

# BORNEO RESEARCH BULLETIN

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## NOTES FROM THE EDITOR

The present volume of the *BRB* represents something of a departure from past *Bulletins*. All of the papers that follow are related and focus on a single region of Borneo, the Danau Sentarum National Park of West Kalimantan.

This remarkable park, while in many ways unique, in other ways epitomizes, at once, both the natural and human diversity of Borneo, and, at the same time, its threatened and seemingly precarious future. On behalf of the Borneo Research Council, I thank, in particular, the collection editor, Wim Giesen, who, together with Julia Aglionby, introduce the park in their opening essay. I would also like to thank the individual authors, whose papers describe its many distinctive features, including indigenous resource use, the role of fire in shaping the local landscape, wildlife diversity and habitats, traditional honey and wax collection, fish, turtles, crocodiles, birds, orangutan, proboscis monkeys, and conservation issues and future prospects for park co-management.

Once again, I thank, too, Phillip Thomas, of the US National Library of Medicine, who formatted and did the computer work necessary to prepare this volume for publication. In addition to its size, the present issue presented a number of special challenges, which Phillip manfully overcame, despite surgery midway through the process. Volume 32 returns to our usual format and, I am pleased to say, is already well in hand. To the contributors, I apologize for the delay occasioned by the appearance of the present volume.

As some of you know, your editor has returned to Sarawak. Please note that my new address is now: Chair of Dayak Studies, Institute of East Asian Studies, Universiti Malaysia Sarawak (UNIMAS), 94300 Kota Samarahan, Sarawak, MALAYSIA (or email: [csather@mailhost.unimas.my](mailto:csather@mailhost.unimas.my)). In connection with the establishment of a Dayak Studies Program, I am pleased to announce the inauguration of two publication series: the Dayak Studies Oral Literature Series, and a data paper series, the Dayak Studies Contemporary Society Series. Three oral literature volumes and one contemporary society volume are currently in final preparation for publication and others are planned. For further information, including information on the submission of manuscripts, please contact me here at UNIMAS. The Institute of East Asian Studies has also undertaken the distribution of the four proceedings volumes of the 2000 Borneo Research Council meetings, *Borneo 2000*.

A minor item. In the last volume, in my review of David and Sue Fielding's book, *Borneo, Jewel in a Jade Rainbow*, I failed to mention that, for those living in the UK or Europe, the book may be purchased (softback £25, hardback £30, incl. postage) by writing directly to D.H. Fielding, March Cottage, Littlewoth, Faringdon, Oxon SN7 8ED, England.

Finally, we note here with sadness the death of Peter Goethals during the last year. An obituary by George Appell immediately follows. We also note with sadness the loss of Anthony Richards and Volume 32 will include a memoriam section in honor of Anthony.

**Copy Editor Wanted for Borneo Research Council Publications**

A copy editor is needed to work on the manuscripts submitted for the BRC's Monograph series, Proceedings Series, and Occasional Paper Series.

We need someone who is familiar with social science concepts and, if possible, familiar with the literature on Borneo or Southeast Asia. The copy editor would be expected to read a manuscript for intelligibility, punctuation, spelling, references, etc. The copy editor would ensure that the manuscript followed the "Style Guide and Information for Authors" of the Council and conformed to the *Chicago Manual of Style*. We would expect that the copy editor will work with the author of the manuscript to request changes and ensure agreement with any changes.

We believe that there will be two manuscripts submitted per year. Compensation will be within the usual range for such work. If interested, please contact with qualifications: Dr. G.N. Appell, Borneo Research Council, P.O. Box A, Phillips, ME, USA 04966, Fax: 207 639-4600, E-mail: [firebird@somtel.com](mailto:firebird@somtel.com)

**Member Support**

Here we wish to record our thanks to the following individuals for their contribution over the last year to the BRC endowment and general fund:

**Endowment Fund**

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Again, we thank all of you for your generous support.

## MEMORIAL

PETER R. GOETHALS

1926-2000

Peter R. Goethals, 73, Southeast Asian anthropologist, died of prostate cancer on May 8, 2000, at his home in Holualoa, Hawaii. He was the grandson of General George W. Goethals, chief engineer in the construction of the Panama Canal and first governor of the Canal Zone. Peter served in the U.S. Navy in the Pacific from 1944-46. He received his A.B. cum laude in anthropology from Harvard in 1950, and his Ph.D. in anthropology from Yale University in 1961 on the basis of research on kinship and marriage in Western Sumbawa. This led to a number of publications on Sumbawan society and language. Peter taught anthropology at the University of Virginia, University of North Carolina, and Duke University.

Peter and I were life long friends from our first meeting as undergraduate students in anthropology at Harvard following WWII. In 1962 Laura and I had a lovely visit from Peter at our field site among the Rungus Momogun, which permitted us to engage in long discussions on anthropological research. In addition to his research on Sumbawa, he did research on landlord-tenant relations among padi farmers in Trengganu and studied the problems of agricultural reform legislation in padi growing areas on behalf of the Ford Foundation and the Malaysian Ministry of Agriculture. Under sponsorship of the Asia Foundation and the Sabah Ministry of Local Government, Peter made a study of the problems of the administration of native law and custom in Sabah in 1965. He also worked as an applied anthropologist on several USAID projects in Indonesia and was director of the Social Science Training Station at Hassanuddin University, Ujung Pandang, Sulawesi 1976-77.

For his 50th reunion book at Harvard (2000) he wrote the following:

To me they [referring to his research and projects in Indonesia and Malaysia] have demonstrated not only the universally vital linkage between sound research and effective social science teaching, but also the value potential of "hands on" development assistance...(such as, for example, teaching in the language of the host country). Whatever the fascinations of living and working in this part of the world, reminders of highly-intractable, long-range problems abound: authoritarian government, unchecked population growth, and rampant ecological destruction. Obvious but perhaps less basic problems include: a controlled press, inter-ethnic conflict, widespread poverty, unemployment, pervasive political corruption, and lingering foreign economic exploitation...there is so much worldwide disarray, rootlessness, conflict, and resource discrepancy between groups that tough and tumultuous times lie in the near future.

Peter was a lovely man, considerate, with empathy for others, and a positive outlook on life and a wry sense of humor. He is remembered not only for his kindness but also for

his stimulating, witty intelligence, and grace, and a well-honed sense of right and wrong, justice and injustice. He will be sorely missed by his friends and colleagues.

He leaves his wife and childhood sweetheart, the author Sandol Stoddard; a daughter, Stephanie Goethals Grobel by his first wife, and two grandchildren. (George N. Appell, P.O. Box A., Phillips, Maine, 04966, U.S.A.)

#### **Publications Relevant to Sabah**

Goethals, Peter R.

- 1966 Three Measures for Inducing Judicial Change in Sabah's Native Courts. Report submitted to the Ministry of local Government, Jesselton.
- 1967 Review of the Film: William R. Geddes: *The Land Dayak of Borneo*. *American Anthropologist* 69:127.
- 1993 Gelenggang Dahulu: A Glimpse of Sabah's Native Court System in 1965. In: *Change and Development in Borneo: Selected Papers from the First Extraordinary Conference of the Borneo Research Council, Kuching, Sarawak*, Vinson H. Sutlive, Jr., editor. Williamsburg, VA: The Borneo Research Council.
- n.d. Justice or Law: Native Court Authority in Rural Sabah.
- n.d. Social Control and Custom Law in Sabah: A Preliminary Survey. Report to be submitted to the Ministry of Local Government, Jesselton, Sabah, Malaysia.

Goethals, Peter R. and Eldon D. Smith

- 1965 *Tenancy Among Padi Cultivators in Malaysia*. Kuala Lumpur: Ministry of Agriculture.

## RESEARCH NOTES

### INTRODUCTION TO DANAU SENTARUM NATIONAL PARK, WEST KALIMANTAN, INDONESIA

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#### INTRODUCTION

The Danau Sentarum National Park (further referred to as DSNP or the Park) covers an area of 132,000 hectares, and is located in the floodplain of the upper Kapuas River in West Kalimantan, Indonesian Borneo (Figure 1). The Park lies between the Kapuas River and the border with Sarawak, and is located between 0°40'-0°55' N and 112°00'-112°25' E at an average elevation of 35 meters. DSNP consists of a series of interconnected seasonal lakes (=danau), interspersed with swamp forest, peat swamp forest, and dry lowland forest on isolated hills. The area was first gazetted as a *Suaka Margasatwa* (Wildlife Reserve) in 1982 by decree SK No. 757/Kpts/Um/10/1982, when it extended over 80,000 hectares, with just under one-third consisting of open water. In 1994 it was enlarged to 132,000 hectares to include extensive tracts of peat swamp forest, and several hill ranges with dry lowland- and heath forest (Figure 2). In April 1994, Danau Sentarum was declared Indonesia's second Ramsar Wetland of International Importance, thus drawing international attention to this unique area. On 4 February 1999, its status was upgraded to that of *Taman Nasional* (i.e. National Park) by decree SK 34/Kpts-II/1999, and includes the 132,000-hectare core area, along with a 65,000-hectare buffer zone proposed in 1997. The latter is disputed and has been partly earmarked for oil palm estate development (see Wadley *et al.*, 2000).

