensis* is abundant in the Sanctuary and harbours millions of bees. The trough formed by massive and cylindrical trees, often highly buttressed such as *Koompassia malaccensis* and other dipterocarp species also serve as a breeding ground and home to a number of amphibian species, while the hollow bole of big trees are home to a variety of birds including the magnificent rhinocerous hornbills.

(h) Plant genetic resources and germplasm conservation

LEWS is a very suitable location for the establishment of *in situ* genebanks. It is the single largest Totally Protected Area (TPA) in Sarawak and protects a significant proportion of the State's remaining virgin forest. It supports large areas of lowland and hill dipterocarp forests, the backbone of Sarawak's timber industry. The forest is also rich in wild fruit trees, ornamental plants, food crops (e.g. Piperaceae and Zingiberaceae) and plants of medicinal value. They form an important genetic resource and *in situ* germplasm for breeding and crop improvement in a non-destructive way in future. Seed of useful trees for planting needs elsewhere in the state can be collected in certain zones of the TPA.

(i) Plants with ornamental potential

There are a number of plants with ornamental potential, particularly from the herbaceous group. These are mainly from families Acanthaceae, Araceae, Asclepiadaceae, Begoniaceae, Commelinaceae, Dilleniaceae, Ericaceae, Gesneriaceae, Melastomataceae, Myrsinaceae, Orchidaceae, Palmae, Rubiaceae and Zingiberaceae. The study and introduction of species with ornamental potential is one way in which the Sanctuary's non-timber resources can be sustainably utilised.

2.1.2 Fungi and Lichens

More than 500 fungi species belonging to 71 genera in 39 families were collected from various ecotypes. The number of fungi species made up about 11.0% of the known forest fungi species in Sarawak (about 4,600 species). A very large percentage of the marcrofungi in the Sanctuary were recorded in mixed dipterocarp forest (63.0%) and riparian and alluvial forests (32.0%), while less abundant in other forest types. The Polyporaceae (11 genera) and Tricholomataceae (8 genera) are the most dominant families in the studied areas. Collections by forest types are described below:-

(a) Alluvial Forest

Most fungi were found on a wide variety of substrata, growing on rotten tree trunks, dead branches or fallen twigs, leaf litter, soil and other forms of organic matter.

Two poisonous, eight edible and ten medicinal species were found here. Some edible species, e.g. *Pleurotus ostreatus* (oyster mushroom), *Auricularia auricula-judae (kulat bibir), Lentinus sajor-caju (kulat jelutong)*, and *Calostoma* sp. *(kulat mata babi*) are commonly sold as food at local markets.

(b) Old Secondary Forest

Although the result was not very encouraging, some fungi species probably formed mycorrhizal association with forest trees. Species of *Thelephora, Boletus, Russula* and *Tricholoma* were found locally on the forest floor.

(c) Lowland Dipterocarp Forest

The highest number of collections were made in the lowland dipterocarp forest at Ulu Engkari. Some parasite bracket fungi species such as *Fomes* sp. (Polyporaceae) on living *meranti majau (Shorea leptoclados*) and *Phellinus* sp. (Hymenochaetaceaae) on living *kumpang pali* (Myristicaceae) were encountered.

Fungi of socio-economic importance are plentiful in this forest type, e.g. *Xylaria polymorpha (kulat tusu babi), Anauroderma* sp. *(kulat menaul), Ganoderma lucidum (kulat lang), G. applanatum (kulat lang), Lentinellus cochleatus (kulat burak)* and *Pycnoporus sanguineus (kulat bungkang).* They are commonly used as food or medicine by the Iban people.

Species of *Boletus, Amanita, Thelephora, Cortinarius,* and *Tricholoma* are common. Many of them may form mycorrhizal roots with forest trees.

(d) Hill Dipterocarp Forest

Collecting localities included forest areas around the camp site on Ubah Ribu ridge at about 700 m a.s.l. Many species occur in diverse habitats including soils and rotten wood. They include simple saprophytes and a number of parasitic species.

(e) Submontane and Montane Forest

Sampling in submontane mossy and montane mossy forests was undertaken at Bukit Lanjak (1,285 m a.s.l.). The occurrence of macrofungi in these vegetation types indicates a decrease in species and quantities. The fungi possess small to medium-sized fruit bodies which are tough, leathery or even corky.

(f) Occurrence of the fungi in relation to seasons, ecotypes and rainfall

Most species will grow between 15-35 °C while the optimum temperature lies in the range of 20-30 °C.

Light is essential only for producing spores. They are more common and abundant during warm, rainy seasons. The main growing season begins from late October or early November to February, with the peak period between December and February. During the dry season, only the wood inhabiting species are found to grow well.

Due to their dependence on organic materials for food, most of them may appear whenever such materials are available. Some species are extremely specific in their growth associations, being found only on dung or associated with roots of certain trees. Generally, macrofungi can flourish very well in alluvial/riparian and mixed dipterocarp forests.

In LEWS, almost all swidden land and potential swidden land fall roughly into the lowland dipterocarp forest zone. The richest flora (and fauna) are found in this vegetation type. The Euphorbiaceae and Dipterocarpaceae are the two dominant groups. The dense vegetation prevents drought, minimise moisture evaporation and protects forest soils from direct exposure to the sun.

At the same time, a large amount of organic material decomposed from dead plant parts and animal products provide the necessary habitats for forest fungi.

In submontane mossy and montane mossy forests at about 1,100 m a.s.l., damp mosses grow over tree trunks and branches and form a layer of cushion making it difficult for the fungi to penetrate. The small trees are enveloped in dense growths of the moss. Cool weather coupled with peaty, acidic soils and the presence of many exposed areas that are totally bare of tree growth are factors that discourage fungi development.

(g) Lichens

Lichens are abundant and widely distributed in riparian/alluvial forest and lowland dipterocarp forests. The fundamental part of lichen is called the thallus which is composed of a fungus and an alga. Basically, three main kinds of lichens can be distinguished by their habit of growth and the manner of attachment to the object on which they grow (the substratum):

(i) Crustose lichens : the crust-like thallus tightly appressed to the substrate. Most lichen species in LEWS belonging to this class, e.g. *Graphis* sp. and *Opegrahpha* sp.

(ii) Fruticose lichens : thallus erect and rising from the substrate. They may be entirely unattached or may arise from a disk or holdfast. No specimen was collected in the Sanctuary area.

(iii) Foliose lichens : they are leaflike and prostrate but not so firmly attached to the substratum. *Collema* sp. and *Parmelia* sp. are the typical foliose lichens collected in LEWS.

During the study, 42 lichen species were collected. Lowland dipterocarp forest has the highest lichen species diversity than other forest types. The most common species found here are the "Crustose lichens": Pyremulaceae (*Pyremula* sp.) on *bilat (Parashorea macrophylla),* Graphidaceae (*Graphis* sp.) on *empili (Lithocarpus* spp.) and *kumpang seluai (Knema* sp.). Some unidentified species are recorded on living trees of the Myristiacaceae, Myrtaceae (*Eugenia* spp.) and Leguminosae *(Koompassia malaccensis).*

"Foliose lichens" are also common in occurrence. The Parmeliaceae (*Parmelia* sp.) was found on Sapotaceae (*nyatoh*), while Physciaceae (*Physcia* sp.) was collected from an unidentified small tree.

In general, the riparian/alluvial forest is richer in crustose lichen species than the lowland dipterocarp forest. They occur on the leaves of Dipterocarpaceae (*Vatica* sp.), Palmae, Euphorbiaceae (*Cleistanthus* sp.), Leguminosae, Myrtaceae (*Eugenia* sp.) and Zingiberaceae. Many species were also observed on the stem (or bark) of Myrtaceae, Annonaceae, Polygalaceae, Euphorbiaceae and Dipterocarpaceae. In the riparian forest they occur on exposed rocks. Their growth on bare rocks initiates the weathering away of such rocks.

Lichens are less common in hill dipterocarp forest and sometimes thoroughly disappear in submontane and montane forests.

2.1.3 Ethnobotany

The information was classified into a number of categories based on uses. Food and medicine were the most popular categories. Out of the total 245 species or varieties recorded from Ulu Kanowit, 176 or 72% were found to have edible parts including oil from fruits, while 57 species or about 23% possessed medicinal

properties. In the Ulu Skrang area, species with edible parts amounted to 113 or 49% out of the total 233 while medicinal plants comprised 61 species or 26% (Table 1).

(a) Wild vegetables

The number of wild vegetables from Ulu Kanowit and Ulu Skrang total 102. These are classified into young leaves and cabbages and young stems. Species that produce edible young leaves are trees, shrubs and treelets in the undergrowth. Cabbages and young stems are mostly obtained from palms including many rattans. The majority of the plants are known only to the local people.

Table 1 Plants and their uses in ulu Kanowit and ulu Skrang

Uses	Number of species	
	Ulu Kanowit	Ulu Skrang
Vegetables		
Young leaves	35	17
cabbages (young shoots)	44	16
Flavouring (leaves, fruits)	3	9
Fruits	89	70
Oil	5	1
Medicine	57	61
Mats and other household items, fish traps	4	18
Fish poison	1	4
Shampoo/soap	1	1
Construction (boats and thatching)	-	5
Dye	1	5
Bark	-	7
Latex		
Knife handle	-	1
Anti-adhesive	-	1
Pepper post	-	2
Leaves for wrapping	-	3
For polishing	-	1
Decorative	-	1
Betel leaves	-	1
Perfume	1	3
Strainer	-	1
Heat insulator	-	1
Cigarette wrapper	-	1
Protection again evil spirits	4	3
Total	245	233

(i) Young leaves or *Kantok*

Wild vegetables are made up of young leaves and cabbages in nearly equal proportions. The young leaves or *kantok* in the Iban language are obtained from a wide variety of trees, shrubs, herbs and climbers. The most popular among these are the ferns *Diplezium esculentum (paku)* and *Stenochlaena palustris (midin).* These ferns are also much sought after by the urban consumers. One reason for this is that as wild plants they are free from pesticides.

Kantok are also obtained from *Gnetum gnemon (daun sabong)* and *Pangium edule (kepayang),* respectively a treelet and tree growing near inland river banks. These are sold in many jungle produce stalls in town but are not as popular as the ferns. *Kantok* from *Mangifera pajang (mawang)* and *Elateriospermum tapos (kelampai)* are less well-known. All four species also produce edible fruits. The fruits of *Pangium edule* contain a hydrogen cyanide compound and must be boiled in water for many hours before they can be eaten. An additional use of the seed is for perfume and soap. The fruits are dried thoroughly to remove the poison, ground into fine powder and applied as a perfume. The dried seed is used as soap.

(ii) Cabbages and Young Stems

Thirty seven species of palms, 4 species of gingers and 3 species of bananas are known to produce edible parts including cabbages, undeveloped leaves and young pseudo-stems. Of the 37 species of palms, 27 are rattans. The cabbages and undeveloped leaves are normally cooked but many of the palm cabbages can also be eaten raw. The young stems of gingers are strongly aromatic and are used for flavouring meat and fish dishes.

Palms have a wide distribution in a variety of habitats and are most common in the lowland mixed dipterocarp forest. Their habits range from the climbing rattan to the tall woody-stemmed *Eugeissona (pantu)* and *Oncosperma (nibong)* spp. up to a height of over 25 m, and the smaller *Licuala (palas, biruk)* and *Salacca (ridan)* of the undergrowth. The edible rattans belong mainly to species of *Calamus, Daemonorops, Korthalsia* and *Plectocomiopsis.* They constitute an important diet among the local hunters and forest produce gatherers, and are also sought after by forestry officers and surveyors who may run out of food before the end of their trips.

The gingers and bananas are associated with secondary vegetation as they colonise shifting cultivation sites, forest gaps and clearings, and are common in logged-over forests. The gingers grow best in shady environment and many have a clustering

habit. The bananas are more widespread and may colonise an entire hillside after the rice is harvested.

The parts of the ginger and banana plants that are eaten are the young pseudostems and undeveloped leaves and meristems. These are obtained by peeling off the outer fibrous layers of leaf sheaths. They may be eaten as a vegetable after cooking or boiling in water, or added to meat and fish dishes. The strongly aromatic gingers, in particular the *Hornstedtia magnifica* (*kecala)* and *Etlingera fimbriobracteata (tepus)*, constitute a very important ingredient in local cooking. The young inflorescences are also used. The ripe fruit can be eaten raw and has a sweet-sour taste.

(iii) Plants used for Flavouring

Apart from the popular gingers *Etlingera fimbriobracteata* and *Hornstedtia magnifica*, nine other species have been recorded. These consist of seven trees, two climbers and one herb. The more well-known species among the trees are *Eugenia cephalanthum* (*bungkang*), *Pangium edule* (*kepayang*), *Garcinia forbesii* (*kundong*) and *Garcinia parvifolia* (*chirei*). The young leaves are cooked with fish or meat dishes to produce an acidic or sour taste. The *Garcinia* fruits are similarly used. The fresh fruit walls of *Garcinia forbesii* may be dried and kept for later use. The leaves of *Pangium edule* serves an additional function of preserving meat when making *kasam,* a meat dish preserved in salt in bamboo containers. The leaves are finely cut and mixed thoroughly with the fresh meat before putting it in bamboo containers. The leaves keep houseflies out and prevent their eggs or larvae from hatching or growing on the meat.

Scorodocarpus borneensis is aptly called *bawang hutan* in the local language, meaning forest garlic. The fresh bark, leaves and fruits emit a very strong garlic smell. It is not a favourite flavouring agent because many find the smell too pungent and repulsive.

The climbers with leaves used for flavouring are *Embelia ribes (akar kencham)* (Myrsinaceae) and *Pycnarrhena borneensis (daun tubu)* (Menispermaceae). The leaves of the *Begonia* spp. are similarly used although this herb is better known for its ornamental value.

(b) Wild fruits

Fruit trees constitute an important food chain of the forest ecosystems. The majority of them are confined to the lowland habitats from alluvial forest to mixed

dipterocarp forest. They are relatively rare in the secondary forest except for members of some families such as the Moraceae (e.g. *Artocarpus* spp.) and Leguminosae (e.g. *Pithecellobium jiringa*). The 1994 primate survey found a high concentration of fruit trees in the southern region of the Sanctuary covering Mabau, Lelap and Batang Ai. This region is the stronghold of the orangutan.

Between 70 and 89 species were recorded in the Ulu Skrang and Ulu Kanowit respectively, with the total number amounting to 127 species. The major fruit producing families are the Moraceae (19 species), Sapindaceae (15 species), Euphorbiaceae (9 species), Palmae (12 species), Fagaceae (7 species), Anacardiaceae and Zingiberaceae (7 species each), and Bombacaceae (5 species) and Dipterocarpaceae (4 species).

In view of the increasing popularity of local fruits and the many varieties available, there is great opportunity for selection and propagation of high quality and high yielding species.

The forest fruits not only provide nutrition to humans but are also a major food source for numerous species of primates and birds. At least 62 species are eaten by the orangutan and other primates.