DSNP is a key conservation area on Borneo, supporting about 250 fish species (including 12-26 endemics), about 250 bird species, Borneo's largest inland population of proboscis monkey, one of the largest remaining populations of orangutan, possibly three crocodile species, and several dozen endemic plants. The lakes support a large traditional fishing industry, utilized by over 6,500 fisher folk inhabiting 39 villages in and adjacent the Park. Forests are heavily utilized as well, both for construction timber and for a wide variety of non-timber forest products.

Apart from limited input to fisheries management by Dutch colonial administration in the early 20<sup>th</sup> century (Wadley, 2000a) and by the Fisheries Department since the late

1940s, management of DSNP's natural resources has largely been based on customary law. Officially, DSNP is managed by the Directorate General of Nature Protection and Conservation (*Ditjen Pelestarian Konservasi Alam* or *PKA*; formerly *PHPA*) of the Ministry of Forest and Estate Crops (MOFEC). There was no active management or representation by PKA in Danau Sentarum until the UK-Indonesia Tropical Forest Management Project (UK-ITFMP), which was funded by the British Overseas Development Administration (now Department for International Development) from 1992-1997. UK-ITFMP aimed at (re-)establishing community-based management practices and was successful in some areas, such as reinforcing local customary law, strengthening legislation, and creating local appreciation of conservation values.

**Figure 1. Location of Danau Sentarum.**

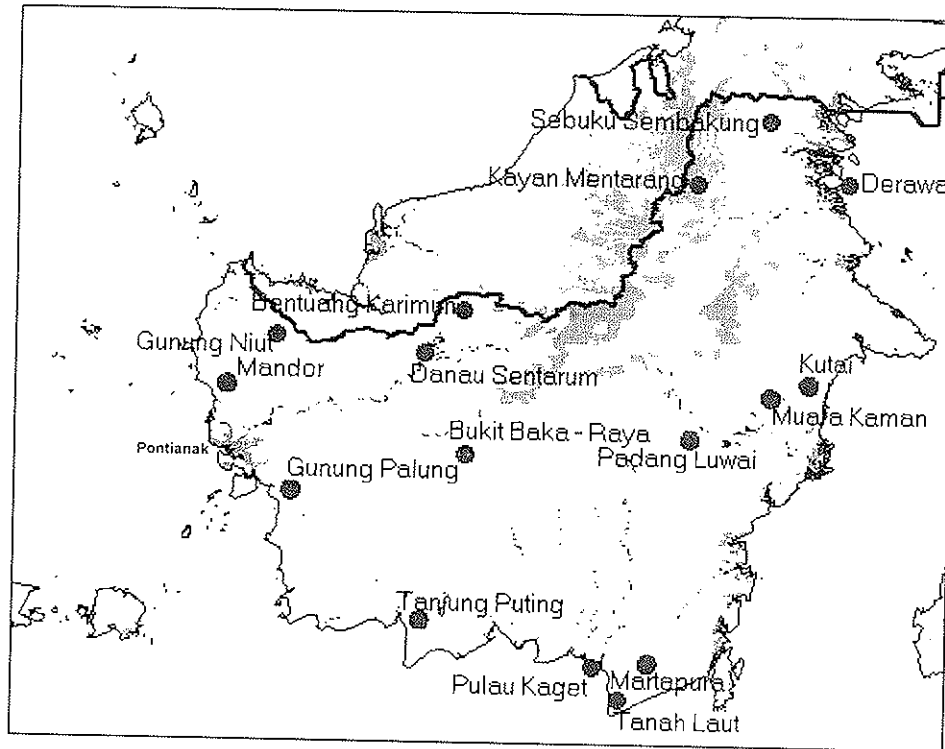
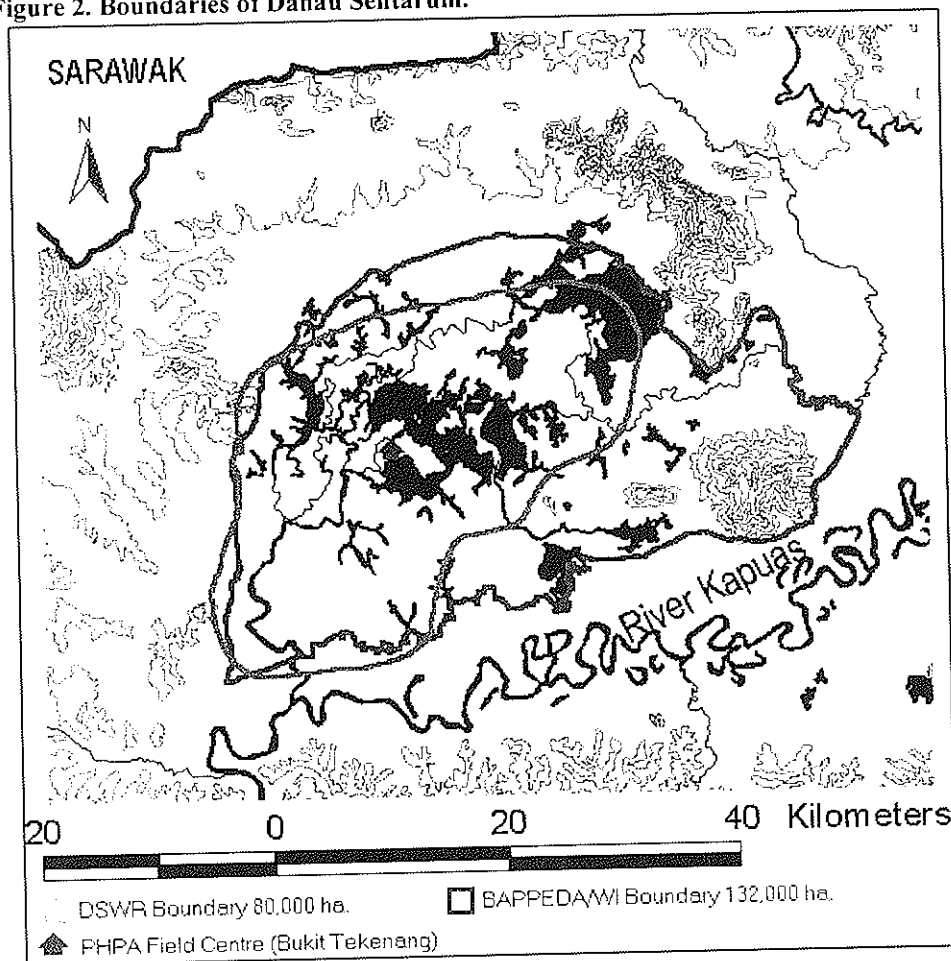


Figure 2. Boundaries of Danau Sentarum.



## PHYSICAL AND BIOLOGICAL SETTING

### Hydrology and water quality

Annual rainfall in the Park fluctuates around 3,900 mm per year, while the surrounding hills and mountainous catchment area receive 4,500-6,000 mm per year. The upper Kapuas basin is very flat, and waters of the Kapuas River accumulate upstream of the natural "bottleneck" near Semitau, just downstream of the Park. Because of high precipitation levels, most of the low-lying areas in the basin are flooded in the wetter months. Three-quarters of the lakes in the 6,500 square kilometer upper Kapuas basin are included within the Park. These lakes act as a buffer for the Kapuas River system, mitigating floods and buffering water levels in the dry season. According to a model developed by Klepper (1994), one quarter of peak floods of the upper Kapuas River are siphoned off into DSNP's lakes and swamp forests, thereby significantly reducing flood damage downstream. During the dry season, up to 50 percent of upper Kapuas River waters may consist of water flowing



from the lakes and swamp forests, thereby maintaining water levels and safeguarding downstream water supplies.

DSNP is dominated by a marked fluctuation in water levels of the lakes and streams, which may rise and fall up to 12 meters during an average year. During about nine months of the year the lake system is relatively full (average maximum depth 6.5 m), though levels may fluctuate substantially. During the remainder of the year (usually late June-early September), waters usually retreat to the deepest channels and the lakes often dry out entirely. On average this occurs in about two out of every three years. Water enters the system via various streams and inlets, but the main out flowing stream is the Tawang River, which reverses its flow after peak floods. This annual cycle of rising and falling water levels dominates the ecosystem and exerts a strong influence on the lives of its people, plants and animals (Figures 3 and 4).

Because of peat deposits in and around the lake system, the waters of the lakes and streams are colored by tannins, very nutrient-deficient and acidic (pH 4.5-5.5). Light penetration in water is about one meter, while conductivity averages at 16  $\mu$ S (range 9-24  $\mu$ S). Dissolved oxygen levels are fairly low, averaging at 4.4 mg/l, while surface temperatures are high (30.4°C). Suspended matter consists mainly of clay and organic matter, and usually ranges from 10-15 mg/l.

#### **Geology, geomorphology, and soils**

The geology is relatively simple, as the Danau Sentarum area consists largely of recent deposits, together with outcroppings of arkosic sandstone (Molengraaff, 1901; Giesen, 1987). Recent deposits mainly consist of illite and kaolin clays in the lake basin, with pockets of shallow to moderately deep topogenous peat occurring at the base of hills and in depressions between levees. Nodules of goethite (bog iron ore) are common throughout the lake basin, and beds of this ore are exposed during the dry season. Soils on slopes consist of highly weathered and nutrient poor loams and sands, with traces of goethite and gibbsite, while those on the flat ridge tops consist of fine to moderately fine sands and loamy sands. In general, soils throughout the area have a low to very low nutrient status and are infertile. The flat topography is relieved by several isolated hills in the Park, that rise from 120-370 meters above the lakes, and hill ranges to the west, northeast and east of the lake basin that rise to about 500(-700) meters.

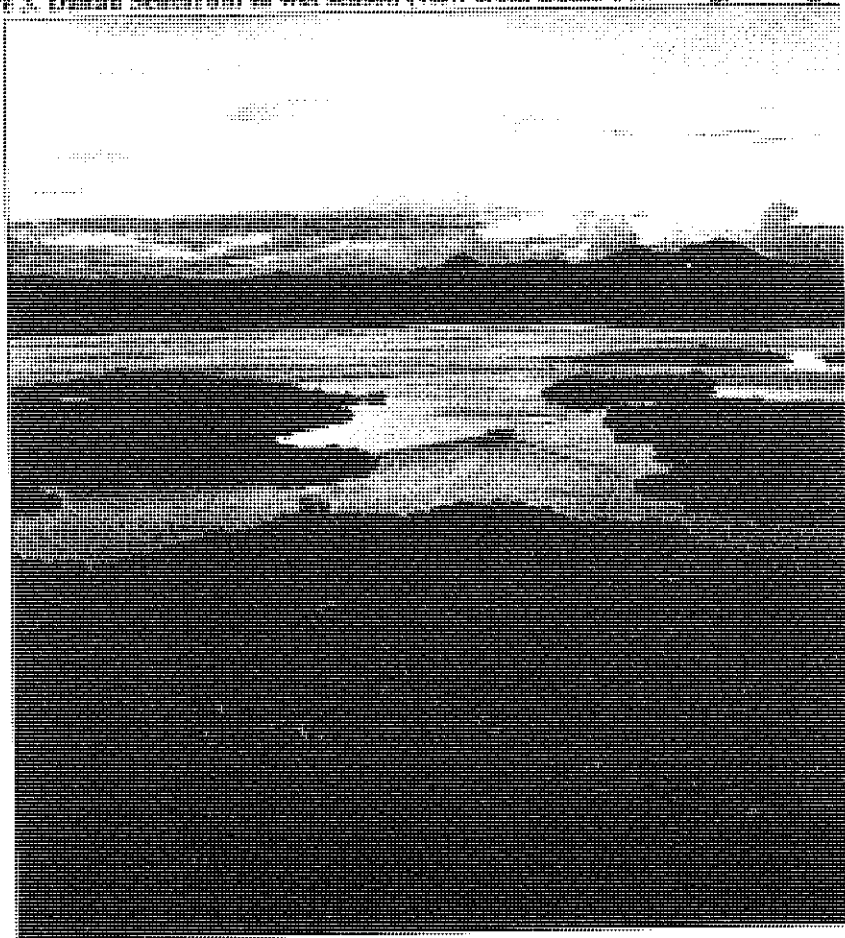
#### **Flora and habitats**

More than 500 plant species have been recorded at DSNP, belonging to 99 families (Giesen, 2000). Of these, 262 species occur in the swamp forests, three-quarters of which are trees and shrubs. Aquatic herbaceous species are uncommon, probably because of the significant annual fluctuations in water levels, and are generally limited to more permanent bodies of water near the Kapuas River. The flora includes 30-43 species endemic to the DSNP area, and during recent surveys, eight species new to science were discovered (Giesen, 1996, 2000).

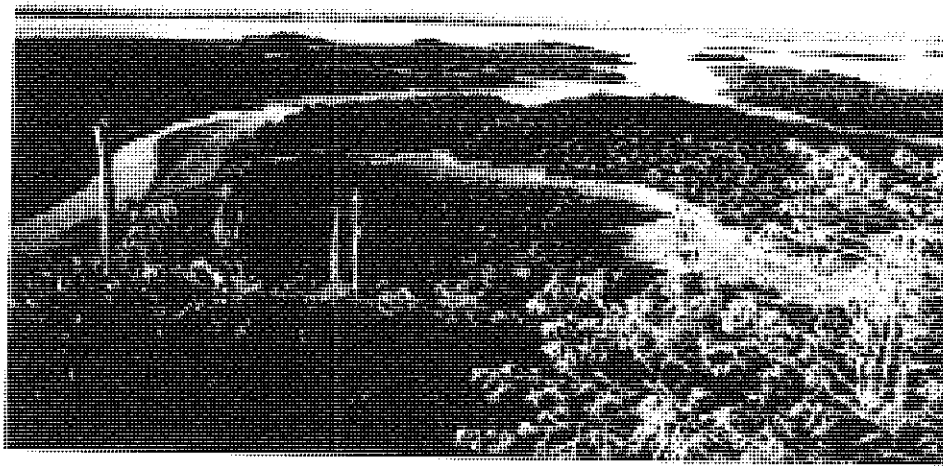
Characteristic for DSNP are the swamp forests and lakes, which respectively account for 48.75 percent and 23 percent of the Park. Three major types of swamp forest can be identified: tall, stunted and dwarf swamp forest, which have an average canopy height of 22-30, 8-15(-22) and 5-8 meters, respectively (Giesen, 1996, 2000). Dwarf swamp forest develops in deeply flooded areas, and may be flooded with 4-5.5 meters of water for 8-12 months per year. Tall swamp forest is flooded for 2-3 months annually by 1-2.5 meters of

water, and some areas are characterized by peat soils of 0.5-4 meters depth. Stunted swamp forest is intermediate between tall- and dwarf swamp forest in terms of flooding depth and duration. Almost two-thirds of the swamp forest consists of stunted swamp forest, while one third consists of tall swamp forest. Dwarf swamp forest forms a minor element, accounting for 4.8 percent of all swamp forest. Swamp forests are prone to fires, possibly due to the accumulation of large amounts of organic matter in the wet months, and repeated fires appear to be leading to an expansion of dwarf and stunted swamp forest, at the expense of tall swamp forest. Most fires are caused by human interventions, and a marked increase can be noted since 1990 (Dennis *et al.*, 2000). Recently burnt areas and swamp forest regenerating after fires together account for a very significant 17.66 percent of the Park (Dennis *et al.*, 2000). Heath forests, which extend over 0.2 percent of the Park, are characterized by uniform, fairly small statured trees (average up to 20-25 meters), and usually occur on very poor, leached sandy soils on the tops of sandstone ridges. Lowland forest is found on the low hills and ridges around the lake basin, and consists of tall to very tall tree, with emergents attaining 35-45(-55) meters.

Figure 3. Dumas Sentarom in wet season (view from Bukit Taburan, looking NNE).



**Figure 4. Danau Sentarum in dry season (view from Bukit Tekenang, looking NNE).**



### **Fish**

The lakes of Danau Sentarum are remarkable for their fish diversity, and 240-266 fish species have been identified at the Park and in smaller streams around the area since 1992 (Kottelat, 1995; Widjanarti, 1996; Jeanes and Meijaard, 2000a), including 12-26 new to science. As the lakes measure only 25,000 hectares, this diversity is remarkable when compared to Europe, where a total of only 195 primary freshwater fish are known. In fact, Danau Sentarum harbors one of the world's most diverse fish fauna's of any floodplain lake system: of the 71 tropical and temperate lakes listed for their biodiversity by WCMC (1992), Danau Sentarum (which is not listed) is surpassed only by Lake Tanganyika and Lake Malawi. In the Indonesian context Danau Sentarum is also very rich. Kalimantan, with 394 species (including 340 primary freshwater species), has the richest fish fauna of all Indonesian islands (Kottelat *et al.*, 1993). Of these Kalimantan species, 310 have been recorded in the Kapuas River, which is Indonesia's species-richest. The DSNP fish fauna includes two highly popular aquarium fish: the rare and valuable red variety of the endangered Asian Arowana *Scleropages formosus* or *siluk* (listed on Appendix I of CITES), and the Clown Loach *Botia macracanthus* or *ulanguli*. The latter is only known from Danau Sentarum and several locations in Jambi, Sumatra. The Park also harbors many interesting species from families that are primarily marine, such as soles, stingrays and pufferfish.

### **Reptiles and amphibians**

Three species of crocodile occur at DSNP, including the rare and endangered False Gaviel (*Tomistoma schlegeli*), the Estuarine Crocodile (*Crocodylus porosus*), and a third as yet unidentified species (Frazier, 1994, 2000; Jeanes and Meijaard, 2000a). These are listed on Appendix I of CITES, and the first two are also protected by Indonesian law.

Reptiles further include 11 species of turtle and tortoise (Walter, 1996, 2000; Jeanes and Meijaard, 2000a), two species of Monitor Lizard, and numerous snakes. Amphibians are rare in the Park, and the only species found throughout is the River Toad *Bufo asper*, with more species being found in permanent waters near the Kapuas River.