(c) Edible oil

For generations, the Iban people have extracted *minyak engkabang* or illepe nut oil from the fruits or nuts of the *engkabang* trees. The Iban communities in the LEWS buffer zone extract the oil from five species of *Shorea* in the family Dipterocarpaceae. These are *Shorea beccariana* (*engkabang langgai*), *Shorea macrophylla* (*engkabang jantong*), *Shorea seminis* (*engkabang terendak*), *Shorea smithiana* (*engkabang rambai*) and *Shorea splendida* (*engkabang bintang*). All *engkabangs* are protected in Sarawak.

To extract the oil, the fruit walls are removed and the kernel dried under the sun. The dried kernel is pounded thoroughly and fried in a *kuali* until the oil begins to appear. The warm kernel is put in a small bamboo container and pressed between two pieces of wood to squeeze out the oil, which is collected in a bamboo container. This pressing process is repeated two to three times until all the oil is extracted. The kernel is fried before each subsequent pressing. The oil cools into a yellow solid inside the bamboo container.

The fragrant oil adds a delicious flavour and taste to cooked rice and enhances one's appetite. The solidified oil melts quickly when its end is dipped into a plate of steaming hot rice. It is occasionally used to prepare fried rice.

Commercial use of the engkabang oil is for the manufacture of chocolates and cosmetics such as lipsticks and face cream. During the bumper crops in 1982, 1987, 1990 and 1995, between 12,746 and 23,444 tons of the nuts were exported from Sarawak, valued at 13 to 17 million Malaysian ringgit.

(d) Traditional medicine

The practice of traditional medicine among the Iban people has an equally long history as the use of wild plants for food and construction materials. In the olden days herbal remedies provided the only relief when modern medicine was not available. The medicine was usually administered through *bomohs* or *manangs* (medicine men). Depending on the ailments, the healing process would often involve some kind of rituals during which spirits would be called upon to help, through prayers and chanting of verses. Today, whatever knowledge on traditional medicine and healing that remains is confined within a small group of older people. Much information has been lost with the passing on of *bomohs* or *manangs* who were the most knowledgeable on the subject.

In the present survey, 101 species of wild plants were reported to possess medicinal properties. They occur in a variety of habitats in primary and secondary forests. They have been grouped into eight categories according to their functions to treat different ailments (Table 2). The most popular categories are treatment of various types of skin diseases, body pains and swellings, fever, malaria and cholera, snake and insect bites, and stomach ache, gastric, diarrhoea and vomiting.

Table 2 Uses of medicinal plant from Skrang and Kanowit

Uses	Ulu Skrang	Ulu Kanowit
Skin diseases including itichiness, herpes, ulcers	12	7
Body pain & swellings	11	1
Fever, malaria, cholera	9	3
Snake & insect bites	7	5
Stomach ache, gastritis, diarrhoea, cough, vomiting	10	6
Eye infection	-	5
Cuts & wounds	4	6
Recovery after birth	-	5

Note : Minor uses includes small pox, goitre and sore eyes recorded from Ulu Skrang, and bone fracture, birth control, breast cancer, etc. from Ulu Kanowit

Remedies for other ailments are less well known, such as *Grammatophyllum speciosum*, a giant orchid, for jaundice in newborn babies, *Torenia polyonoides* (Scruphulariaceae) for goitre, a *Massaenda* spp. (Rubiaceae) for birth control, and *Adenostemma lavenia* (Compositae) for breast cancer.

Although much information on the uses of jungle herbs is still available, in practice very little of them is used as most patients prefer to go for modern medicine instead. The local communities are generally more familiar with the many herbs from the young secondary jungles and farms close to their longhouses, while knowledge of the primary forest species is usually limited to few older people.

The wealth of indigenous knowledge on the medicinal properties of forest plants contributes an important database for use in research and discovery of new products or remedies to satisfy man's needs. In order to widen the resource base, continuing effort should be made to establish more TPAs in the State's remaining pristine forests for the preservation of more genetic materials from a variety of forest ecosystems.

(e) Firewood

The Iban classify firewood generally into three groups depending on the ability of the wood to burn. The first group refers to wood that burns easily when fresh. This includes all species of *Lophopetalum (perupok)* (family Celastraceae), *Agathis (bindang)* (Araucariaceae) and a few species of *Mallotus* in the Euphorbiaceae especially *Mallotus penangensis* (*ensarai*) and *Mallotus muticus* (*belati*).

The second group of fuelwood burns easily as soon as some moisture from the freshly cut wood is removed by placing it beside or above a fire place. Examples are all species of *Parastemon (ngilas)* (Rosaceae), many species of *Lithocarpus (empili)* (Fagaceae) and *Diospyros (kayu malam)* (Ebenaceae), hill species of *Eugenia (ubah)* and *Tristaniopsis (selunsor)* (Myrtaceae), *Knema* and *Myristica (kumpang)* (Myristicaceae) and *Elateriospernum tapos (kelampai)* (Eurphorbiaceae). Although *Horsfieldia* belongs in the same family as *Knema* and *Myristica*, its wood does not burn as easily and is referred to as *kumpang lusu* or *lazy kumpang* by the Iban.

The third group includes wood which must be sufficiently dried before it can be used. Included here are species of *Baccaurea* (Euphorbiaceae), in particular

Baccaurea lanceolata (limpaong) and *Baccaurea angulata (uchong). Horsfieldia* spp. (*kumpang lusu*) also belongs in this category. The fresh wood is cut, split and brought back to the kitchen and dried above the fire place.

In recent years, the local communities in the buffer zone have gradually switched from firewood to the use of gas. Gas tanks are purchased from nearby towns and brought to the longhouses in longboats. Nevertheless, wood fire is still preferred during communal cooking when large quantities of food need to be cooked.

(f) Construction materials

The forest provides ample materials for the construction of longhouses, farm huts and longboats. Selection of timber for house construction is based on end use. Strong and durable timber such as *belian (Eusideroxylon zwageri)* and *selangan batu (Shorea* spp.) are used for main support. Most other less durable and often decorative species are selected for a variety of uses such as general structuring or framing, walling, flooring and boat building.

Many species used in house construction are also good for boat building. As longhouses are traditionally built along the rivers, longboats provide an essential means of communication and transportation of farm products and materials.

Sources of construction and building materials come from 29 families of forest trees of which the Dipterocarpaceae is the most important. The majority of the species belong to *Shorea*, a genus that includes the *meranti* and *selangan batu.* Species of *Dipterocapus (keruing), Dryobalanops (keladan, kapur), Upuna borneensis (penyau)* and *Vatica (resak)* are much less commonly used, although *Upuna borneensis* is one of the favourite species for boat building whenever it is available.

Materials for farm and jungle huts do not need to be durable as these huts are usually built for temporary use. While the main structures are built of timber, the walls and roofs are normally made from the leaves of palms, gingers, ferns and a few species of trees with large foliage, such as *Campnosperma (terentang)* and *Artocarpus (pingan).* The bark of *Artocarpus* also makes good walling material but this is rarely used nowadays.

(g) Mats and baskets

Mats and baskets are regarded as valuable assets by the local communities. Every household, no matter how poor, will own at least a few of them. They are made for

a number of uses. The best mats are kept exclusively for rituals and ceremonies. They are called *bidai* (Rajang Iban) or *idas* (Saratok Iban). A more common name is *tikai limpit*. They are made from long strips of good quality rattan held together by the inner bark of *tekalong (Artocarpus elasticus)*. The best quality rattans are *wi letik* from the species *Calamus caesius* and *wi sega* from *Calamus optimus*.

Mats are also used for sleeping, for entertaining guests and for drying of padi, corn, pepper and other farm products. The materials used are *rattan, bemban (Donax canniformis), kerupok* or *nas (Pandanus* spp.), *sengang (Hornstedtia* and *Etlingera* spp.) and bamboo.

The majority of the rattan belong to the species of *Calamus.* Species of *Daemonorops* and *Korthalsia* produce a number of well-known rattans called *wi lepa* and *wi tut (Daemonorops sabut, D. semoi),* and *wi danau (Korthalsia jala),* used to produce mats of medium quality.

The same materials are used to make a wide variety of baskets and containers. The largest of these baskets, called *lanji* are up to 1.5 m tall and 30 cm in diameter, and are used for carrying padi from the farm back to the longhouse. Due to the large size, big rattan canes are used to make a frame for support and to provide strength to the *lanji*. Padi containers may also be made from the bark of *Prunus arborea* (*enteli*) in the Rosaceae.

Ajat or *badok* are medium-sized baskets usually up to 60 cm high and do not have a frame. *Raga* are smaller than *ajat* and are usually carried as a backpack. Back straps for these baskets are made from the inner bark of *tekalong (Artocarpus elasticus*). In the olden days, this bark was also used to make clothing. *Selok* are worn as a waist pouch and are used for carrying pepper berries or padi during harvest. *Chapan* is a shallow spade-shaped container used for winnowing rice and for carrying and drying of small items. *Lupong* is a sacred item used only by the *manang* or medicine men to keep their medicine and other items for healing. It is a tabboo for anyone to step over a *lupang.*

(h) Other uses

The forest plants have many other uses besides the ones already described. They produce a number of interesting products that are rarely known outside the local communities. In the olden days, when the rural communities were completely cut off from the outside world, they could only rely on the plants to provide them with such products as fibre, dyes, perfume, shampoo and soap. Today, these natural products are rarely used, but the knowledge that has been handed down would form

the basis for research into the development of natural plant products and provide an opportunity for study on the sustainable exploitation of the rich plant resources.

(i) Fibres

The most popular and useful fibres are produced from the bark of *Artocarpus elasticus* (*tekalong*). Uses include construction of walls and partitions, ropes, straps for baskets and containers, and belts.

Fibres from the bark of *Prunus arborea* (*enteli*) and leaves of *Curculigo latifolia* (*lemba*) (Hypoxidaceae) are used to make blankets (*pua kembu)* and clothing *(kain*). The fibres of *Curculigo* are from the long, lanceolate leaves. They are obtained by scrapping the upper and lower epidermis of the wetted leaves in water with a split bamboo. The warp threads used to make *pua* and *kain* are first dyed. The parts of the threads where dyeing is not required are tied with the fibre.

The dry fibres of the climbers *Friesodielsia glauca* (*randau rarak*) (Annonaceae) and *Spatholobus* spp. (*penduk*) (Leguminosae) are used as fuses to start a fire. Fish lines are made from *Gnetum raya* (*akar tegang*). This is a climber of the primitive family Gnetaceae. The soft stems of the *resam* fern *Gleichenia linearis* (Gleicheniaceae) are used for making ornaments such as head bands and bangles and for decorating *parang* sheaths or scabboards after the hard outer covers are removed.

(ii) Dyes

The two main colours of *pua kembu* are black and red. Black dyes are obtained from the leaves of *Rourea mimosoides* (*kayu kemarang*), *Symplocos fasciculata (jirak)* and *Morinda citrifolia (mengkudu),* and the tubers of *Tetrastigma pedunculare (buah tanah*). The last two species also produce red dyes. Other sources for red dyes are *Psychotria elmeri (engkerabai)* and the fruits of *Morinda citrifolia*. The dyes are extracted either from the fresh leaves, fruits or tubers.

(iii) Perfumes

Many forest plants are strongly aromatic and fragrant. They have been used to produce substances such as spices *(Cinnamomum* spp.), incense (*Aquilaria* spp.) (Simaroubaceae) and oil (*Myristica fragrans*) (Myristicaceae). Recorded sources for perfumes are the fruits of *Lindera pipericarpa (medang serai)* and *Urophyllum hirsutum (duin*), and the stems and leaves of *Vandellia* spp. (*bunga penit*). *Lindera*

is related to *Cinnamomum* (Lauraceae) while *Urophyllum* belongs to the same family as coffee in the Rubiaceae. *Vandellia* is a herb in the Scrophulariaceae.

(iv) Shampoo and soap

The best known species for shampoo is *langir* or *Xanthophyllum amoenum*, a tree of the family Polygalaceae. It was popular also among other ethnic communities who lived in the more remote areas and is still occasionally available in jungle produce stalls and shops.

The ripe fruits are edible. The fruit skins are collected and dried. A few pieces of the dried fruit walls are boiled in a pot of water. A warm solution for hair wash is ready after adding cold water to get to a suitable temperature. The cleansing power of this product is so effective that the hair becomes "squeaky' clean and shiny after the wash.

Another species which is used both as a shampoo and a soap is the secondary forest shrub *Ilex cissoidea (aras)* (Aquifoliaceae). When the fresh leaves are agitated or crushed in water, they produce a white lathery substance. This is used to rub on the body or hair. Soap is also similarly produced from the leaves of the small fleshy herb *rumput pupok (Salomonia cantoniensis)* (Polygalaceae). Sap from its fresh leaves is also used externally to treat snake bites.

(vi) Insecticide

The people from Rumah Dau in Ng Entalau in the Sri Aman Division reported the use of the herb *Pogostemon articularis* (Labiatae) to kill bed bugs. Mats and mosquito nets infested with the bugs are soaked in a solution obtained from boiling the plant in water.

(i) Rituals and ceremonies

It is the long tradition of the Iban people to appease the spirits of heaven, water and earth and to thank them for a bountiful rice harvest and good luck. A number of *Gawai* or festivals are performed each year for specific purposes, such as *Gawai Hantu* (festival of the ghosts), *Gawai Kenyalang* (festival of the hornbills) and *Gawai Dayak* which is the grandest and most important festival held to celebrate a good rice harvest. It is also the Dayak New Year which falls officially on 1 June of each year.

During each festival, *miring* is performed. This is a ceremony to offer sacrifice to the spirits. The ritual or ceremony cannot be performed without a number of plants which are considered as sacred to the Iban people. These include the herbs *Cordyline terminalis (sabong)* (Agavaceae), *Costus glabra* and *Costus speciosus (letik* or *tepung buluh)* (Zingiberaceae).

Among the many uses, the most popular ones are to keep off malevolent spirits. The variety of plants used include the shrubs *Vernonia arborea (entupong)* (Compositae) and *Fagraea crassipes (sukong)* (Loganiaceae), and the herb *Homalomena sagittifolia (belingau). Belingau* (Araceae) is also carried by hunters for good luck during hunting trips.

2.1.4 Genebank Establishment

(a) Criteria in genebank establishment

Genebank establishment is a relatively new activity in Malaysia. In the past with vast natural forest resources, it was considered not necessary to have genebanks. In order to develop large scale forest plantations and the availability of planting stocks becomes critical. Necessary information for genebank establishment such as phenology and genetic variation of species are lacking as these studies are always long term in nature. The criteria set below are believed to be important in genebank establishment.

(i) Prospecting of a suitable site in the area

A site that is accessible, rich in suitable species, with sufficient number of individuals and of suitable terrain to permit genebank establishment, monitoring and maintenance and fruit collection shall be selected.

(ii) Selection of suitable species for inclusion in the genebank

Dipterocarps are the most important and abundant timber species in mixed dipterocarp forest in Sarawak. These dipterocarps of sizes and forms suitable for timber production are likely to comprise the bulk of the genebank trees. These species are medium to slow growth but produce solid hardwood for various uses. Non-dipterocarp timber species, both well-known and lesser known, shall also be included to widen the range of timber types available. Wild fruit tree species are included as potential genetic sources and for improvement of local fruit species.