### Birds

DSNP's avifauna has been relatively well studied, and has been found to include 237 confirmed and 45 unconfirmed species belonging to 52 families (van Balen and Jensen, 1994; van Balen, 1996; Jeanes and Meijaard, 2000a; van Balen and Dennis, 2000), which is half of the species recorded on Borneo to date (MacKinnon and Phillips, 1993). These include 9 threatened and 22 near-threatened species, including the Argus Pheasant *Argusianus argus* and the Storm's Stork *Ciconia episcopus stormi* (van Balen and Dennis, 2000). The Argus Pheasant, which is listed on Appendix II of CITES, occurs mainly in the hills to the southeast of the Park, where it can regularly be heard. Storm's Stork is listed as extremely rare (Silvius and Verheugt, 1989), and may be considered the world's rarest stork (pers. comm. Silvius, 1994). The vast majority of bird species are forest-dwellers, and waterfowl are relatively rare, probably because of a lack of herbaceous aquatic vegetation cover. Colonial water birds such as egrets and herons have been wiped out due to hunting and egg collecting, and the area has probably never had many ducks or waders.

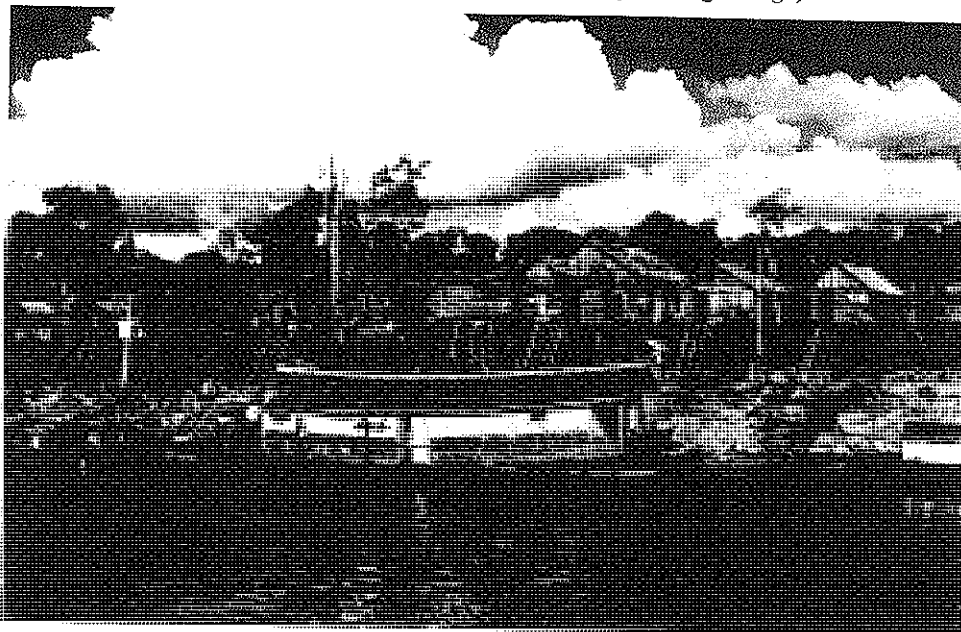
### Mammals

Apart from studies of the Orangutan *Pongo pygmaeus* (Russon *et al.*, 1996; Meijaard *et al.*, 1996; Russon *et al.*, 2000) and the Bornean endemic Proboscis Monkey *Nasalis larvatus* (Sebastian, 1993, 1994, 2000; Wood, 1995), DSNP's mammal population has been poorly studied. 55 species have been directly observed in the Park, and a further 88 species have been recorded from secondary, anecdotal sources (Jeanes and Meijaard, 2000a), bringing the total to 143 species. This includes 16 threatened species and 26 species endemic to Borneo. DSNP has the largest inland population of Proboscis Monkeys, but they are elusive, probably due to past hunting pressures, and unlike other populations of this species, they venture far from waterways frequented by fisher folk (Sebastian, 2000). A remarkable recent discovery is that the swamp forests and peat swamp forests around Danau Sentarum harbor what may be one of Borneo's largest populations of Orangutan (Meijaard 1997; Russon *et al.*, 2000).

### Uniqueness

Habitats similar to DSNP formerly occurred in East Kalimantan, along the Mahakam River, but this area was already heavily disturbed early this century (Endert, 1927; Giesen, 2000), and is now virtually devoid of primary habitat. On Sumatra, similar lake systems used to occur along the Siak Kecil River in Riau Province, but these forests have been logged and burnt and are now severely degraded (Giesen and van Balen, 1991). The largest floodplain lake system in Asia, Lake Tonle Sap in Cambodia, is an order of magnitude larger than Danau Sentarum and used to harbor similar flooded forests. However, centuries of intensive use by Khmer fisher folk have greatly impoverished the area (Giesen, 1998), and Danau Sentarum is superbly rich by contrast. Habitat-wise, DSNP can therefore be regarded as unique. At a species level, DSNP also has a high level of uniqueness, with in the range of 30-43 plants, 12-26 fish species and perhaps one endemic reptile unique to the area (Giesen, 2000; Jeanes and Meijaard, 2000a).

Figure 5. Nanga Pengembung village at DSNP (Malay fishing village).



#### PEOPLE AND EXPLOITATION OF NATURAL RESOURCES

Although located in a remote part of Borneo, the DSNP area has a long history of human settlement and exploitation (Wadley, 2000b; Colfer *et al.*, 2000). Up to about 200 years ago, the area was inhabited by various ethnic groups (later collectively known as 'Dayak'), who cultivated hill rice using swidden practices, and supplemented their diet largely by means of hunting and gathering forest produce. Fishing was also a very important part of the local economy, especially in the Kapuas lakes region (Wadley, pers. comm.). These people had strong animist beliefs that were closely associated with the forests and its wildlife. Islamic Malay culture spread from the Malacca Straits area, Sumatra and Malaya to the coastal parts of West Kalimantan at least 300-400 years ago, and by the late 18<sup>th</sup> century, it had spread up to the large towns along the Kapuas River, in the vicinity of what is now the Park. The Dayak were generally not displaced, but in the period 1800-1860 many were converted to Islam and assimilated into the Malay culture. The Malay language spoken nowadays in the Upper Kapuas region owes as much to local Dayak languages (e.g. Embaloh and the various Iban groups) as it does to more traditional coastal Malay (Wadley, pers. comm.). Apart from language and religious practices, changes that occurred include the moving of villages from forested areas, where the Dayak traditionally inhabited longhouses, to single family dwellings in villages located along rivers and lake shores. Compared to Malays along the Borneo coast and in Malaysia, however, the Malays in the DSNP area still maintain strong links with the forests, as they still harvest timber and minor forest products, and practice some form of shifting cultivation. Currently, there are 39 villages located in or immediately adjacent the Park, having a total of about 6,500 inhabitants, of which about 85 percent is Malay

(Aglionby, 1997). The population density of the DSNP area is about five persons per square kilometer.

### Malay villages

The DSNP area is largely inhabited by Malays, which inhabit 34 of the 39 villages located in or immediately adjacent the Park (Colfer *et al.*, 2000). Their total population numbered about 4,000 in 1990, and is currently expected to be about 5,500. During the fishing season (usually June-August) this swells temporarily by about 20 percent, as relatives from the Kapuas River towns may join them for several months. About six of these villages are temporary fishing camps, but the majority is permanent, and several of the largest villages boast mosques, schools, primary health centers and police stations (Figure 5). While some villages have been established during the last two decades, many have a much longer history, and some are several hundred years old (Giesen, 1987; Wadley, 2000b). All Malay villages maintain strong ties with larger Malay towns located along the Kapuas River, and the sub-district boundaries follow the old Malay fiefdom boundaries established by the colonial administration in 1880 (Wadley, n.d.). During religious festivities or censuses, for example, Malay villages in the Park are largely deserted, as most inhabitants move back to their ancestral town along the Kapuas River to join relatives. In order to cope with the rise and fall of water levels, houses are generally built on poles or float on rafts of timber.

### Fishing

The Malay economy revolves entirely around fishing, which is the major source of protein and provides most of the Malay family income (Colfer *et al.*, 2000). When water levels are high, fishing activity is at ebb and carried out for subsistence only. During the onset of the dry season (usually June), as water levels drop, fishing activity picks up, and when the lakes have almost dried out, fishing activity peaks and almost everyone is involved. Fishing practices include the use of a wide range of cast nets, gill nets, fixed nets, funnel nets, lift nets, traps, barriers, hooks-and-lines, and even excavated pits (Giesen, 1987; Dudley, 2000). Most fish are sun-dried and salted, as the remote location excludes the possibility of marketing fresh fish, with the exception of several high-value species. The latter include ornamentals, such as the Clown Loach and the Asian Arowana, but also highly prized food fish such as the Marbled Goby *Oxyeleotris marmorata* or *ikan lemas*, Sultan Fish *Leptobarbus hoevenii* or *jelawat*, Featherback *Chitala lopis* or *belida* and Giant Snakehead *Channa micropeltes* or *toman*. The latter three also form the basis for floating cage culture, whereby fish are fattened in captivity before being shipped to market. Certain catfish are processed as smoked fish, and these are mainly *Kryptopterus apogon*, known locally as *lais bemban*. Other fish products include fermented fish or *buduk*, fish crackers or *krupuk* (for which mainly *C. lopis* is used), and fish eggs (mainly of Kissing Gouramy, *Helostoma temminckii* or *biawan*) (Giesen, 1987; Dudley, 2000). The estimated total annual catch ranges from 7,800-13,000 tons, which is about 97.5-162.5 kg/ha, which is similar to that of the Mahakam Lakes in East Kalimantan (139 kg/ha, Dunn and Otte, 1983) and that of Lake Tonle Sap in Cambodia (147 kg/ha, van Zalinge and Touch, 1996). Each village has a head fisherman or *ketua nelayan*, who presides over fishing activities and assures that proper practices are adhered to in the villages' fishing area. Certain techniques are prohibited, such as the

use of fixed bag nets (*jermal*) in certain areas, the use of fish poisons, and—strangely enough—the use of earthworms as bait.

The fishing industry is a valuable one. A large (50-60cm), reddish-golden colored Asian Arowana can sell for as much as several hundred US dollars in the lake area, and be worth more than US\$1,000 (or even US\$ 5,000) by the time it is sold in Jakarta. Marbled Goby, valued locally at about US\$10 per kilogram, are shipped live, in oxygenated plastic bags, to markets in Singapore and Japan. Clown Loach are shipped the world over, as they are not bred successfully in captivity. The total value of the market is currently valued at about US\$ 2.2 million (Aglionby, 1997), but it should be noted that the Asian Arowana is now very scarce and barely contributes to the local economy.

### Malay farming

Rice is the most important staple of the Malay, and most of this is obtained by purchase, as suitable areas in which to cultivate rice are very scarce in the Park area. The Malays practice some swidden or *ladang*, but this is limited to the upper levees of the main rivers in the basin, and crops other than rice are generally grown, such as cassava, maize, eggplant, cucumbers, beans and chili's (Colfer *et al.*, 2000). About 4,500 hectares have been cleared altogether for *ladang*, which is about 3.5 percent of the Park.

### Honey industry

Honey is an important product at DSNP, and the honey industry dates back to at least the early 1800s (van Lijnden and Groll, 1851; Mulder *et al.*, 2000). The industry is well-described by de Mol (1933), who reported that at that time, about 500 families collected honey and wax in the area, each family operating 40-150 *tikung*.<sup>1</sup> Harvesting occurred mainly at the end of the wet season, or early dry season, by smoking the bees—migratory Asian Giant Bee *Apis dorsata*—out by means of a torch. Bees also make use of large boughs of trees, and such a natural honey tree is called *lalau*—which are also marked and “owned” for a season by the person discovering the combs. The industry had withered somewhat over the past decades due to dwindling honey prices, but has picked up again due to promotion by UK-ITFMP. The total honey yield of the Park was estimated to be 20-25 tons in 1993, with almost one third of all families participating, having 10-500 *tikung* each (Rouquette, 1995; Mulder *et al.*, 2000). In 1993, the value of the industry was about US\$ 7000 locally, but almost ten times this in Pontianak, the provincial capital. In villages where honey is collected in reasonably large amounts, regulations have existed for a long time, and in some villages a person specifically responsible for the honey (the *ketua madu* or *ketua priyau*) is appointed (Rouquette, 1995; Mulder *et al.*, 2000).

### Malay harvesting of timber

Timber is in high demand in the Malay villages, for a wide range of uses, including housing, boat and canoe (*sampan*) construction, simple furniture, *tikung*, walkways, and floating cages. Although a wide range of timber species may be used, including a range

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<sup>1</sup>*Tikung* are thick planks made from the *tembesu Fagraea fragrans* tree, U-shaped in cross-section, 1-1.5 meters long and with a deep notch at each end. They are placed horizontally in target trees, with the convex side down. *Tikung* are individually owned, and if migratory bees make their nest on one, the honey/wax belongs to the owner of the *tikung*.

of dipterocarp (*meranti*) species, the most desired timber species is *Fagraea fragrans* (Loganiaceae), known locally as *tembesu*, which produces a very durable, high quality timber that is very resistant to rot and termites (Peters, 1994b). Harvesting is restricted to periods of high water, to facilitate transport of the timber, and usually carried out in October-December, in the lull period following the fishing season (Peters, 1993, 1994a, 1994b). As a general rule, the intensity of logging is inversely proportional to the intensity of fishing. Generally, harvesting of timber in the area governed by a particular village (i.e. the *wilayah kerja*, or utilization area) is controlled by the village head or head fisherman *ketua nelayan*. Villagers may harvest freely for themselves, provided that it is for their own use, while permission is granted to outsiders, provided that they follow protocol (i.e. ask permission), and harvest for their own use rather than for commercial purposes.

#### Malay harvesting of non-timber forest products

Malays harvest a wide variety of non-timber forest products in the Park's swamp forests, and in addition to honey, the most important are three species of rattan (cane): *duri antu* (*Calamus schistoacanthus*), *duri tapah* (*Calamus tapa*) and *duri pelanduk* (*Ceratolobus hallierianus*) (Peters, 1994c; Peters and Giesen, 2000). One person can harvest up to 150 canes on a good day, and from 3,000-5,000 per year, depending on market conditions and the flooding cycle. Locally, rattan is used for tying and bundling, and most importantly, for the construction of fish traps and barriers. Commercially, rattan is usually sold in bundles of 50 canes, sold for about US\$ 1.00 (1994 rate). Women and children are generally the most important rattan collectors in a community.

The Malays extract many other products from the swamp forests and lakes of the Park, including many fruit, vegetables, timber, herbal medicines and plant dyes (Table 1). Over the years the inhabitants of the lake area have discovered uses for such a variety of plants, that there are few species that are not found to be useful in one form or other. Giesen (1987) recorded that, for a total of 207 plant species, 81 percent were put to use by local communities, being either consumed directly as fruit or vegetable (30%), used for construction (27%), medicine (6%) or other household uses such as dyes, rope, weaving, household appliances, glues and insect repellent (18%). Plants used as firewood only totaled a mere three percent, and numerous plants have multiple uses. Malays hunt Sambar Deer *Cervus unicolor*, but are restricted by religious beliefs from hunting other wildlife.

**Table 1. Use of plants at DSNP**

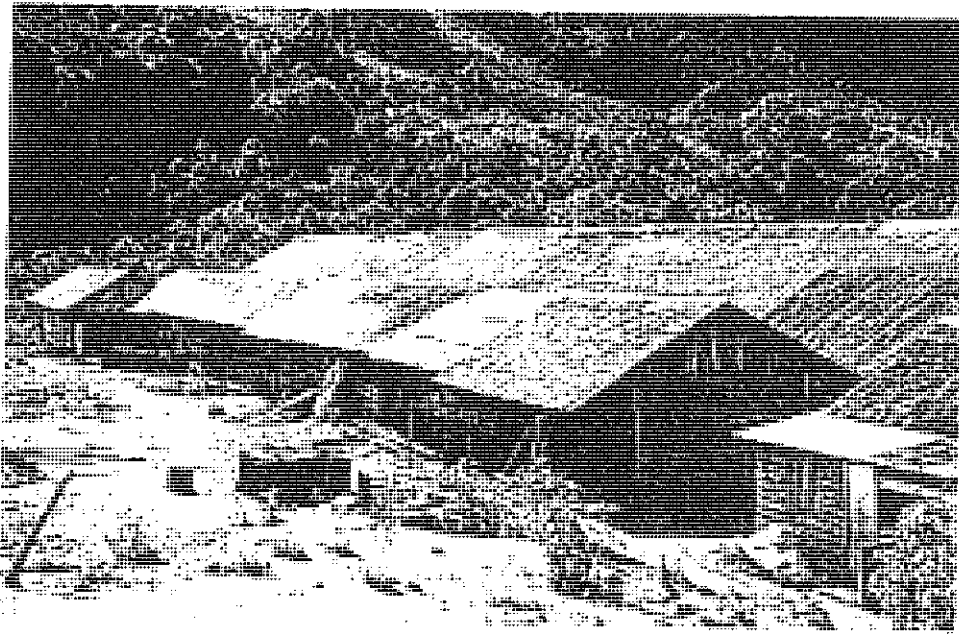
Type of use	Number of plant species (n=207)	Percentage*
Eaten by wildlife	106	51
Human consumption (fruit, vegetable)	62	30
Construction	56	27
Other (household use, glues, rope, weaving, dyes)	27	18
Medicine	13	6
Firewood only	6	3
No known use	27	13

Adapted from Giesen (1987), who listed 207 plant species in his inventory of DSNP.

\*More than 100% because one species may have more than one use.



Figure 6. Iban village near DSNP.



#### Dayak communities

Dayak inhabiting the DSNP area belong to three ethnic groups: Iban, Embaloh and Kantu'. The Embaloh and Kantu' inhabit the areas east and west of the lakes, respectively, and the Iban mainly occupy the area to the north and northeast. The flat area to the north and northeast of the lakes is called the Emperan, and the Iban in this area call themselves the Emperan Iban (Wadley, 2000b). Currently, there are about 1,200 Dayak in the area, inhabiting 5 of the 39 villages located in/adjacent DSNP (Colfer *et al.*, 2000). The majority of Dayak in the region live in the hills and higher ground that surrounds the Park, and their villages are located well outside DSNP. These people mainly depend on upland rice based on shifting cultivation, in combination with hunting and harvesting of forest products. Fruit trees are cultivated in and around the communities, and rubber plantations may also be established, often at some distance from the village. Forests within the utilization area of a given village may be veritable forest gardens, and following centuries of enrichment planting, certain patches of forest are particularly endowed with desirable species, such as *tengkawang*.<sup>2</sup> The Dayak agroforestry system practiced on the periphery of DSNP has resulted in a mosaic of habitats, consisting of shifting cultivation patches (often in various stages of regrowth) and patches of forest preserved for various purposes. The latter may be preserved for religious purposes, an abundance of honey trees, unfavorable soils conditions (e.g. many boulders), or an abundance of fruit trees (Wadley, 1999).