(iii) Selection of suitable individuals for inclusion in the genebank

Trees capable of producing a reasonable amount of fruit shall be selected by setting a lower size limit at 20 cm diameter at breast height (dbh). It was found appropriate at LEWS. Only healthy trees of good form are included.

(iv) Identification of each genebank tree to species

Efficient, rapid, accurate identification of trees to species level, allowing the inclusion of the largest number of suitable trees in the shortest field time, is accomplished by comparing a sample of leaves, fallen or catapulted from the crown of each tree, with Sarawak Forest Department Herbarium specimens. The vernacular name of each tree, supplied by knowledgeable members of the local community shall also be recorded to aid identification.

(v) Recording of the position of each tree in its subplot

A sketch map shall be prepared to show the subplots, relief and the location of each tree included in the genebank.

(vi) The genebank plots to be permanently marked

As the genebank is a long-term undertaking, the plots must be marked and maintained in such a way that they will be able to last several decades and can be being easily found when the plots are visited.

(b) Establishment of genebanks

(i) Ulu Engkari Genebank

A total of 42 species from 602 individuals were selected in the 4.42 ha genebank at Ulu Engkari. These included 14 species of dipterocarps and 9 species of wild fruit trees. *Shorea parvifolia* (*meranti sarang punai*) with 123 trees is the species with the highest number of individuals recorded. Other common species are *Vatica odorata* (*resak runting kesat*), *Shorea macroptera* (*meranti melantai*), *Shorea laevis* (Selangan batu) and *Shorea quadrinervis* (*meranti sudu*). Among the non-dipterocarps, *Dacryodes rostrata* (*kemayau*) has 8 individuals and *Calophyllum biflorum* (*bintangor*) has 6 individuals.

(ii) Ulu Mujok Genebank

62 species from 643 individuals were enumerated in the 6.20 ha plot. A total of 44 species of dipterocarps and 18 non-dipterocarps including 6 wild fruit trees were recorded. *Dipterocarpus caudiferus* (*keruing putih*) with 69 trees is the species with the highest number of individuals. This is followed by *Shorea collaris* (*lun kelabu*), *Shorea quadrinervis (meranti sudu)*, *Shorea havilandii* (*selangan batu*) and *Vatica oblongifolia* (*resak membangan*). Common non-dipterocarps include *Koompassia malaccensis* (*menggris*), *Cratoxylum arborescens* (*geronggang*), *Pentace truncata* (*baru*) and *Mangifera khoomengiana.*

2.1.5 Insects

(a) Moths

Fifteen macromoth families with 787 species and 3,185 individuals were sampled. There are an estimated total of 3,429 species in Borneo, and the present samples comprise 23 %, or about a quarter of the Bornean species.

The geometrid subfamily Ennominae has the highest number of species (168) and individuals (1,076). The noctuid subfamily Ophiderinae has the second highest species (123) with relatively few individuals (259), while the arctiid subfamily Lithosiinae has 70 species out of a relatively high number of 379 individuals. These 3 groups were the more generally distributed moths in LEWS.

The hill dipterocarp forest at Ubah Ribu (700 m a.s.l.), with an overlap of lowland and montane elements, was the most diverse in moths and gave the highest Williams Alpha diversity index (178.89). The Myrtaceae, which is known to support a diverse moth fauna, is also abundant in the area. There are also species, including endemics, restricted to the habitat.

The percentage of endemism generally increased with altitude. The Bukit Lanjak summit (1,285 m a.s.l.) sample, despite its small size, produced the highest endemism. Out of the 31 species sampled, 14 are unique including 4 endemics.

The secondary forest site, light-trapped on the helipad behind the Segera camp, gave big and attractive saturniids (the Moon Moth *Actias maenas* Doubleday, the Atlas Moth *Attacus atlas* Linnaeus), as well as numerous sphingids (hawkmoths) and cossids, which were not sampled at other sites. This might be partly due to the site's elevated open nature, with a canopy outlook of a surrounding mosaic of previous swidden with proximity of undisturbed forest. Early to late stage

successional species were apparent, with more emphasis on the latter, which indicates that traditional shifting cultivation practices do not seriously impede forest regeneration. The site's diversity value (127.64) was depressed by the presence of a large number of the White-Tailed Moth *Lyssa menoetius* Hopffer.

When species composition was compared using Preston's coefficient, lowland dipterocarp sites gave coefficients of above 0.7, while alluvial sites produced a coefficient of 0.65. These dissimilarity values are much higher than values obtained from monoculture forest plantations which generally hover between 0.4 to 0.5. This indicates the diverse nature of the moth fauna even within similar forest ecosystem in LEWS compared to plantation systems.

When all the samples from LEWS were pooled as a single entity (with 787 species and 3,185 individuals), a Williams Alpha diversity value of 334.34 $\pm$ 18.86 was produced, which is within the range of 300-350 recorded in other undisturbed Bornean forest habitats.

In addition to the above samples, another 1,240 micromoths (mostly Pyralidae) were collected, but sorting of these specimens was not possible due to time and taxonomic constraints.

(b) Butterflies

Altogether 8 families with 104 species and 450 individuals were sampled. The species made up of about 1/9 of those found in Borneo (910 spp. in total). The upper reaches of Sungai Jela gave the highest number of individuals (80) and species (25).

The hill dipterocarp forest of Ubah Ribu appeared to be comparatively poor in butterflies, as there is no sizable river and clearing, but it has forested hill elements such as *Thauria aliris aliris* Westwood, *Faunis stomphax stomphax* Westwood, both satyrids not found in other samples. It is also noted for the abundance of the sexually dimorphic *Lexias dirtea chalcenoides* Fruhstorfer, which generally replaces a similar lowland species *Lexias pardalis dirteana* Corbet on higher elevations.

The most significant finding was the abundance of the Rajah Brooke's Birdwing butterfly *Troides brookiana brookiana* Wallace in the Nanga Joh area, which is the river mouth of Sungai Joh in Ulu Katibas. Swarms of 10 to 20 of the male butterfly were commonly seen sipping moisture on the wet forest floor or riverbanks. The reason for its abundance could be due to the presence of its larval host-plant, the

Aristolochia vine. This most glamorous of all butterflies is getting scarce in other parts of Borneo. As this is the only insect protected by law in Sarawak, high priority must be placed on the conservation of its habitat apart from stringent control on its illegal capture by commercial collectors. The current market price of the butterfly has gone up to around RM 100 per specimen. Incidentally a pair of Rajah Brooke's were seen mating in the cool air of Bukit Lanjak summit, which was rather unexpected.

Several endemic species were found in the upper reaches of Engkari including Sungai Segerak, Sungai Jela. In fact five of the six endemics sampled were found in Sungai Jela. The five species were *Cepora pactolicus* Butler, *Ixias undatus* Butler, *Prioneris cornelia* Vollenhoeven, *Acytolepis ripte* Druce, and *Nacaduba normani normani* Eliot. The sixth endemic was *Paralaxita nicevillei* Rober collected at the alluvial forest of Ulu Katibas. The present samples made up over 10% of the 50 endemic butterfly species in Borneo.

(c) Dragonflies & Damselflies

25 species (out of a Bornean total of 259) with 256 specimens were sampled.

The most striking result was the almost total absence of the dragonflies and damselflies along the Sungai Bloh sites where logging was on-going further upriver. This river was thoroughly muddy when the rains came. As the immatures of these insects are aquatic, they may not be able to tolerate the drastic changes in the polluted river ecosystem.

Another noteworthy result was the exclusiveness of the species composition of dragonflies and damselflies in the undisturbed habitats of LEWS. These species, many of them sporting metallic blue-green wings, are totally absent in the disturbed urban ecosystems. The most common species in LEWS is *Euphaea subcostalis* Selys, probably endemic to Borneo, which is most abundant along Sungai Jela. The upper reaches of Sungai Jela produced the most number of species (11), which also gave the highest number of butterflies.

(d) Bees

Ten species were sampled, consisting of 8 stingless bees (*Trigona* spp.), and 2 honey bees (*Apis* spp.). There are 29 species of stingless bees and 5 species of honey bees in Borneo.

Generally the bees appeared to be more abundant around 11 a.m. The two most widespread species were *Trigona atripes* gp. *collina* Smith and *Apis cerana* Fabricius.

Most bees were collected along river banks which may be used by the bees as navigation corridors.

Surprisingly relatively few bees were sampled in the deep forest understorey sites. This suggests that the bees have limited foraging range within the forest understorey. The fact that many of the stingless bees are scavengers may also affect their effectiveness as pollinators. However, most stingless bees are known to nest near the base of big trees such as dipterocarps, and the giant honey bee *Apis dorsata* Fabricius usually nests on the branches of the towering *Koompassia excelsa*. There was no mast-flowering of dipterocarps at the time of sampling. The absence of tree towers also made canopy observations impossible.

(e) Termites

The termite fauna of LEWS was found to be rich, which despite the small plots yielded a total of 40 species, 10 of which are endemics. A single plot in the alluvial forest of Nanga Joh produced as many as 11 species. Only 103 species are recorded in Sabah, but that figure may not adequately represent the total number of species found in Borneo. *Macrotermes malaccensis* Haviland, one of the biggest termites, was found in all three forest types.

Most of the taxonomically interesting species (*Schedorhinotermes*, *Microcerotermes*, *Prohamitermes*, *Bulbitermes*, *Nasutitermes*), however, were found in the hill dipterocarp forest, where termite measurements do not fit with those of described species. It shows the termite fauna was under-collected at higher elevations, where possibly many new species still await discovery.

The termite fauna was found to be lowest in diversity at the lowland mixed dipterocarp forest behind the Geronggang camp situated next to Sungai Jela. However, the area surveyed was rather soggy and this could be a local effect and may not reflect the termite richness of the habitat as a whole. Further work will throw a light on this.

Also, the vast majority of the termites sampled are species which feed on dead organic matter. They are hence beneficial to the well-being of the forest by breaking down and decomposing dead vegetation and in the process help in the recycling of forest nutrients. In plantation monocultures, several termite species are

notorious pests, but in the undisturbed natural forest habitats of LEWS, these pest termites appeared to be scarce and are found in low density, as only one major pest species (*Coptotermes curvignathus* Holmgren) was found on a single substrate (a fallen trunk) in the alluvial forest of Nanga Joh in the entire survey.

(f) Beetles, cicadas & other insects

It must be stressed here that these specimens were collected alongside the moth samples, and no particular effort was made to sample them specifically. Even so, as many as 12 species of cicadas were collected from the various forest habitats of LEWS. Seventy three species of cicada occur in Borneo.

The beetles appeared to be more diverse between 400 and 700 m a.s.l. in LEWS. This is particularly obvious for the longhorn beetles (Cerambycidae), three-horned and rhinocerous beetles (Scarabaeidae), stag beetles (Lucanidae), as well as click beetles (Elateridae).

Nothing else can be said about the other insect groups due to their small numbers in the samples.

(g) Overall samples

This 6-month study yielded 6,176 individuals with 1,050 sorted species from 56 families out of 8 insect orders. The specimens are lodged in the Entomology Unit of the Sarawak Forest Research Centre in Kuching.

2.1.6 Small mammals

Based on the present study, 45 mammal species (13 bats, 10 rats, 9 squirrels, 5 tree shrews, 3 porcupines, 1 mustelid, 3 viverrids, and 1 barking deer) have been recorded from Lanjak Entimau. Only 21.7% of the 60 Sarawak bat species are represented in the present study. No shrews (moon rat) were trapped or sighted.

At least another seven species were sighted but failed to be accurately identified to their species level. These included three bats, one mouse (*Mus* sp.), one tree mouse (*Chiropodomys* sp.), one field rat (probably *Rattus tiomanicus*) and one squirrel (*Sundasciurus tenuis*?). Several other small mammal species as reported by Kavanagh (1982) were also not caught in the present study. These included 2 horseshoe bats, 3 tree squirrels, the whiskered flying squirrel, the moon-rat (shrew), the pentail tree shrew and the lesser mouse deer. Other mammals species not found

in this study but also reported by Kavanagh (1982) are the sambar deer, the yellow-throated marten, the western tarsier, and the pangolin.

Currently there are altogether 58 mammal species recorded from Lanjak Entimau, of which 48 are true small mammals, or approximately 36% of the known small mammals of Sarawak (Table 1). Among these 48 species of small mammals, 21% (10) are Bornean endemics. No true montane mammals were found, suggesting that Lanjak Entimau may have long been isolated from other mountain ranges of Sarawak in the past.

Table 1 The composition of various small mammal groups found in Borneo, Sarawak, and Lanjak Entimau Wildlife Sanctuary (LEWS)

Small	Borneo	Sarawak	Present	Study by Kavanagh	% (LEWS)
Bats	92 + 1*	60	13	2	25
Rats	26	22	10	-	45.5
Squirrels	34	32	9	4	40.6
Porcupines	3	3	3	-	100
Tree Shrews	10 + 1**	9 + 1**	4 + 1**	1	60
Shrews	8	5	-	1	20
Total	**175**	**132**	**40**	**8**	**36.4**

+ 1* : *Cynopterus minutus* found in Brunei (Kofron, 1997)
+ 1** : the potential new *Tupaia* sp. found in the present study

Among the non-volant mammals, one unusual tree shrew species caught in Ulu Engkari and Ulu Skrang at an elevation of 260 m and closely resembles the montane tree shrew, *Tupaia montana,* has not been identified. Although found together with the common tree shrew (*Tupaia glis*) this unknown species is slightly smaller than the former. Preliminary examination suggests that this unknown tree shrew is likely to be a new species.

The unexpected record of plaintain squirrel (*Callosciurus notatus*) in Ulu Engkari and Ulu Katibas may represent an extension of known range of this species. This is simply because *C. notatus* was thought to be found largely in the western parts of Sarawak and absent from tall forest. The recent range expansion of this species could be due to its high capability to propagate well in monoculture plantations such as oil palm and fruit orchards. This is particularly true in the last fifty years or so in which a large portion of the Sarawak lowland had been converted into agricultural land.

The rat collections are equally represented by *Maxomys surifer, M. rajah, Leopoldamys sabanus* and *Sundamys muelleri*. Both *M. surifer* and *M. rajah* are relatively abundant in the Sanctuary (Table 2).

Table 2 Number of rat specimens collected from different elevational levels in Lanjak Entimau.

Rat species	<300 m	<400 m	<500 m	>500 m	Total
Maxomys rajah	2	5	-	1	8
Maxomys surifer	1	1	1	7	10
Maxomys whiteheadii	2	2	1	2	7
Maxomys ochraceiventer	1	-	-	-	1
Sundamys muelleri	7	1	-	-	8
Leopoldamys sabanus	6	3	-	-	9
Rattus exulans	-	-	-	1	1
Niviventer cremoriventer	1	-	-	-	1
Niviventer rapit	2	1	-	-	3

The Lanjak Entimau Wildlife Sanctuary is also found to inhabit all the three Bornean porcupines in abundance. A local man from Ulu Skrang, Mr. Anjan ak. Ngelambong confessed that he had killed as many as 100 porcupines, mainly the common *Hystrix brachyura,* in the past few years. The present study shows that this animal can be easily lured by using essence with fruit flavor, and hence snared. Incidentally, the short-tailed mongoose was also attracted to the essence.

2.1.7 Reptiles and Amphibians

A total of 148 herpetofaunal specimens (129 amphibians and 19 reptiles) representing 23 species of amphibians and 11 species of reptiles were collected.

All the 5 families of amphibians in Borneo were represented in this sampling excursion. The family Ranidae [riverine frogs] made up 52% of the amphibians species present and was the dominant family. The Ranidae are generally the most widespread group in the Sanctuary. Of the Ranidae, the riverine genera such as *Rana* and *Meristogenys* were common in all sampling sites. Second most abundant were the Bufonidae [true toads] such as *Bufo* spp. and *Ansonia* spp. which accounted for 23% of the total amphibian species. The Rhacophoridae (tree frogs) represented 17%. The least abundant were the Megophryidae (1%) and Microhylidae (1%). This is probably due to their habitat, the forest floor, being not sufficiently sampled.

Stream composition for frog species in LEWS were similar to those observed in 1994, with the exception of finding the river toad, *Bufo asper,* which was relatively abundant when compared with earlier surveys.

The reptiles encountered were rather relatively low in number as compared to the amphibians. There was only one species of freshwater turtle; the chelonian *Heosemys spinosa*, eight species of lizards and three species of snakes. The capture rate for reptiles was about one individual every three days. This occurrence probably can be attributed to insufficient sampling, in particular for snakes, which require long-term intensive effort to obtain a considerable number.

A total of 12 species of amphibians and one species of lizards were found to be endemic to Borneo. No rare or new species were found during the sampling activities. Diversity indices were not calculated since the samples [particularly the frogs] were not randomly collected.

The value of LEWS lies in its preservation of a wide diversity of climax habitats. Within its complex topography, a wide range of micro-environments also exists which is highly crucial in ensuring maximum preservation of herpetofaunal diversity for the future.

- Current knowledge is extremely minimal, so that continued inventories are needed. Inventories are the best way of documenting herpetofauna to obtain solid information on species presence, abundance, ecology and distribution. It also leads to discoveries (in Sarawak at least) of new species and new records. The potential for discoveries of new Bornean species is quite substantial.

- Monitoring based on these initial inventories will provide a clear picture of natural population and community fluctuations, and local versus regional (or even larger scale) changes in herpetofaunal communities. Examples include *Meristogenys* sp., which is sensitive to disturbance and will make a good indicator for pristine streams and rivers. The density of *Limnonectes leporina* increases with stream siltation which might be caused by habitat disturbances.

Therefore, regular surveys will help to keep tabs on the "health" of LEWS, and a wider area. Surveys within LEWS can be compared with surveys outside the boundary to monitor changes, for purposes of boundary management.

- LEWS can serve as a training ground for biological managers, where they may learn taxonomy and ecology of herpetofauna and come to appreciate long-term issues with respect to conservation of this group.

2.1.8 Fish fauna

(a) The Stream Habitats

Most of the rivers of the LEWS flow over rock and gravel beds. Stream banks are mostly of soil substrate and bank gradient varies between 30° to 70°. Similarly, Sungai Bloh which forms the southeast boundary between the Sanctuary and the logged-over forest of the east have stream bank gradient of between 20° to 60°. The streams would generally turn silty after a rain in its catchment upstream. Similarly, Ulu Skrang river is also a shallow and fast flowing river with many rapids. Streams vary from 0.5 to 15.0 metres in width and 0.2 to 1.5 metres in depth. Average water speed varied from 0.02 to 0.73 metre per second. The dissolved oxygen content of the river varied from 7.1 to 8.6 mg l^{-1} while the pH ranged from 7.1 to 7.5. The water temperature varied between 24.0 to 26.5 °C.

(b) Fish Species Inventory

A total of 3,668 specimens were collected from the 77 fishing stations. There were 82 species belonging to 31 genera of 8 families recorded from the field collections. The number of species collected made up some 33% of the known freshwater fish species in Sarawak. The number of species known from the Sanctuary is made up entirely of lowland mixed dipterocarp forest stream species. A large percentage of fish in the Sanctuary are Cyprinidae (46%) which are most common. Others are balitorid fish (33%) adapted to stick on to rock surfaces in fast flowing streams. Catfish and eels (8.5%) are also common in occurrence. The rarest of the fish are the freshwater puffer which are collected only twice in the Bloh river system. Some of the fish species found in the Sanctuary that are endemic to Borneo are *Gastromyzon embalohensis* sp. nov., *Glaniopsis* sp.1, *Glaniopsis* sp.2, *Paracrossochilus acerus, Purhomalopter microstoma, Puntius collingwoodi, Hampala bimaculata, Homaloptera* cf. *stephensoni* and *Garra borneensis.* New distribution records of freshwater fish recorded were *Lobocheilus bo, Glaniopsis* sp. and *Protomyzon griswoldi*, which were previously recorded only from North Borneo.

A number of potential new species were noted in LEWS. One of these is the forest walking catfish, *Clarias* sp. which resembles *C. teijsmanni*, but differs in its head structure and body colourations. Similarly, *Hemibagrus* cf. *nemurus* differs from *Mystus nemurus* in its body measurements. The genus *Mystus* is now replaced with *Hemibagrus*. At least three *Gastromyzon* species are likely to be new to science but would require further comparative studies with Type materials in the Bogor museum. One of the *Gastromyzon* has bright red dorsal, anal, pectoral, pelvic and

caudal fins. Its body is dark brown in colour. This colour feature is prominent in all juvenile and adult specimens examined. One specimen of black *Leiocassis* sp. that was found in the Sungai Kelimau Mit would require further identification. There are two *Glaniopsis* species collected from the Katibas that require further study.

Most notable of the Katibas system is the obvious rareness of *Barbodes schwanenfeldii* or *tengadak* fish specimens. This fish is the most expensive food fish collected by the locals from this river system. Two types of *tengadak* are recognised by the locals. The cheaper variety has reddish caudal fringes while the expensive type has whitish edgings. The youngs of *Tor* sp. are found in most of the small streams sampled. The most common food fish collected for domestic consumption by the locals are *pelekat*, *kepiat*, *adong* and *kulung*.

(c) Fish species diversity, occurrence and abundance

A total of 28 aquatic systems comprising of main streams and tributaries in LEWS were studied during the project. These comprised 4 streams in Engkari, 12 from Katibas, 6 from Bloh and 6 from Ulu Skrang.

Fish species diversity in the Engkari river and the Kaup river is high. The Ulu Engkari has a higher fish species diversity and richness. Even though there is less fish species as compared with the Kaup river, the fish species are much more uneven in their abundance distribution where one species may have over 42 specimens while another species may have a single specimen. The Engkari Hilir had the highest species richness of the sites studied in the south of Lanjak-Entimau. Non-indigenous fish species introduced into Batang Ai Lake by the Department of Agriculture had not been found at the periphery of the Sanctuary.

Many variables had been used by ichthyologist to predict the distribution of fish fauna in streams and river systems. Since the water quality of most of the streams is similar, the difference in the distribution of fish fauna can be attributed more to habitat differences.

(d) Critical areas for the conservation of Ichthyofauna

The central catchment area of Lanjak Entimau which had been proposed as the core zone in the first management plan of ITTO in 1996, must be preserved completely for guaranteeing the continuous supply of good quality water. This area also provides habitats for the breeding of important food fishes such as *semah* (*Tor* sp.), *adong* (*Hampala* sp.), *kepiat* (*Puntius* sp.), *bantak* (*Osteochilus* sp.), *tengadak* (*Barbodes schwanenfeldii*) and *kulong* (*Lobochilus* sp.). Meredith (1995) also

proposed similar nature conservation zone usages for Batang Ai National Park. The wilderness zone of the northern boundary of Batang Ai National Park is adjacent to the southern boundary of the Sanctuary, thus offering further protection against the exploitation of the protected area.

Small streams on the higher elevation of the Sanctuary had less species diversity when compared with the main rivers. This does not mean that these streams are not important for conservation. Most of the *ensurai* and *engkabang* trees are located along the banks of larger rivers. Their flowers and fruits fall directly into the rivers and are often eaten by the cyprinid fishes. It is therefore important that such trees along river banks be left undisturbed.

Stream canopies of about 80% are important as most small fish species and juveniles utilise the shaded areas to hide from predators. The lower light intensity over the stream provides suitable habitats among rock and riffles for the balitorid fishes. Lower light intensity also discourages the growth of green algae on the rocks. Where the light penetration is high, coupled with inorganic fertilizer run-offs from the surrounding farms, benthic rock surfaces are often covered with green algae growth. Species of *Osteochilus*, *Lobochilus* and *Gastromyzons* were seen to feed actively over the surfaces of rock boulders where there are no growth of green filamentatous algae.

The present study indicates that rapids and rocky areas are important as habitats for the *semah* (*Tor* sp.) and *tengadak* (*Barbodes schwanenfeldii*) as they feed on materials such as insects, reptiles, amphibians, fish, flowers and fruits that are caught in the turbulent water. This is evidenced from the gut contents of fish specimens collected from the rapids. The importance of feeding areas along rivers and streams in the Sanctuary was also noted. Such areas are always in close proximity to the wild animal wallows along the lower bank of the river. It is important to manage other wildlife resources in close tandem with fish as they could have symbiotic relationships.

The upper Katibas river beyond Nanga Menyarin that lies within the core area of the Sanctuary is identified as one of the critical areas for the conservation of ichthyofauna. This is because the youngs and adults of the *tengadak* (*Barbodes schwanenfeldii*), *semah* (*Tor* sp.) and other families of fish are still found in abundance. It is necessary to protect the river from human disturbance in order to conserve the fish species.

In the multiple use buffer zone, much human activities are generally focused on the fish resources as they are harvested for subsistence and sale. These activities will

eventually cause a drain on the fish resources within the Sanctuary. Recruitment of young into the downstream population could only occur after each rainy season when young fish are washed down from the core zone. The Sanctuary will be able to sustain such activities if the use of the rivers are limited to the traditional inhabitants who fish for their own subsistence.

(e) Ichthyofauna and habitat change

There are shifting cultivation activities along Sungai Merating in Bloh where the land along the right bank was cultivated with hill padi in 1997 during the fish sampling programme. However, the fish species diversity is still very high (H'=1.2189) compared to the undisturbed stream at Sungai Joh. Fish species richness remained the second highest in the Sanctuary after Sungai Joh. In another stream of similar size at Sungai Kelimau Mit along the Katibas where the stream flows over a shifting cultivation area that had been fallowed for about 5 years, fish species diversity decreased slightly (H'=1.0359) and species richness was almost 30% lower than Sungai Merating. From this study, it can be inferred that the impact of shifting cultivation land use on fish fauna in a forest stream is less in the initial period. It may take a long time before a disturbed stream like Sungai Menyarin (fallowed for over a hundred years judging from the size of the planted *durian* trees) can recover back into its initial diversity. Stream habitat changes attributed to human activities would affect the feeding and breeding of fishes downstream. Fishes of the family Balitoridae were able to tolerate turbid water and deposit of silt for short periods at relatively frequent intervals

2.2 COMMUNITY DEVELOPMENT

2.2.1 Indigenous Crop Cultivation

(a) Planting materials

Planting materials of fruit trees and rattan were supplied by ITTO Kuching. Fruit tree seedlings were procured from commercial nurseries and Sarawak Agriculture Department (SAD) while some were collected and raised in nurseries during the fruiting season in December 1997 to February 1998. Rattan seeds and seedlings were purchased from commercial nurseries. For indigenous vegetables, most of the planting materials were collected by the farmers themselves. Cover crop cuttings of *Arachis pintoi* and Nitrogen-fixing Tree (NFT) cuttings of *Gliricidia sepium* and *Erythrina poeppigiana* were supplied by SAD.

(b) Land preparation

Land clearing involving underbrushing, felling and burning was done by the farmers with nominal contract payments. Preparation of planting holes and beds was similarly done by the farmers.

(c) Planting

All planting materials and other inputs including fertilizers, were provided and delivered to the longhouse. Planting was done by farmers on contract at a nominal rate of payment. Planting of cover crops and NFTs was done by farmers without payment.

(d) Low Input Package

In order to ensure sustainability in remote areas, a low input cultivation system is recommended. The use of NFTs (e.g. *Gliricidia sepium* and *Erythrina poeppigiana*) is advocated as the leaf litter and prunings from the trees can be used as green manure to maintain the soil fertility.

For fruit trees, *Arachis pintoi* is recommended as the cover crop. The advantage of this cover crop is that it does not climb up the fruit trees and smother them. It conserves the soil especially on steep slopes, adds organic matter in the leaf litter and fixes nitrogen symbiotically.

(e) Maintenance

Maintenance is done by farmers without payment as their contribution towards the project and to demonstrate their commitment to the project. Weedicides are provided for weeding to facilitate establishment of cover crops. Pesticides are provided as and when required, to keep pests and diseases under check. Fertililzers are applied according to schedule.

(f) Recording

Records are kept on crop performance soon after planting. Plant height was recorded to establish a data base for subsequent growth rate assessment. At the same time mortality rate was recorded. Dead points were gap filled. Plant height recording was done every six months. When plants reached heights that became inconvenient to measure, girth records are kept. Subsequently data of first flowering and fruiting, yield and quality assessment will be carried out.

(g) Transfer of technology

In order to ensure sustainability, transfer of technology was effected through dialogue sessions, *in situ* training and hands-on training of Sarawak Forest Department (SFD) staff and farmers. In addition, a manual on cultivation of indigenous crops was provided including translation of important sections into the Iban language for use by the participants. Training course in the relevant crops with emphasis on agronomy and economics of production and utilisation is proposed for the development of LEWS, Phase III.

(h) Mortality

The success of crop establishment is assessed by means of the mortality rate. Establishment of fruits and rattan was good based on the mortality rate. The mean mortality rate of 10.1% (0-44.4%) is acceptable under farmers conditions.

The mortality rate for fruit tree demonstration plot in Ng Bloh Station is 5.3% which is excellent.

The main causes of mortality were :

(i) Delayed planting and inadequate care of seedlings;
(ii) Water logging on heavy soils;
(iii) Weedicide damage; and
(iv) Mammalian pest damage.

(i) Plant Height

Plant height was measured after planting and subsequently at six month intervals. This will allow annual height increase assessment. Plant girth, date of first flowering and fruiting and yield and quality assessments shall be recorded.

(j) Preliminary Economic Assessment

An estimation of the income that can be derived from 10 plants each of *Dimorcarpus longan (isau), Canarium odontophyllum (dabai)* and *Parkia speciosa (petai)* (0.25 ha) is provided to give an idea of the economic potential of these three crops in improving the income generating capacity of the participants.

Based on yield, ex-farm price and seasonality of each fruit, a conservative estimation of the income is RM1,083 to RM1,875 per month which is 2.2 to 3.8 times the State's poverty line of RM495 per household of 5.1 persons.

2.2.2 Fish management and rearing

(a) Pilot fish rearing project

(i) Construction and stocking

Construction of valley ponds and concrete tank for fish rearing was completed which showed the interest and organizational ability of the participants. Delays were inevitable because of the community approach. To ensure commitment to the project, stocking was to be completed by the participants by collecting fish fry or fingerlings of the various popular species from the streams or rivers. A number of tails had been collected and stocked during the study period; the Sarawak Agriculture Department (SAD) also supplied *tengadak* fry. They had been advised to stock in fish as soon as possible.