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<sup>2</sup>*Tengkawang* is a generic term for a number of mast fruiting species of dipterocarp that produce oil-containing nuts that are exploited, and used for instance as a cocoa butter substitute.

Dayak villages vary from small longhouses, housing up to 5-8 families, to large longhouses (15-30 families; Figure 6) and market towns such as Lanjak, where families have individual houses. Iban Dayak have been engaged in migrant labor for a long time (Wadley, 2000a), and many young men spend several years working in nearby Sarawak, usually in the logging industry or on plantations. When there are few opportunities for cash income at home, adult male absence due to labor migration may be 50 percent or more in most longhouses. Villages have become quite dependent on the supplementary income provided by this migrant labor, no so much for subsistence, as for schooling and consumer goods (Wadley, 2000a).

Dayak villages located within the Park are actively involved in fishing, although they are more oriented towards dryland activities such as shifting cultivation and hunting than their Malay neighbors (Colfer *et al.*, 2000). Iban Dayak hunt a variety of wildlife within and near the Park, including turtles and tortoises, Reticulated Python *Python reticulatus*, Bearded Pig *Sus barbatus*, Sambar Deer, Malayan Sun Bear *Helarctos malayanus*, Orangutan, and numerous bird species. Turtles and tortoises are generally hunted in the dry season, and a large proportion of the catch—an estimated 50 tons—is traded live in Sarawak (Walter, 1996; Walter, 2000). Crocodiles—especially *Crocodylus porosus*—were formerly hunted as well, but populations are now so low that they are rarely hunted nowadays. Nests of the Edible-nest Swiftlet *Collocalia fuciphaga* and Black-nest Swiftlet *Collocalia maxima* are harvested from a number of caves located in the sandstone ridges in the southeastern part of the Park. These are marketed in Chinese communities in West Kalimantan and in Sarawak.

**Table 2. Monetary benefits derived from extracted resources.**

Natural Resource	Rupiah	US \$
Lake and river fishing	2,905,800,000	1,285,752
Fish cages	1,800,000,000	796,460
Ornamental fish	505,000,000	223,451
Wood	356,085,000	157,560
Edible swiftlet nests	136,900,000	60,575
Turtles and tortoises	56,000,000	24,779
Rattan	54,800,000	24,248
Honey and beeswax	50,000,000	22,124 <sup>3</sup>
TOTAL	5,864,585,000	2,594,949

Adapted from Aglionby (1997)

### ECONOMIC BENEFITS DERIVED FROM DSNP

Many of the benefits derived from the DSNP cannot be directly expressed in monetary terms. The lake basin plays several very important functions, such as buffering Kapuas River waters (flood prevention, maintenance of river transport and water supplies), and providing a habitat for many species of fish, reptiles and other wildlife. The lakes of the Park have a strong effect on the flow of the Kapuas River. In the dry season, up to 50 percent of upper Kapuas River discharge may consist of lake water, while in the wet season, up to 25 percent of peak flow is absorbed by the lakes (Klepper, 1994). Also, most of the extracted resources are for local subsistence, and do not enter the

<sup>3</sup>In 1993 this was valued at US\$7000; since then, this has increased to US\$ 22,000, because of projects aimed at increasing added value.

market economy. Extracted resources that do enter the market economy were valued at about US\$ 2.6 million in 1996, while direct (unmarketed) domestic benefits were estimated to be about US\$ 16 million (Table 2, Aglionby, 1997).

### CHALLENGES TO MANAGEMENT OF NATURAL RESOURCES

Exploitation levels appear to have been sustainable until about 2-3 decades ago; since then, however, the resource base appears to have been steadily eroding, with fish catches declining and forest area dwindling (see also Wadley *et al.*, 2000). The main reasons for this are complex, involving an influx of immigrants, increased non-adherence to local customary law, population increase, increased access to external markets, and a steady development of adjacent areas (e.g. by large-scale logging enterprises and plantation enterprises). Interviews with the leaders of 30 villages indicate that 90-93 percent find that fish, honey and wood resources have declined over the past decades, while 80 percent find that rattan resources have declined (Aglionby, 1997). This is of course highly subjective, but the trends are supported by other data.

#### Fisheries resources

Because of the large year-to-year variation in fish catches, it is difficult to assess with certainty that the overall trend of the resource is one of decline. Official fisheries data are unreliable, and with numbers of fisher folk also increasing, subjective individual accounts are also not reliable. However, 17 commonly caught fish species are possibly over-fished, as is indicated by average size of specimens caught, compared to maximum size attainable for each species (Dudley, 2000). Certain species have certainly been over-fished, as they were formerly fairly common, but now have virtually disappeared, in spite of general environmental conditions in the Park remaining favorable. The latter include the Asian Arowana, and a number of cyprinids, such as the Sultan Fish, Freshwater Dorab (*belantau*, *Macrochirichthys macrochirus*), and *temunit Labeo chrysopekadion*.

#### Wood resources

Remote sensing data show that about 25 percent of the Park's swamp forests have been burnt over the past decades (Dennis *et al.*, 2000), of which about half had burnt since about 1990. DSNP has a long history of burning, dating back at least to the mid-19<sup>th</sup> century and possibly for more than 1,000 years (Dennis *et al.*, 2000), but remote sensing imagery indicates that burning is becoming more frequent and widespread, especially since 1990. Following burning, biodiversity is lost, as the regenerating forests are lower in stature and have a much lower species diversity than the original swamp forest (van Balen and Jensen, 1994; Giesen, 1996; Giesen, 2000).

Studies by Peters (1994b) on the *Fagraea fragrans* (*tembesu*) resources of DSNP indicate that wood resources are becoming depleted. Woodcutters complain that large *tembesu* trees are becoming more difficult to locate, and that they have to travel further and further into the forest to locate a merchantable stem. The number of people in the Park that own chainsaws appears to be decreasing. In Nanga Kenelang village, 20 persons had a chainsaw in 1983, and by 1993 this had declined to 11. Transects in the swamp forests show that 80 percent of desirable trees with >40cm dbh have already been cut, and those that remain are of poor quality (e.g. hollow stem). There is little sign of regeneration, and large trees (>60cm dbh) currently being sought are probably >200 years old, while a 40cm dbh tree may be 50-60 years old (Peters, 1994b).

### Other resources

Crocodiles were once abundant in the DSNP, as is graphically described by Beccari's (1904) account of his 1867 visit to the area, whereby he lost several of his travel companions. In the mid-1980s there were still some traders in crocodile skins located in the towns along the Kapuas River, and these received most of their stock from the lakes (Giesen, 1987; Frazier, 1994, 2000). By the early 1990s this trade had died out, partly due to the decline on the world market, but also due to dwindling numbers in the wild. A survey by Frazier in 1994 concluded that crocodile numbers are low, and conditions for crocodile population viability within and around the Park are sub-optimal. The latter is mainly due to the high degree of human disturbance and activity—threats to crocodile populations that have existed for some time (Frazier, 2000).

Colonial water birds were formally common in the Park, as is evident from local names for certain locations (e.g. birds-nest lake, bird-island lake, bird-breeding lake), accounts from old residents, and Beccari's (1904) account of large numbers of white water birds (probably egrets). Probably the clearest evidence comes from Enthoven's (1903) report of water bird colonies "with many nests in the tops of almost submerged trees and shrubs." He goes on to describe "if water levels are low when eggs are laid, the Batang Loepars <Iban Dayak> eagerly collect these eggs, which are considered a great delicacy and ideal for garnishing a dull platter of rice." Older residents report that formerly hundreds of birds used to converge in colonies but that egg collecting had decimated their numbers (Giesen, 1987). Nowadays, colonial water birds such as egrets, herons, night-herons and bitterns still occur in small numbers, but apart from Purple Heron *Ardea purpurea*, none breed in conspicuous colonies (van Balen and Dennis, 2000).

## CAUSES OF DWINDLING RESOURCES

### Population increase and poverty

The population of the DSNP area appears to have grown by almost 40% in the period 1985-1995 (Aglionby, 1995), which according to Wickham (1997) is increasingly forcing people to unsustainably and/or illegally harvest resources to meet their daily subsistence needs. Annually, there appears to be a bottleneck in the income of the Malay population in the Park area (Aglionby, 1995; Wickham, 1997), with a strong decline in income at the end of the fishing season (September-October). To counter this decline in income, additional sources of income are sought, such as timber and non-timber forest products. In years during which water levels do not drop considerably in the dry season, the fishing season is poor and this leads to a significant drop in fish-derived incomes. As a result, the impact on non-fish resources of the Park becomes more pronounced and may lead to conflicts between communities (Wickham, 1997). Low income levels prevent families planning resource utilization with a long-term outlook, and in DSNP the main staple—rice—has to be purchased with receipts from other resources. The average annual per capita income in the area is US\$ 265 (1996 figures), which covers basic subsistence requirements (US\$ 221), but leaves only US\$ 44 for all other needs (Aglionby, 1997). However, even this meager level of income appears to be maintained through unsustainable resource use.