(ii) Economic potential

Rearing of high value indigenous fish species should prove to be a good alternative source of fish supply for food and cash income. The economic potential of the pilot project (Table 1) is estimated based on the SAD's results and price assumption on a recent survey.

Table 1 Economic potential of indigenous fish rearing pilot projects

Location And water volume	No. of fish stocked (Rate:9 tails/m^3)	Total yield (average at 1 kg/fish/year)	Estimated income/ year***	Estimated Income/ household/ year
Rh Gerasi, Ulu Mujok. Valley pond 253 m^3	2,280 tails	* 1,596 kg	RM 79,800	RM 1,995
Rh Api, Ulu Katibas. Concrete tank 76 m^3	650 tails	** 487 kg	RM 24,350	RM 1,873
Rh Enggong, Ulu Katibas. Valley pond 130 m^3	1,170 tails	* 819 kg	RM 40,950	RM 6,825

* Mortality rate 30 % ** Mortality rate 25%

*** Ex-farm price RM50.00/kg

Several assumptions were made. The mortality rate is 25 - 30%; the average fish weight at harvest after one year of stocking is 1 kg and the ex-farm gate price is RM50.00/kg. If input costs such as construction cost (approx. RM7000.00 per pond or concrete tank), feeding costs and labour cost become available in future the net profit and Internal Rate of Return (IRR) can be calculated. Considering that Rh Gerasi, Rh Api and Rh Enggong participants numbered 40, 13 and 6 households respectively, the incomes from the project per household were estimated at RM1,995.00, RM1,873.00 and RM6,825.00/annum which demonstrates that such project can contribute significantly towards the income generating capacity of the participants depending on the number of participating households. It is important that the projects are properly managed.

(iii) Response of the people to the pilot project

The participants have interest in the project but there seemed to be not enough commitment to treat the project as top priority and carry out the project in a timely and proper manner. There seems to be a lack of organization and leadership. There is a need to convince the villagers on the technical possibility and financial viability of the project. In such remote locations where commercial fish feeds are expensive and difficult to obtain, locally available feed materials must be used to reduce costs and increase profitability. Also marketing must be properly organized to ensure good prices.

The idea of fish rearing is not alien to the community as some of the people already have their own ponds or concrete tanks. Other longhouses enquired if fish rearing projects could be extended to them. More villagers should be encouraged to take up

indigenous fish rearing but they should also not depend on subsidy right from the beginning.

(b) Assessment of fish resources

(i) Fish species inventory

As the survey covered species of fish popularly harvested for food, only about 12 species were included out of the 82 species listed in the ITTO fish inventory report.

(ii) Fish abundance

One of the most significant findings is that the major popular species *empurau, tengadak* and *semah* once abundant in the river systems have decreased appreciably by 50 - 100%. Even *penyau* (cf. *Puntius schwanenfeldii*) which is similar to *tengadak*, has become very rare. The main reason for the decline in population of these species is over exploitation. Less popular species such as *kepiat (Puntius collingwoodi), kulong (Lobocheilus bo), bantak (Osteochilus* sp.) and *seluang (Rasbora* spp.) are the most common now in all the rivers.

The pristine tributaries of Sg Bloh such as Sg Joh and Sg Jenuah still have *semah* and *empurau* although none of the rivers yielded *tengadak.* Sg Takai and Sg Beguwa, tributaries of Sg Katibas also have abundant *semah* while Sg Takai and Sg Bedawak have both *semah* and *empurau.*

In Mujok, it was found that Ulu Sg Mujok, Sg Semawang and Sg Spuna Ili did not yield any *semah, empurau* or *tengadak.* Sg Juh, another tributary of Sg Mujok appears to have abundant *semah* . The commonest species in all this river system is *kepiat*, followed by *kulong* and *seluang.*

(iii) Species Composition

The survey showed that composition of species have changed over the years. The popular high quality species have decreased significantly in comparison with the less popular species. The less popular species are now the targets of fishing and may follow the same fate as the other popular species if uncontrolled fishing is allowed to continue.

(iv) Fish Consumption

Based on the interview of nine longhouses in Ulu Katibas, Ulu Mujok and Ulu Engkari, the amount of fish consumed ranged from 2-15 kg/household/month (mean 6.6 kg), The highest is Rh Api in Ulu Katibas (315 kg/month) and lowest Rh Raba (42 kg/month) in Ulu Engkari. It can be reasonably assumed that the fish consumed is also the fish caught as the amount sold for cash is minimal.

(v) Fishing and Fishing Effort

Although a number of fishing methods are used, the main gear used are cast-net (*jala*) and gill-net (*pukat*). It can be assumed that each household has at least one each of cast-net and gill-net. Based on the amount consumed, the mean catch per day is assumed to be at least 500 g. There is a decline in the catch compared to 1.7-2.8 kg per trip. The declining catch means that more effort is required for fishing in terms of time spent, area covered, casting frequency, petrol used and even fishing gears used. The mesh size ranged from 1.27 cm (1/2") to 12.7 cm (5"). In view of the marked decline of larger fish, the mesh size is reduced to the detriment of the fish population.

(vi) Causes of fish decline

Fish decline is due mainly to over exploitation, pollution due to forest destruction, degradation and loss of breeding grounds and illegal fishing methods.

(vii) Fish Prices

Only large-sized high value fish are sold for cash. The prices are exceptionally high for *empurau, tengadak* and *semah* highlighting the great demand and fish scarcity. It also implies that, it would be financially viable to rear these species commercially.

(viii) Natural Breeding Grounds.

The locals are very knowledgeable about natural spawning grounds of various fish species. Although the locals are aware that fish should be allowed to spawn to replenish the stock, they would not pass the opportunity of catching them during spawning when the fish are most vulnerable. The attitude seems to be that if they do not catch, others will. The Sarawak Forestry Department and ITTO need to take the lead to educate the people and enforce the rules to protect the breeding grounds

for fish in LEWS. Natural spawning grounds play a very important functional role in the replenishment and enhancement of river fish stocks and should be conserved.

2.2.3 Hunting practices and status of game species

(a) Field Surveys

A number of favourite hunting spots in Ulu Batang Ai (Site 1) lies within Batang Ai National Park. These are the Tanjong Assam salt lick and Penyelaong salt lick. Both salt licks are about one day's walk south of the Sanctuary's boundary. No animal was shot during the two days with the hunters. Footprints at one of the salt licks indicated that two sambar deers (*Cervus unicolor)* visited the salt licks the previous night. A number of dried bearded pig's jaws was on display on the kitchen wall of the hunting hut indicating previous kills. Most of the animals were killed at an ex-shifting cultivation plot (temuda) near their longhouse. Besides bearded pigs and sambar deers, pig-tailed macaques (*Macaca nemestrana*) and porcupines (*Hystrix brachuria*) were sometimes trapped with snares around their shifting cultivation plots. These species were considered as pests to their crops.

In Ulu Skrang (Site 2), hunting was mainly along the logging roads outside the Sanctuary. Both local hunters and hunters from towns such as Julau, Sarikei and Sibu hunted in this area. During the surveys, outside hunters in two pickup trucks were spotted in the area. According to the logging camp manager as many as ten groups of town hunters come to hunt during weekends. During a night hunting with the timber workers using a pickup truck, one sambar deer was shot. Another group of hunters who were hunting just outside the boundary of the Sanctuary killed two bearded pigs in the same night. Enjak, a local canteen operator, mentioned that when logging operations just started in the area, a hunter with a pickup truck can easily kill up to five animals on a night's trip. Nowadays a local hunter can hardly get anything and would consider himself fortunate if he could get a bearded pig out of two or three hunting trips in the area.

In Ulu Bloh (Site 3), the most preferred hunting spots by local hunters are old shifting cultivation plots just outside the Sanctuary and the riparian forest. However, during fruiting seasons local hunters mentioned that they would often travel up to three kilometers into the Sanctuary. Hunting in old secondary forests and along rivers are often carried out with the help of hunting dogs. With limited cartridges, trained hunting dogs are considered an important asset to most local hunters in Ulu Katibas. An experienced hunting dog can detect and locate game animal from a slow-moving boat and within a thick undergrowth. During the

hunting trip with local hunters, two bearded pigs and a barking deer were seen. Preserved bearded pig meat was served for lunch at a farmhouse belonging to the one of the hunters. The meat was part of the kill made a day earlier. Most of the preserved meat was sold to a nearby canteen.

(b) Community Surveys

Community surveys covered a total of four longhouses in Batang Ai (Site 1), two timber camps in Ulu Skrang (Site 2) and two longhouses in Ulu Katibas (Site 3). Out of a total of fifteen hunters from the four longhouses in Batang Ai, seven were active hunters. In Ulu Katibas, six of the twelve hunters surveyed were active hunters. The actual number of hunters in Ulu Skrang is not known but it is expected to far exceed those of Batang Ai and Ulu Katibas. Three active local hunters in Ulu Skrang are the main suppliers of wild meat to the two canteens at the timber camp.

No detailed information was collected regarding hunters from outside. It was reported that much of the hunting in Ulu Skrang was done by outside hunters using pickup trucks equipped with freezers. It was also not unusual for these hunters to harvest two or three ungulates per night during the fruiting season (Enjak, pers. comm.). Wild meat was sold to canteens in the timber camps and to towns such as Julau, Sarikei and Sibu.

Bearded pigs were hunted more than deer. On average ten pigs were killed per month by hunters from four longhouses in Batang Ai. The last two longhouses in Ulu Katibas recorded a slightly higher harvest of 12 pigs per month. The rate of harvest was highest in Ulu Skrang, averaging 20 pigs per month. This does not include the number hunted by outside hunters from towns.

(c) Market Surveys

Tamu (meat market) at Lubok Antu town received a regular supply of wild meat from Batang Ai selling at an average price of RM9.00 per kg. The price of wild meat was similar in *tamu* in Pakan and Julau, both received their supply from Ulu Skrang. In Song (Site 3), the price of wild pigs range from RM8.00 to RM10.00 per kg. The price of wild meat is slightly lower in the interior canteens with an average of RM6.00 per kg in Ulu Skrang and RM 4.00 per kg in Ulu Katibas. The difference in price in the interior market as compared to the town markets attracts some of the local hunters to sell their catch in towns thus creating a regular supply.

The price of wild meat has remained quite stable for the last five years within these areas (Table 1). Despite the irregular supply of deer meat, the price was similar to that of wild boar meat. Salted meat was mainly sold in Julau, Song and Kanowit at a relatively lower price.

Table 1 Market survey on price of wild meat

Locality	Supply	Avg. price/kg (RM)	Origin	Supplying Sites
Lubok Antu	Regular (daily)	9.00	Batang Ai	Site 1
Julau/Pakan	Regular	9.00	Skrang	Site 2
Sarikei	Irregular	10.00	Skrang/Lemanak	Site 2
Sepantu Camp	Regular	6.00	Skrang	Site 2
Song	Regular	8.00	Katibas	Site 3
Kanowit	Regular	8.00	Katibas	Site 3

(d) Estimated Economic Returns from Sale of Wild Meat.

The sale of wild meat especially that of wild pigs in areas surrounding the Sanctuary covering Batang Ai, Ulu Skrang and Ulu Katibas generated an estimated annual income of RM126,680 to the local people. The estimated economic value of wildlife meat harvested by outside hunters in Ulu Skrang was not available.

(e) Response by Local Hunters to the Ban on Trade in Wild Meat

The Wild Life Protection Ordinance 1998 puts a total ban on sale of wildlife and wildlife products taken from the wild. The law however does not stop local people from hunting non-protected species for their own consumption. The active and regular hunters who earn their major income from sale of wild meat were interviewed. Of the 21 regular hunters interviewed, nine (43%) disagreed with the total ban while 14% agreed with the ban provided there were alternative means of income. Another 14% agreed with a seasonal ban on sale. Only 5% agreed with the total ban.

2.2.4 Perception of the local community towards conservation and protection of the Sanctuary

Parks and nature reserves have long been thought of as the best way of preserving wild life. Following the Earth Summit in Rio de Janeiro in 1992, and the

ratification of the Biodiversity Convention, many countries are seeking to transform as much land as possible to strictly protected regimes. The central concept has been conserving the natural state of pristine environments. This implies trying to keep nature as they are, but they can never remain unchanged for a number of factors, particularly with increasing human population and economic development. Moreover, the creation of most of the protected areas involved the local communities, who are often excluded by the project management. It is well recognised that the rural and subsistence communities depend on the wild resources for their livelihood. For this reason, if wild habitats are lost, these resources will no longer be available, and those who will suffer most are the poorest.

Consequently, conflicts between the conservation effort and the local people is a key issue since without local involvement in the management of protected areas, adequate protection can only be achieved if the protecting agency has the authority and ability to enforce regulations. This is both undesirable and often unattainable, and this realisation represents a major shift in practical conservation philosophy. From various experiences, forest protection and exclusion through policing has not proved sustainable and has resulted in considerable local resistance. It is, therefore increasingly being recognised that wild life conservation must operate hand in hand with sustainable use by local communities.

Incentives for wild life management are only effective if the communities have a long-term vested interest in managing the wild life resources for their economic gain. Managing wild life as wild food resources is an important step towards sustainable use and management of the Sanctuary. This is because unless they are made available to local communities, commitment to manage the resources will remain limited. Wild foods are a part of their diets not only during period of shortages, but also on a daily basis. Developing effective institutions for common property resource management represents a major challenge for policy makers.

Presently, the Sanctuary is fortunate as the population remain sparse and status quo. Nevetheless, the local people will be faced with a new set of circumstances and regulations with the development of the Sanctuary. It is, therefore, not unusual for any Project to encounter initial resistance especially when the local people are not properly consulted and well-informed about the project. Considering their close proximity to the Project areas, it is, therefore, essential to find out ways in which their perceptions and needs may best be taken into account to achieve sustainable management.

Overall, the local communities are positive and receptive towards the conservation and protection the Sanctuary. An overwhelming majority or 92% of the surveyed

households agreed that the development of the LEWS would bring the benefits to them. Practically, none of the respondents showed their disagreement, while only the remaining 8% was uncertain whether the Sanctuary would benefit them.

With judicious exploitation by the locals, the management and protection of the Sanctuary will, in the long run, ensure them a continuous supply of food and other valuable produce. The benefits of having a constant supply of wild animals, like wild boar and deer, and fish are being experienced by those living closest to the Sanctuary. In view of these, the neighbouring villagers were unaware that they have exercised their informal control over the immediate areas in an effort to ensure continuous supply of food and other jungle produce for themselves. They have in fact served as an effective watchdog for any possible encroachment into the Sanctuary, especially from the outsiders or villagers downriver.

Ban on hunting and trade on wild meat

Legislative bans on threatening activities have been widely implemented in many countries to safeguard certain species. However, a ban is, in practice, like any legislation, only effective if the enforcement is effective. Some conservationists argue that bans can only be a short-term measure, but a long-lasting protection can only be envisaged if the people can be persuaded or convinced of the noble objectives.

A desire of the local communities to conserve the existing resources, particularly the wild life, was further supported by the fact that about 75% of the surveyed households agreed with the ban on the sale of wild meat. They have slowly realised that the ban will certainly help to conserve the wild animals, thereby ensuring continuous supply of food themselves. Those who disagreed felt that the ban has put some restriction upon them from earning supplementary cash income like before.

Again, from the survey results, 63% of the households agreed with strict enforcement of the regulations. This includes a complete ban on any logging activities adjacent to the areas as the activity could adversely affect the environment, particularly pollution of inland waters in the catchment areas.

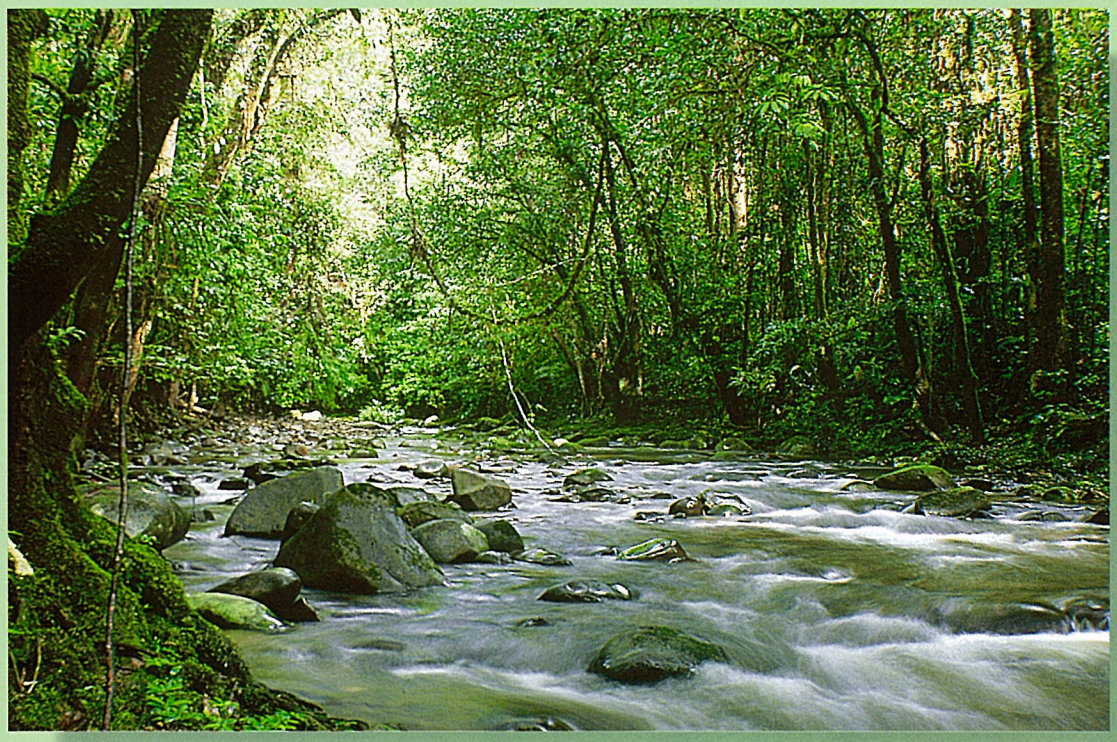
Among those who agreed with a more stringent enforcement of the Regulations, 67% of them would still want the Forest Department to be the lead agency as well as being the implementing agency. Currently, they realise that the Stations are not managed and utilised properly in view of inadequate staff. The remaining 33% suggested that the community leaders and the local people should be given the

mandate to enforce the neccessary regulations as they are at the grass-root and always around. This implies that in order to be effective, the Forest Deparrment should as far as possible get the support and co-operation of the local villagers, particularly their headmen (Tuai Rumah).

With the exception of their sceptism on the possible restrictions on their traditional activities, all these perceptions clearly indicated that the local communities value the Sanctuary, particularly its rich natural resources. They appreciated the great potential that can be derived from the effort to manage and conserve the Sanctuary.They were willing to cooperate with the government agency in the management and protection of the Sanctuary provided that they could derive benefits from it in the future.

A general view of lowland dipterocarp forest

Mixed dipterocarp forest on Ubah Ribu ridge



A riparian forest

A strangling fig, *Ficus* sp., an important food plant for animals

Fruits of *Baccaurea* sp.

A numbered tree in genebank

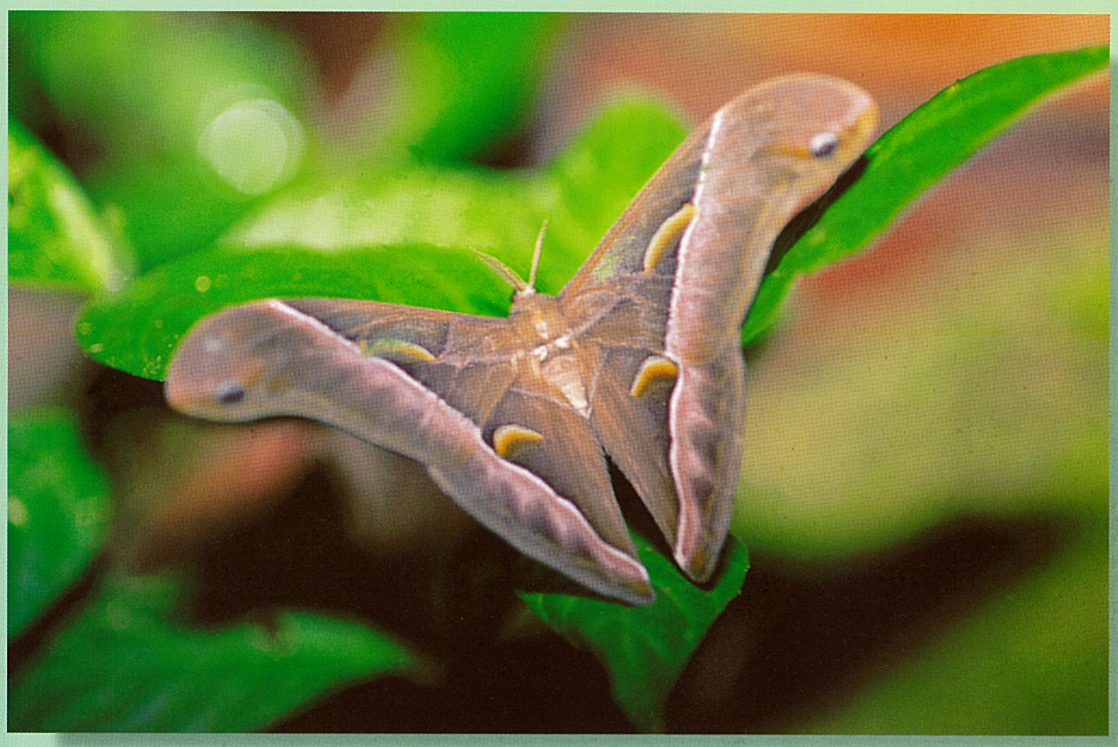
Eugeissona utilis,
a palm with many uses

Begonia sp., a beautiful herb also used in cooking

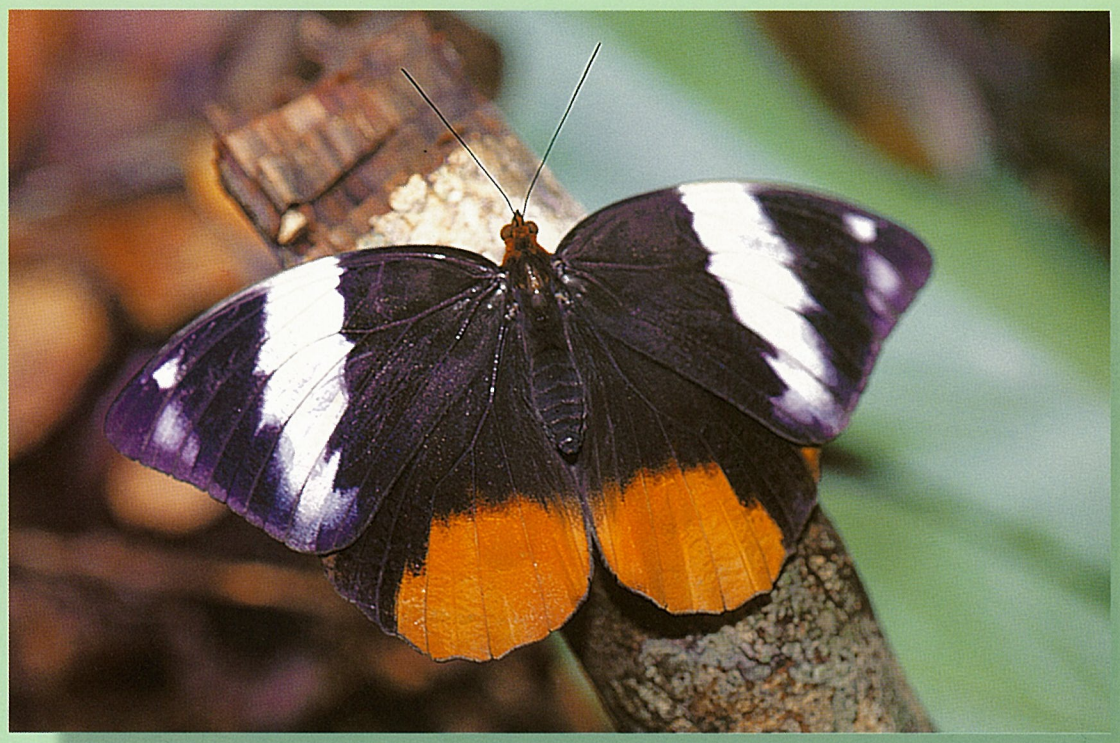
Gnetum gnemon, a common climber in many forests

A montane species of *Schefflera* on Bukit Lanjak

Troides brookiana brookiana, the only protected insect in Sarawak



Thauria aliris aliris, a large butterfly in hill forest



Samia tetrica, an emperor moth common in lowland forests

Copulation wheel of dragonfly, *Orthetrum glaucum*

Bronchocoela cristatena, a common green crested lizard

Rana picturata, a handsome stream frog

Trimeresurus wagleri, a common pit viper

Gastromyzon embalohensis, endemic to Embaloh and Katibas

Pontius sp., a relatively rare species

Nemachilus sp., possibly a new species

Hunters with hunting dogs in a longboat

A pig wallow

An Iban longhouse in Ulu Katibas

Shifting cultivation outside the Sanctuary

PART 3 – MANAGEMENT GUIDELINES

3.1 RATIONALE AND OBJECTIVES

The baseline data on biodiveristy that have been obtained so far already reflects the richness and importance of the Sanctuary as a conservation area. Together with Betung Kerihun N.P. it is set to become the centre for biodiversity conservation and research in Borneo as well as in the humid tropics.

The Lanjak Entimau Wildlife Sanctuary Project has been regarded as one of the most important projects of ITTO. It also serves as an example where the concept of collaborative management involving the local communities has been tested.

As an integral part of the Trans-boundary Conservation Area it is no longer logical to consider Lanjak Entimau Wildlife Sanctuary (LEWS) as independent conservation unit. In his report on "Strategies for the Conservation Management of the Lanjak Entimau-Betung Kerihun Trans-boundary Conservation Area" in 1997, Don Gilmour from IUCN remarked that:-

> The launching of the Trans-boundary Conservation Area by Government ministers from Sarawak and Indonesia in 1994 was a clear statement of the political importance attached to the initiative. It set the scene for an increased emphasis in both States on issues of biodiversity conservation in general and the identification and management of representative protected areas in particular. Thus the Conservation Area can become a focus for these activities by providing a high profile working model of both cross boundary cooperation in the conservation field and for pursuing a more focussed conservation agenda within each of the States.

Gilmour further elaborated that:-

> The combination of attributes of the Conservation Area – large size; intact ecosystems; secure tenure; stable social and political systems; physical infrastructure; existing local research institutions; indigenous knowledge of biodiversity and its use among local communities – gives it the potential to become a global centre for field studies of tropical rainforest biodiversity.

A number of important considerations will need to be borne in mind to ensure that the scientific benefits of the Area are fully realised and equitably shared. Among these are the need to:-

- make sure that all research is carried out on a collaborative base between scientists from within the region and those from outside;

- pursue a goal of financial sustainability so that there is full cost recovery of any scientific work;

- respect the indigenous knowledge of the local people regarding biodiversity and its use so that any benefit coming from the use of that knowledge is shared equitably.

From the above statements, it is imperative that the Sarawak Forest Department must continue to strengthen LEWS as a centre for biodiversity by continuing collaborative research with Betung Kerihun National Park in ecological studies and biological inventories as well as in encouraging community-based agro-forestry activities as a part of its strategies on sustainable management.

3.2 A REVIEW OF THE MANAGEMENT PLAN

In the Project "Development of Lanjak Entimau Wildlife Sanctuary as a Totally Protected Area" the link between biodiversity conservation and sustainable resource development is emphasised. In order to realise the full potential of biodiversity conservation, it is necessary to tap the values of both timber and non-timber resources. During Phase I and II of the Lanjak Entimau Project, including the 1997 Borneo Biodiversity Expedition, a lot of scientific knowledge on biodiversity has been acquired. The usefulness of such knowledge must be linked to practical management and policy.

For LEWS, biodiversity conservation has attained a major significance when it became a part of the Trans-boundary Conservation Area with Bentuang Karimun National Park in Kalimantan in 1994. Through collaborative management Malaysia and Indonesia can work together towards the common goal to develop the biological resources for their own benefits as well as those of the global community. Tangible benefits can be more fully realised through the sustainable development of both timber and non-timber products.

In Sarawak, as in Kalimantan, the local communities have always been regarded as an unseparable part of the forest environment. About 12,400 of the Iban people live in 102 longhouse in the periphery of LEWS and many depend on it for their livelihood support. One of the strategies of the management plan is to reduce the conflicts between protection and use of the resources. The local communities must be allowed to participate actively in the process of management planning and implementation.

The Management Plan gave a brief background of the topography, watersheds and drainage, geology and soils and flora and fauna of the Sanctuary. Background on the socio-economic aspects was also given based on the studies carried out. The Management and Development objectives and Management Programmes are given in Part III and Part IV of the Plan respectively. The sections that are relevant for review are contained in Part IV of the Plan.

3.2.1 Specific Goals

3.2.1.1 Conservation of biodiversity

Conservation of biodiversity was going to be accomplished through:

- research and acquisition of scientific data on species and communities;
- monitoring of threatened, endangered or "indicator" species;
- improvement in the understanding of interactions within the biological community and natural forest processes.

Inventories and acquisition of scientific data on species and communities were undertaken. The database was further strengthened with studies on the flora of vascular plants, fungi and lichens, insects and small mammals. Continued efforts was made in the gathering of more information on plants of ethnobotanical value. However since the studies only covered a small part of the Sanctuary, there is a need for the Executing Agency to strengthen biological inventories to other parts of the Sanctuary.

Monitoring of threatened, endangered or "indicator" species was partly accomplished. Study on the orangutan was carried out jointly with the Indonesian scientists during the ITTO Borneo Biodiversity Expedition in 1997, with emphasis on the population structure and distribution.