### Undefined access rights

From 1982-1999, when DSNP's status was that of wildlife reserve, the people living in the area were deemed "illegal residents" according to national law. Most of the communities were totally unaware of this because they have had usufruct rights for hundreds of years, and had settled in the area long before it was gazetted. With the change in status in 1999 to that of National Park, this problem has disappeared, as a National Park may incorporate various forms of resource use and habitation. The local community believes they have full usufruct rights based on their historical rights, when the area was divided into different sultanates that included the current Park area, and more recently, when DSNP and the surrounding area was divided into utilization zones (Aglionby, 1997; Wickham, 1997). Each village has its own utilization zone (*wilayah kerja*), which is managed by a locally elected head fisherman with responsibility to enforce traditional law or *hukum adat* on resource harvesting. However, *hukum adat* is losing its power as communities are influenced from outside, and as government by state replaces that by elders (Aglionby, 1997). Access to the area is difficult to limit, as all waterways in Indonesia are open access, and people from outside may come on a seasonal or incidental basis. Because of traditional ties with the large towns along the Kapuas River, there is a seasonal influx of persons during the peak fishing season, leading to a temporary 20 percent increase in population. Complicating matters even further, local government officials have at times also declared the Park's fisheries resource an open access resource, available to all outsiders, despite local protests.

### More efficient harvesting techniques

Due to the introduction of modern technology, more efficient harvesting techniques have been introduced into the area. These include the introduction of mass-produced hooks (at the turn of the century), gill nets (late 1940s-1950s), rifles (1950s-1960s), engine-powered boats (1970s), finer fishing nets (1980s), chainsaws (1980s), and chemical fish poisons (1980s-1990s). Gill nets were introduced after the Second World War, and immediately lead to a great increase in fisheries production (Vaas, 1952). Currently, however, small-meshed gear is commonly used, and Dudley (2000) has assessed that about half the gill nets used have a mesh size of less than two inches. This undoubtedly leads to fish being caught at sub-optimal sizes. The fishing effort has also been increased by the introduction of outboard engines, which increases fishing efficiency and makes remote fishing areas more accessible. Currently, about half of all fishing families have (access to) a small outboard engine (Dudley, 2000). Chainsaws were first introduced in the 1970s, and became popular in the 1980s, when commercial logging enterprises were active in the area. By the late 1990s, however, the number of chainsaws appears to be decreasing, and halved again in some villages (Peters, 1994b).

Traditionally, Dayak in and around DSNP carry out stream fishing using a concoction based on the roots of the leguminous climber *Derris elliptica*, locally known as *tuba*. During the past few years, however, industrial chemicals (e.g. potassium cyanide) and pesticides (notably the insecticide Thiodan<sup>4</sup>) are also used on occasion because they are cheap and highly effective in stunning and killing fish. However, unlike *tuba*, which soon becomes less active, use of these chemicals has resulted in large, downstream fish kills. In August 1994, for example, fish were killed along a 30 km-long stretch of river in the

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<sup>4</sup>Thiodan is the brand name; the active ingredients are Dichlorvos and Bioallethrin.

central part of the Park, resulting in the demise of fish kept in floating cages, and representing a loss of about US\$ 150,000 to the fishing communities (Aglionby, 1997). The use of commercial poisons appears to be largely in the hands of Dayak merchants, who aim at large kills for the purpose of sale (Wadley, pers. comm.).

#### **Development and commercial forestry**

The Park is slowly losing the isolation that has long shielded it from some of the adverse aspects of development (Wadley, 1998). In the mid-1980s, slow passenger-*cum*-cargo boat plying along the Kapuas River, provided the only means of transport along the 200+ kilometer stretch from Sintang to the villages near the DSNP. At that time, a 30 kilometer-long dirt footpath provided the only access to Sarawak, taking the better part of a day to cover. Nowadays, a paved road leads almost the entire way to Semitau, some 30 kilometers from the Park's southern border, and several passenger speedboats pass by daily. Jalan Lintas Utara in the Badau and Lanjak area is largely paved, although not the section between the two, and a dry weather road provides access from Lanjak to Lubuk Antu, in Sarawak, reducing travel time in the dry season to just over an hour. Easier access means that markets are more easily reached. As a result, less produce is lost by spoiling of goods, and higher prices are fetched. Certain live fish products are now being shipped to distant markets, which was once viable for highly valuable species only. At the same time, market demand for certain products increase, and this may lead to an increased pressure on remaining resources.

Deforested slopes to the northeast of DSNP have been earmarked for replanting with oil palm, perhaps in combination with a resettlement scheme. On the one hand, reforestation of these grassy *Imperata* covered slopes is probably desirable in order to curb erosion. On the other hand, oil palm production notoriously goes hand in hand with a heavy use of pesticides (especially rodenticides) and fertilizers, thereby affecting water quality in local streams and lakes.

Commercial logging companies held concessions in the tall swamp forests on the periphery of the Park, and in the adjacent lowland forests. They have not operated on the steep slopes of the hills and ridges, nor have they been active in the swamp forests of the original 80,000-hectare reserve (Giesen, 1987; 1996). The latter has not been entirely out of respect for conservation ideals of the area, but because the original 80,000 hectare reserve holds little timber of commercial importance. At present, commercial logging activity near the Park is limited, as prime areas have already been selectively logged. However, small-scale logging carried out by locals who sell logs to these companies appears to be on the rise since 1997 (Wadley *et al.*, 2000). Logging companies are active along the Embaloh Leboyan River, and log rafts and barges are transported through the Park, as this is the only point of exit from this river. Logging companies create a demand for temporary unskilled labor, food supplies, and other products (e.g. rattan), but may disrupt local communities because of socially unacceptable behavior (alcohol abuse, prostitution). They affect the Park by their workers introducing and illegally using firearms, and because of the transport of log rafts, which causes physical damage of river-lining forests, and release of insecticides used to cure the logs. Locals with chainsaws also carry out commercial logging, but on a much smaller scale than the aforementioned companies. In 1995 there were 91 chainsaws in the DSNP (Aglionby, 1997), a number that was on the decline (Peters, 1994b).

### Fires

Apart from occasional lightning strikes, fires are generally caused by human intervention, and may be ignited for a variety of reasons. Some fires are accidental, for example, escaping from cooking fires of persons in the forests (e.g. hunters or honey collectors). Deliberate burning may be carried out to clear an area for shifting cultivation, or to make it easier to set up nets with which to catch fish. It has been suggested that burning is associated with catching Asian Arowana (Luttrell, 1994), as these nocturnal fish are reportedly attracted by lamps, which are better observed unimpeded by dense shrubs and trees. Currently, about one quarter of all swamp forests have been affected by fire, and the steady increase in incidence of fires suggest that it is associated with shifting cultivation and netting, rather than Arowana fishing, as the latter have become exceedingly rare and are seldom fished for nowadays.

### Lack of information

Many government officials and local communities do not realize that DSNP is a special place, a unique ecosystem with a unique biodiversity, and one that is officially protected by Indonesian law (Aglionby, 1997). Many are also not aware of fairly simple ecological processes, and government officials and fisheries biologists have at various times proposed damming off the Tawang River, which forms the main outlet of the DSNP lakes. The Department of Public Works proposes that a dam could enhance the natural buffering capacity of the lakes, as water could be released late in the dry season, providing freshwater for coastal towns. The costs would be immense, however, both in terms of financial investment and for the natural ecosystem, as prolonged flooding would lead to forest death, and a subsequent decline in fisheries. Also, transport through the area would no longer be possible, as the Tawang forms the main transport route for people and produce. Fisheries biologists have suggested that maintaining water levels (by means of a dam) would prevent the annual dramatic loss of fish numbers, and stabilize fish populations. What they fail to realize is that floodplain fisheries depend on the annual cycle of flood and declining water levels, and that tampering with this cycle usually leads to a severe decline in fisheries.

### MANAGEMENT APPROACHES

Management of DSNP's natural resources has largely been based on customary law *hukum adat*, which recognizes *wilayah kerja* (utilization areas), which are resource assess areas belonging to each village. *Hukum adat* is well developed for the most valuable or more threatened resources, such as fisheries, major wildlife, honey and edible bird's nests, but less well developed for other forest resources such as rattan and timber. According to Peters (1994a), this is an indication that these resources have only recently been subject to increased pressures.

After the Second World War the Fisheries Department established a large fisheries center in Selimbau, on the Kapuas River close to the Park. Officers from this center carried out regular fish sampling and maintained a record of fisheries data for a number of key fishing villages. Also, a fishing market was maintained, extension work was carried out, and fish stocking programs were launched. The latter were mainly based on exotics such as Nile Tilapia *Oreochromis niloticus* and Snake-skin Gouramy *Trichogaster pectoralis*, both of which fortunately did not thrive in the lake system. In addition, the Fisheries Department also provides licenses for *jermal* (funnel nets), as a

way to limit the number of *jermal*, while at the same time raise revenue for the department. On the whole, the Fisheries Department has little impact on fisheries management, and their operations in Selimbau appears to be drawing to a close, with buildings on the verge of collapse, and the market already closed down by 1985 (Giesen, 1987).

Officially, DSNP is managed by the Directorate General of Nature Protection and Conservation (*Ditjen Pelestarian Konservasi Alam* or PKA; formerly PHPA) of the Ministry of Forest and Estate Crops (MOFEC). PHPA are represented in the provinces by the Natural Resources Conservation Units (*Konservasi Sumber Daya Alam* or KSDA), and the *Sub-balai* KSDA of West Kalimantan resides under that of West Java. There was no active management or representation by PKA in Danau Sentarum until the UK-Indonesia Tropical Forest Management Project (UK-ITFMP), which ran from 1992-1997 and included a conservation project at Danau Sentarum. This project, commonly referred to as the DSNP Management Project, was implemented by the international NGO Asian Wetland Bureau (now Wetlands International).