Further surveys to monitor the migration of the primate within the Trans-boundary Conservation Area are necessary. It has been proposed that this be undertaken jointly with Indonesia.

A brief study on the fish fauna revealed over-fishing of the high-value fish species to a dangerous level. One way to reduce the impact on the natural stock was to encourage fish-rearing projects among the local communities.

There were no specific activities in Phase II to improve the understanding of interactions within the biological community and natural forest processes. Studies on interactions and ecology of keystone species are recommended for future studies by the Executing Agency.

3.2.1.2 Research and Education

Research and educational goals were to be attained through:-

- ensuring local participation in basic biodiversity research projects;
- channeling research findings into staff and student training, as well as other educational and interpretive programmes.

These goals have been satisfactorily achieved during Phase II activities on biological resource inventories and community-based activities. Since each of these activities was short-term (six months) in nature, on-the-job training was emphasised for staff and the local participants. Training for students on nature conservation needs to be further strengthened. The Forest Department conducts regular educational and interpretive programmes among the schools as well as the longhouse communities.

3.2.1.3 Community involvement and socio-economic benefits

Community involvement and promotion of socio-economic benefits were to be achieved through:-

- regularly scheduled consultative meetings with local community leaders;
- employment of local residents in management programmes;
- development of beneficial or profitable ventures in the buffer zone areas.

Regular meetings with the local communities were carried out. Many ideas had in fact formed the basis for studies in Phase II, such as community-based activities and non-timber use of the forest resources. The local communities also gave valuable information on the exploitation of game animals and the problems associated with it. Dialogues with the people will be strengthened with the formation of the Special Wildlife Committee for the Sanctuary in year 2000.

Priorities were given to the local people in employment. This includes permanent jobs in the various Ranger Stations.

Development of ventures beneficial or profitable to the people was initiated in Phase II and will be extended to Phase III. The emphasis would involve various forms of training in the sustainable use of the biological resources to improve their economic and living standards.

3.2.1.4 Long-term goals

The Management Plan has included the following long-term goals for the Sanctuary's management:-

- conserve biological diversity;
- ensure the maintenance of ecological integrity;
- enhance scientific knowledge through research;
- promote public education through interpretive programmes;
- protect the Batang Ai reservoir through the control of erosion; and
- preserve scenic beauty.

Inclusive within these goals is the preservation of cultural resources and integrity.

Steps taken to fulfill these long-term goals began with the implementation of Phase II activities. The cutting of the more than 160 km long boundary was an important step in the Government's conservation efforts. Regular checks in illegal hunting and fishing activities were stepped up. Awareness campaign was organised to educate the people about the need to preserve the Sanctuary's game and other equally important resources.

Protection of biological diversity was ensured by dividing the Sanctuary into a number of zones. The buffer zone is where the local communities live. The wilderness zone allows certain approved activities to be carried out besides research. The central core zone is out of bound to all visitors except research

personnel. The Government's infrastructure facilities are presently confined to the buffer zone.

In the implementation of all the activities of Phase II, disturbance or manipulation of the pristine ecological condition had been carefully avoided.

Besides the effort made by the Education Unit of the National Parks and Wildlife Division of the Forest Department, public education was also given by the Project consultants through numerous dialogues during field work, training and study tours. This has helped to change the perception of the people towards conservation.

3.2.1.5 Protection

A basic management requirement is to ensure effective protection of the Sanctuary's resources from indiscriminate human exploitation. One of the most important developments in 1999 was the implementation by the Forest Department on the ban on sale of wild meat. The Forest Department organised statewide awareness campaign even before the ban became effective to explain to the people the need for such an action. The result has been that the majority of the people are generally satisfied and supported the Government's policy on the ban. This had an impact on the Sanctuary because certain areas were visited frequently by commercial hunters.

Another significant development is the appointment of local community leaders as Honorary Wildlife Rangers by the Government to assist the authority to check hunting activities throughout the State.

The local communities living in the periphery of LEWS have similarly perceived the ban as a positive move by the Government to sustain its game animals. This was confirmed by a study at the end of 1999. This has been possible partly due to constant dialogues and interactions between government officials and the local people.

Cutting of the Sanctuary's boundary began during Phase II. The entire boundary of over 160 km long has been completely cut to a width of five metres. Strategic points along the boundary were selected for the building of sub-camps to be used by patrolling parties. Prominent markers and sign boards were erected at intervals to warn outsiders to keep off the TPA. Monitoring of sections of the boundary that were cut earlier had been carried out by the Wildlife Rangers.

The Forest Department has also made every effort within its limited manpower to carry out anti-poaching and anti-encroachment measures through education and supervision of entry points to the Sanctuary. However, the shortage of manpower is a critical factor in ensuring a more effective supervision.

3.2.1.6 Infrastructure

The construction of the Sanctuary's headquarters, field station laboratory, ranger sub-station and sub-camps had to be re-scheduled a number of times due to factors such as the economic downturn, Federal Government regulations on tendering procedures and the weather conditions. The field station laboratory was completed in early 2000. The headquarters complex, substation and subcamps are scheduled to be completed at the end of 2000. To provide facilities for field supervision, the Executing Agency built a temporary headquarters at Nanga Bloh from materials salvaged from the Joint ITTO Borneo Biodiversity Expedition in 1997.

3.2.1.7 Training

Training for rangers, forest guards and local community residents in field techniques and use of equipment (e.g. GPS, compass, meterological instruments) was carried out. Some 40 local residents were also taken on a tour of agro-forestry projects set up by the Forest and Agriculture Departments. More than two dozens of the local residents have taken employment in the various field stations in the Sanctuary.

No formal conservation courses were organised for local community leaders and residents apart from on-the-job training courses and study tours mentioned earlier. These were supplemented by visits by the Education Unit of the Forest Department. The local communities have acquired sufficient knowledge and understanding of the concept of conservation and have perceived the Government's conservation effort positively.

The Forest Department has prepared and distributed posters on protected plants and animals as well as the forest mushrooms to all the longhouses. Facilities and materials for interpretive and educational training will be built in Phase III.

The field and office staff have been trained in the use of audio-visual documentation of biological diversity.

3.3 PRIORITIES FOR STRENGTHENING ECOLOGICAL STUDIES

Ecological studies in LEWS began with the identification of different types during Phase I. Other activities essentially involved inventories of the flora and fauna, during which valuable information on species ecology was also collected.

In view of the immense richness of biological resources, however, our ecological knowledge on the plants and animals of LEWS is still very limited. This limitation could become a hindrance in our effort to effectively protect and manage the resources sustainably. This is particularly so with the larger animals which are constantly subject to human exploitation.

Some aspects of ecology that are important for management are population dynamics and plant-animal interaction involving major animal groups and keystone species. Studies in phenology, pollination, seed dispersal and breeding systems, and growth and sustainability of yield are relevant. The information can be usefully applied in the management modelling of economically important plant and animal species.

The following recommendations are made:-

Recommended Action 1
Obtain a complete set of aerial photographs or satellite imagery for study on distribution and extent of forest types. Identify forest types or habitats that may possibly be new, unusual or rare.

Recommended Action 2
Conduct reconnaissance soil survey to correlate forest types with soil types for the preparation of a soil-vegetation map.

Recommended Action 3
Conduct forest ecological studies in previously unknown forest types to study their forest structure, physiognomy and species composition.

Recommended Action 4
Conduct ecological studies of animal species in new forest types or habitats to study species density and distribution.

Recommended Action 5
Conduct ecological studies of keystone plant and animal groups or species relating to population dynamics and plant-animal interaction.

Recommended Action 6
Establish permanent field stations to monitor changes among animal groups or keystone species (e.g. birds, herpetofauna) due to seasons or modifications in habitat.

3.4 PRIORITIES FOR STRENGTHENING BIODIVERSITY INVENTORIES

The ITTO Guidelines on the Conservation of Biological Diversity in Tropical Production Forests (Anon 1993) (ITTO Policy Development Series No. 5) defines biodiversity as the total variety of genetic strains, species and ecosystems that are found in nature. For practical purposes it is sub-divided into genetic diversity, species diversity and ecosystem diversity.

Studies have so far shown LEWS to be extremely rich in plants and animals species. They are not only a source of biological wealth but are also a foundation of material health to the people.

Study on biological resources requires an understanding of the plant and animal species and their distribution. This can be achieved only through more inventories.

3.4.1 Role of Lanjak Entimau Wildlife Sanctuary in Biodiversity Conservation

In recent years, biodiversity conservation became an issue of importance on the sustainable forest management (SFM) of production forests. Accordingly, ITTO drew up a set of Criteria and Indicators for SFM that incorporates the element of non-timber biological resource. However, logging activities that result in constant modification of the ecosystems and resources can make conservation and monitoring of resources difficult. *In situ* biodiversity conservation therefore becomes an important role of Totally Protected Areas (TPAs) such as the Lanjak Entimau Wildlife Sanctuary.

LEWS is the largest TPA for Sarawak. In this respect, its role in conservation cannot be under-estimated. The Sanctuary contains eight major forest types or ecosystems for the conservation of biological resources at the landscape level. However, LEWS alone cannot fulfill the objective of preserving the State's plant and animal resources. Biodiversity conservation can be effective and meaningful only if sufficient areas of TPAs are created. It is the aim of the Sarawak Government to set aside up to 10% of its forested areas into national parks and wildlife sanctuaries.

3.4.2 Policy and Legislation

The need for habitat and biological resource conservation for the benefits of the people of Sarawak is enshrined in the Forest Policy, 1954. Sufficient legislations now exist to safeguard the biological resources. These come in the form of the National Parks and Nature Reserves Ordinance, 1998 and Wild Life Protection Ordinance, 1998, as well as the Sarawak Biodiversity Centre Ordinance, 1997 and Sarawak Biodiversity (Access, Collection and Research) Regulations, 1998.

Recommended Action 1
Carry out inventory in previously unexplored forest types or habitats that have been identified. Make a good description of the forests with notes on forest structure, physiognomy and species composition.

Recommended Action 2
Continue inventory in other areas including those previously explored. Inventory should be planned for different times of the year to collect data on the reproductive ecology of both plant and animal species.

Recommended Action 3
Identify non-timber products of present and potential value with recommended use in sustainable management.

Recommended Action 4
Enter all data into database. More officers should be trained to increase their competence in the handling of computerised documentation (see under Training).

Recommended Action 5
Suggest strategies for the effective protection and sustainable exploitation of plant and animal resources and their habitats.

3.5 IDENTIFICATION OF AREAS IN THE BUFFER ZONE FOR COMMUNITY-BASED BIOLOGICAL RESOURCE DEVELOPMENT

Hunting, fishing and collecting of jungle produce by the local people will continue to have an impact on the Sanctuary for many years to come. Studies have shown the need to reduce these activities thus ensuring a more effective protection of the

biological resources. This is done by encouraging the local people to get involved in community-based agro-forestry activities as an alternative source of livelihood support. Pilot studies in Phase II have shown that cultivation of indigenous crops and rearing of high-value indigenous fish species are profitable ventures and will bring good cash income many times more than what many are presently getting.

The strategy in Phase III is to organise training facilities that can become accessible to more people who may be interested in the new venture. A community-based field centre will be established to provide the training facilities for the cultivation of indigenous crops, rearing of indigenous fish and game species, propagation of plant species with ornamental potential, development of handicraft and eco-tourism.

The area of the buffer zone near the Batang Ai National Park are considered the most suitable because:-

- it is easily accessible by road from Kuching to Lubok Antu followed by a short distance by speedboat across the Batang Ai hydro lake;
- the area is densely populated, many longhouses are located along the buffer zone;
- suitable land can be acquired from the local people for the field centre and other facilities;
- "islands" of old secondary forest can be identified for the farming of indigenous game species;
- eco-tourism in the Batang Ai National Park can be more effectively developed and promoted.

Training programmes for the various activities will be organised to suit the needs of the interested participants. These will be drawn up by the ITTO consultants and officers of the Forest Department. The assistance of the Agriculture Department, Farmers Association and Fish Mart will be sought for training on marketing of products and entrepreunership.

The field centre will be maintained by the Executing Agency as an important field facilitity for the development of a long-term programme on eco-tourism and training, development and commercialisation of ornamental plants and other research activities in Lanjak Entimau Wildlife Sanctuary and Batang Ai National Park.

No other areas in the buffer zone will be developed for community-based resource development as one facility is considered to be adequate to meet the needs of the Executing Agency and the people. By not duplicating the facilities, manpower and financial resources can be more efficiently utilised.

3.6 TRAINING

Training has been regarded as a very important component of the LEWS Project right from the outset. Starting with Phase II, the emphasis was on the transfer of scientific knowledge and field techniques from the consultants to staff of the Forest Department including counterparts, forest officers, forest rangers, forest guards and wildlife rangers. On a different level, the local people who participated in the Project as field assistants were given on-the-job training in techniques and skills relating to field inventories.

When community-based agro-forestry activities were introduced during Phase II, further training in relation to these activities was extended to the local communities. This training included cultivation of indigenous crops, construction of valley ponds and tanks for the rearing of indigenous fish species.

The Management Plan on education and training recommends that:-

- the existing education programmes of the National Parks and Wildlife Division of the Forest Department be extended to the local communities to foster dialogues with community leaders on the Sanctuary's functions and goals;

- organise visits by schools and special student programmes relating to Lanjak Entimau to enhance perception of the Sanctuary as a heritage;

- encourage the use of field stations by institutions of higher learning to conduct field courses with the view to producing more local experts in systematic biology and ecology.

The above recommendations will be incorporated with the education and training programmes of the field centre.

In addition, it is felt that the shortage of qualified and trained scientific personnel will be one of the critical problems that the Forest Department will be facing. More qualified and trained personnel will be required in the future when more Totally Protected Areas are established. It is recommended that the Executing Agency pay

serious attention in this field in order to strengthen its institutional structure on research and field inventories.

Recommended Action 1
Strengthen ecological expertise by recruiting and training more ecologists in various fields to meet future needs. There is yet no ecologist in the Forest Department.

Recommended Action 2
Strengthen taxonomic expertise by recruiting and training more taxonomists and para-taxonomists in various fields. The success of field inventory will depend largely on the upgrading of research capability by the Executing Agency.

Recommended Action 3
Recruit more intermediate officers to be trained as field assistants on flora and fauna in field, herbarium and laboratory work. This is necessary also to fill the positions of officers who have retired from service. Organise field programmes for training on ecology, species inventory and taxonomy.

Recommended Action 4
Organise a training programme relating to community-based agro-forestry activities for implementation at the new field centre near Batang Ai National Park.

For the science officers (ecologists, botanists, ecologists), post-graduate programmes are proposed. It is preferable that the officers recruited by the Forest Department register with local universities as M.Sc. or Ph.D. candidates and undertake research of approved topics as part of the Phase III Work Programme in the Sanctuary. Their field work will be supervised by the ITTO consultants and senior science officers of the Forest Department.

The intermediate officers will initially undergo training under the Forest Department's training programme. Separate field training programme on field survey techniques and plant and animal taxonomy will be organised during Phase III.

3.7 RESEARCH

During Phase III, all activities relating to research on biological research of the Sanctuary will be undertaken by the Executing Agency under its annual research

programme on flora and fauna. These research activities would complement those already undertaken during Phase I and Phase II and thus enhance our knowledge of the Sanctuary. The Forest Department as the Executing Agency will prepare annual field programmes to indicate the activities to be carried out each year.

3.8 RE-ZONING OF THE SANCTUARY

Ecolgoical studies have shown that a complete range of all eight major forest types that have already been studied are concentrated in the area close to the southern boundary. Here the boundary between the wilderness zone and core zone follows the watershed running east to west. Thus a large proportion of the eight forest types fall within the wilderness zone. This zone, being close to the buffer zone, is more liable to be encroached thus inflicting damage on the forest. In order to esnure a more effective protection of all the eight forest habitats, the width of the core zone is increased to encompass a full range of the forest types there (see Fig 2). This would also ensure further protection of the areas where the Sanctuary's only montane mossy forests are lcoated.

The boundaries between the buffer zone and wilderness zone and that between the wilderness zone and core zone will be surveyed and marked on the ground. This is necessary as the trail to the Ubah Ribu genebank and the summit of Bukit Lanjak is also a frequent hunting route of the local people living in that part of the buffer zone.

3.9 SPECIAL PROTECION ZONES

Special protection zones (SPZ) are considered necessary for the protection of rare species and habitats. These SPZs include the two genebanks at Ubah Ribu ridge and Ulu Ensirieng. Other SPZs are recommended for the protection of the rare Rajah Brooke's birdwing butterfly (the only insect protected by law in Sarawak), habitats for a number of high-value fish species, and the rare *Rafflesia* and its host plant (Fig 3).

The local people have been informed of the existence of these SPZs. One of the *Rafflesia* sites in Ulu Engkari occurs inside a secondary forest that belongs to one of the farmers there.

Maintenance of boundaries for each of the SPZs is necessary. Special markers and signboards are to be erected to remind the local people to keep off the areas.

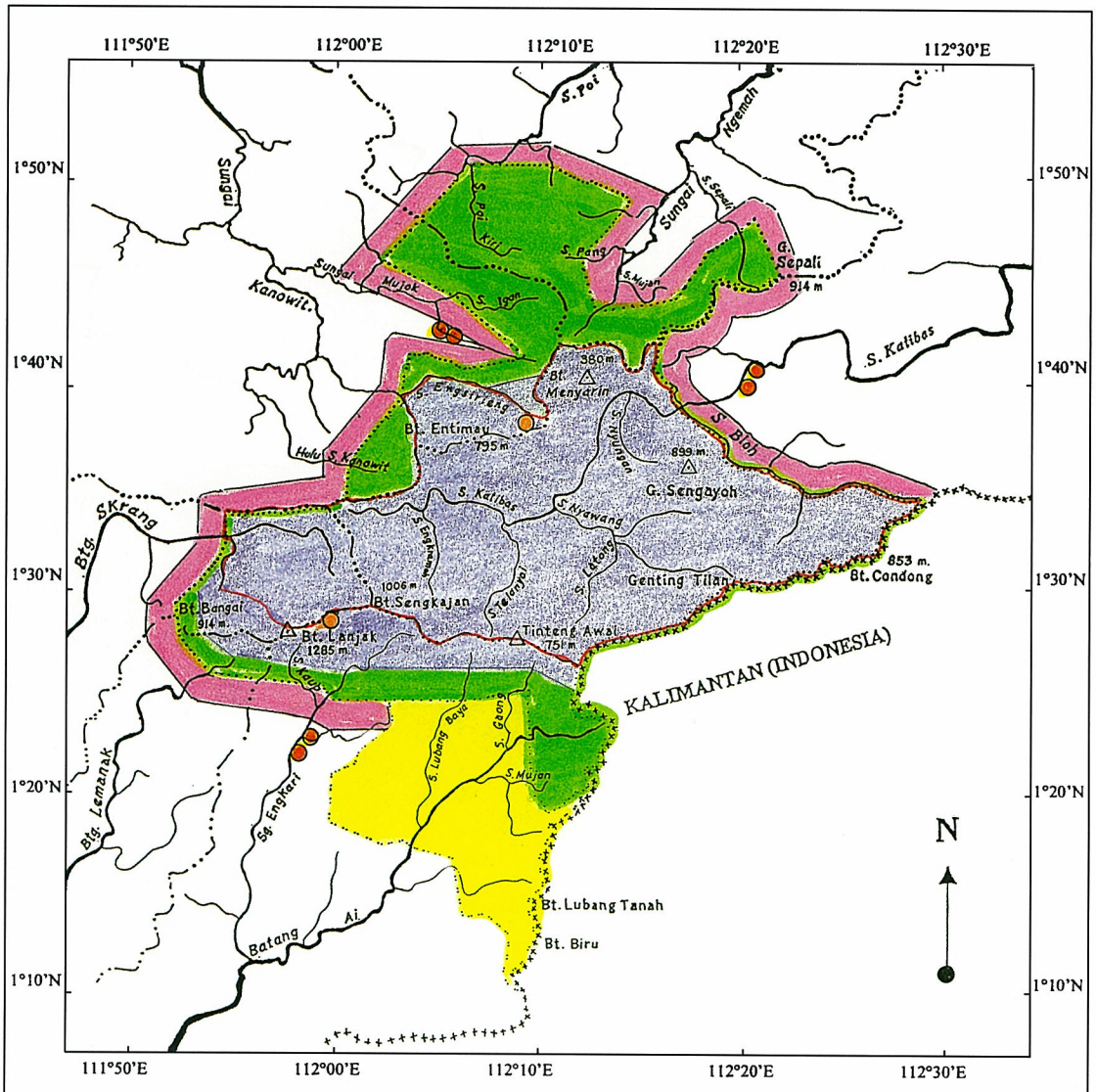


Figure 2 : RE-ZONING OF LANJAK-ENTIMAU WILDLIFE SANCTUARY FOR BIODIVERSITY MANAGEMENT

Legend

Lanjak-Entimau W/S .....

Batang Ai National Park.....

International boundary.....

0 ═══ 20 KM

Scale 1 : 625,000

	Ex-Zoning	Re-Zoning
Core Zone		
Wilderness Zone		
Buffer Zone		

Genebank ●

Culture ●

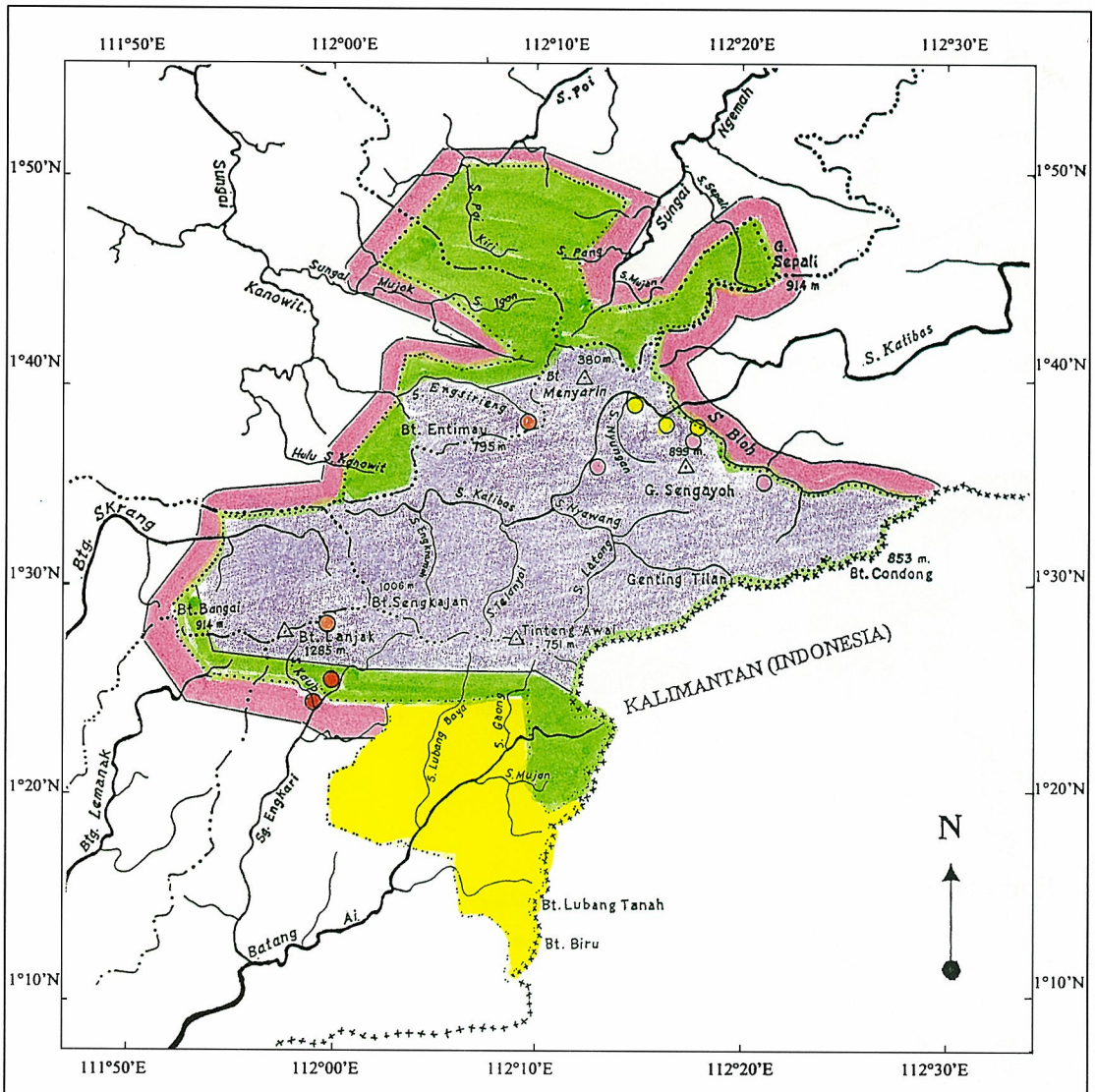


Figure 3 : SPECIAL PROTECTION ZONES IN LANJAK-ENTIMAU WILDLIFE SANCTUARY

Legend

Lanjak-Entimau W/S .....

Batang Ai National Park.....

International boundary.....

0 20 KM

Scale 1 : 625,000

Reference	Colour
Special Zone for **Fish**	
Special Zone for **Insects**	
Special Zone for **Rafflesia**	
Genebank	
Core Zone	
Wilderness Zone	
Buffer Zone	

3.10 EXTENSION TO THE SANCTUARY

Three areas with a total area of about 22,810 ha have been proposed for extension. This extension will be processed under the new Wild Life Protection Ordinance (1998) which allows the process to be very much simplified. Thus it can be expected that the size of the Sanctuary will be increased from 168,758 ha to 191,568 ha before the end of year 2000.

The three extension areas are covered by remnants of primary forest and old secondary forest that are rich in plant and animal species. Their inclusion in the Sanctuary will also ensure the protection of a wider watershed area thus bringing many socio-economic benefits to the local communities living in the longhouses downriver.

It is noteworthy that one of the extensions at Ulu Ngemah was included upon the request of the local communities there. Its inclusion will mean that the area would not be licenced for timber production.

4.0 CONCLUSIONS

A number of significant achievements were made during Phase II of the Lanjak Entimau Project. Firstly, the various studies have established the Sanctuary as one of the richest and most diverse conservation areas in Sarawak. Secondly, the formation of the Betung Kerihun–Lanjak Entimau Trans-boundary Conservation Area in 1994 also made it an important centre for the conservation of the flora and fauna in Borneo. Thirdly, LEWS is the only TPA in Sarawak where the concept of collaborative management involving the local communities has been tested. Fourthly, the ITTO Borneo Biodiversity Expedition in 1997 marked the first collaborative initiative on biological research between two countries sharing a common border.

(a) The Betung Kerihun–Lanjak Entimau Trans-boundary Conservation Area

Through the initiative of ITTO and the full support of the Sarawak and Indonesian Governments, the Betung Kerihun–Lanjak Entimau Trans-boundary Conservation Area was inaugerated in 1994. This Trans-boundary Conservation Area of nearly one million ha of pristine rainforest is the first in the humid tropics.

Both Betung Kerihun and Lanjak Entimau are homes of the threatened orangutan which numbers about 3,000 in Betung Kerihun and 1,000 in Lanjak Entimau. As the primate does not recognise international boundary, the creation of the Trans-boundary Conservation Area as a single conservation unit has significantly increased the habitat and enhanced the survival of not only orangutan but also numerous other plant and animal species that are threatened by continuing habitat destruction.

To be included in this trans-boundary reserve is another protected area in Sarawak. This is the Batang Ai National Park with an area of 24,000 ha. This national park is located south of and shares a common boundary with Lanjak Entimau. It is also contiguous with a small portion of Betung Kerihun National Park in the Ulu Embaloh area. It is home to about 400 individuals of orang utan.

With the inclusion of the Batang Ai National park and the extensions to Lanjak Entimau completed, the Trans-boundary Conservation Area would have a combined area of over 1.15 million hectares of largely pristine rainforest of Borneo.

The concept of the trans-boundary reserve has been taken up by a number of other countries including Peru and Eucador, and Thailand and Cambodia.

Continued collaboration on the Trans-boundary Conservation Area between Sarawak and Indonesia is important to foster further information exchange and discuss plans on research and resource management. This is done through a Task Force to be set up between officials of the two Governments.

(b) ITTO Borneo Biodiversity Expedition, 1997

The formation of the Betung Kerihun–Lanjak Entimau Trans-boundary Conservation Area would require some form of collaborative management between the two Governments to be initiated. In 1997, ITTO sponsored a sub-project of Lanjak Entimau Phase II called the Borneo Biodiversity Expedition to the Trans-boundary Conservation Area. This expedition marked the first initiatve in collaborative research between Malaysia and Indonesia. The six-week expedition held between September and November 1997 was participated by more than 40 Malaysian and Indonesian scientists.

The results of the expedition are contained in a scientific report published by ITTO in 1999. A popular report on the expedition was also published in 1998.

(c) Phase III

The Project will continue into Phase III beginning in 2000 during which activities relating to community-based agro-forestry will be further extended. The Forest Department as the Executing Agency views the Project as an important one in its effort to promote sustainable forest management in the State. In order to reduce the exploitation of the Sanctuary by the local people, the Department will be building a permanent community-based field station in the buffer zone to support the implementation of Phase III activities.

The Department will also be drawing up annual programmes to continue research and resource inventories in the Sanctuary to collect more baseline data for management purposes. Efforts will also be made to set up a Task Force with the Indonesian counterparts to enhance collaborative management of the Trans-boundary Conservation Area between Sarawak and West Kalimantan.

To further promote sustainable utilisation of the Sanctuary's resources, more genebanks will be established, while studies on species with potential for ornamental planting will be carried out. The promotion of handicraft using the local resources will also be considered.

The success and achievments of the Lanjak Entimau Wildlife Sanctuary Project will continue into Phase III with the commitment and collaborative effort of ITTO, the Sarawak Forest Department and the local communities.

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