Under UK-ITFMP, numerous baseline studies were carried out, along with attempts at establishing community-based management and introducing novel approaches to natural resource management. Park management infrastructure was developed by KSDA and UK-ITFMP, and a reserve management network has been in the area since 1992. UK-ITFMP aimed at (re-)establishing community-based management practices and was successful in some areas, such as reinforcing local customary law, strengthening legislation, and creating local appreciation of conservation values. By means of increasing local "value added," the program was also successful in generating additional local income without significantly increasing pressures on natural resources. Two notable examples are the promotion of the honey industry, which aimed at better quality bottled products, and the rattan industry, whereby the production of rattan products was promoted to replace the sale of raw rattan (Wickham, 1997; Mulder *et al.*, 2000). In spite of this, many challenges remain, including external threats (immigration, development), incorporating local customary laws into the Forestry Department's *modus operandi*, and establishing continuity in management approaches (see Wadley *et al.*, 2000).

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## UNDERSTANDING PATTERNS OF RESOURCE USE AND CONSUMPTION: A PRELUDE TO CO-MANAGEMENT

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For co-management of conservation areas to be effective, detailed information on local people's use of natural resources is essential. This chapter offers one method to obtain some of that information, a household recordkeeping study. It is simple to implement and analyze, and provides useful, quantitative data on resource use and income levels. Here we describe the method and present data derived from three such studies of Malay and Iban communities in and around the Danau Sentarum National Park in West Kalimantan, Indonesia. These data show the strong reliance of Malay and Iban peoples on fisheries and forests respectively, and suggest avenues for working with both groups to manage and conserve local resources. This is a companion article to one entitled, "Understanding Local People's Use of Time: A Pre-Condition for Good Co-Management" (published in *Environmental Conservation*) in which we suggest a time allocation method for use in community-based conservation work.

### **Introduction**

In recent years the importance of working with local people in protected areas has been increasingly recognized. There has been a continual stream of information showing how forest people participate in complex systems of resource management and use, often based on long experience with local conditions and involving extensive indigenous knowledge about local flora and fauna. That such ecological knowledge and local natural resources are often intimately intertwined with forest people's cultures and ways of life has also become clear.

However, success in the implementation of such desirable management cooperation has been limited (cf. Wells 1997; Western and Wright 1994), partly we would argue because outside managers often lack appropriate knowledge about local people and how they have traditionally used and managed resources. In order to manage a protected area in a manner that both protects that environment and either maintains or enhances the

quality of life of the people residing in and around it, managers need to know more about existing human impacts on and benefits from that environment. Knowledge of such human patterns can also help managers identify shared goals between local people and conservationists and provide insights on ways to tap into the real management potential that local people represent.

That management of protected areas requires biophysical expertise has long been acknowledged. However, with the recognition that local people must often be involved in formal management, the importance of expertise from the social sciences has increasingly been recognized. There are several kinds of social science expertise that are needed in the management of protected areas, including, for example,

- Anthropological description of the extant human uses of and benefits from the environment (as described in this chapter), as well as the values, norms and goals local people have
- Skills and knowledge of group dynamics for facilitating cooperative interaction and sharing of perspectives among local stakeholders
- Political knowledge to provide a “vertical” bridging function between local stakeholders and the wider governmental, industrial, and conservation worlds

These kinds of expertise have only recently begun to be available to managers of protected areas. Often responsibility for such ethnographic investigations, group dynamics, and political know-how fall to biophysical scientists who may be, quite understandably, poorly prepared to take on such additional (and perhaps unforeseen) responsibilities.

This chapter, based on the conclusion that management of protected areas will increasingly be conducted in a co-management, or partnership, mode, provides one simple recordkeeping method for learning about local people’s uses and benefits from natural resources. Because this volume is focused on the management of Danau Sentarum National Park (DSNP), there is more detail about that park than is necessary strictly to demonstrate how to use the method.

Based on experience with people living in other forested areas of Kalimantan and from Giesen’s (1986) study of DSNP, we identified a number of issues that seemed significant for improving management there:

- What are the people using from their environment?
- What quantities of important products are they harvesting?
- Who is managing and/or collecting these products?
- Who is profiting from them, and by how much?
- Where are they finding what products?
- What is the balance between subsistence and market uses?

Developing a management plan for DSNP that both protects the environment and maintains or enhances local people’s way of life requires knowledge of existing patterns of resource use and standard of living. Without such knowledge, park management could disadvantage local people, fail to mobilize potential positive contributions and, equally important, arouse unnecessary opposition to overall conservation goals.

Capturing the obvious human variation in the area—as the recordkeeping study does—was an important first step at DSNP. Some of the important local variation that emerged from the study, and is discussed below in more detail, includes:

- different resources provided the basis for different ethnic groups' livelihoods—e.g. Iban rice cultivation vs. Malay fishing;
- different seasons brought different products—e.g. for the Malay, honey in January, increased fishing in July and August;
- different resource use patterns characterized different communities—e.g. floating gardens in Bukit Rancong, none in nearby Ng. Kedebu'; and
- men and women dominated in different activities—e.g. for the Iban, male circular migration, female dominance in rice cultivation.

These kinds of variation are common among forest dwellers. Diversity in sources of income and subsistence represent an effective mechanism for dealing with the very real risks that characterize agricultural endeavours in tropical rain forest areas (Dove 1988; Colfer *et al.* 1997a; Wadley 1997a; Puri 1997). There is also commonly specialization or a kind of division of effort, among ethnic or user groups, such as the Malay concentration on wetlands and the Iban focus on uplands. In Long Segar, East Kalimantan, for instance, Colfer found the Kutai emphasizing commercial rattan collection, and the Kenyah avoiding it, with an explicit “division of labor” philosophy. In Sitiung, West Sumatra, the Minangkabau planted rubber and other tree crops which the Javanese eschewed, the Sundanese planted elaborate home gardens including fishponds, and the Javanese focused on rice, soybeans, and cassava production (Colfer *et al.* 1989:91). Each emphasized the link between their crops and their ethnicity. (This sort of specialization appears to have deep historical and prehistorical roots throughout Southeast Asia [see e.g. Higham 1989].)

Such ethnic specialization has important implications for natural resource management and for co-management in general. Although such diversity of use may appear to complicate the managers' tasks, taking it into consideration can contribute to more realistic planning, improved trust and cooperation from local people, nurturing of their initiative, and avoidance of unnecessary and counter-productive conflicts with them. Building on the opportunities, in terms of “social capital” or human resources, available from any community, requires quite specific information about their different forest use patterns (e.g., which plants are most important for which group of people? Where are those plants found? During which seasons are they abundant?).

The kind of data provided by the recordkeeping study must be augmented by cooperative input from biophysical scientists who must play a central role in understanding the conservation implications of these details of local forest use. Local names of flora and fauna must be converted to scientific names; ecological inter-dependencies must be interpreted in light of the impacts of local use on resource availability; the use of indigenous ecological knowledge requires communication and evaluation by those with related expertise (including zoologists, ecologists, fisheries biologists, and botanists).

Another, equally important, component of such co-management, not fully addressed here but mentioned above, is the process of working together with local people. Biophysical scientists and conservation area managers tend to be less accustomed to regular interaction with local people in a partnership mode than are anthropologists. Such interaction, however, is essential for effective co-management. Managing together requires regular communication, as well as an understanding of local values, norms and beliefs. The collection of data in the studies reported here and elsewhere (Colfer *et al.*



forthcoming) can serve as a mechanism for facilitating and ensuring regular interaction between formal conservation area managers and local people—a function of critical importance. (Jeanes [1997] provides a very thorough examination of factors affecting management at DSNP.)

### **Household Recordkeeping**

In this chapter, data from Malay and Iban communities serve as a means to explain a simple method, household recordkeeping, that can help managers to understand how local people use local resources. Such understanding is a necessary first step in using and building on indigenous management systems to fashion new approaches that incorporate conservation concerns in a more meaningful way.

The design of the recordkeeping study was based on a couple of months of data gathering by three of the authors at DSNP, and on Giesen's (1987) ecological monograph.

- the Malay were avid fisherfolk, suggesting a need to know which fish they caught, and which ones supplied them with the most income and food.
- the Iban collected a number of non-timber forest products, suggesting the need to know the repertoire of useful NTFPs in the area—in both flooded (primarily Malay) and hilly (primarily Iban) areas.
- Agriculture was obviously important for the Iban, but little was known beyond the simple observation that it was a swidden system. What were their crops and how dependent were they on agriculture for food and cash? What about agriculture among the Malay, whose agricultural activities would have a more direct effect on DSNP?
- Local interest in income generation seemed probable, but how dependent were these groups on cash income? Determining both what they were doing to make money, and just how poor they really were, had important management implications.
- Finally, documenting people's eating behavior would grant a better understanding of which plants and animals were really crucial to human well-being in the area, and which ones they might be persuaded to stop harvesting (all within the Wildlife Reserve; and endangered ones outside it).

More importantly, perhaps, the results could be used while the study was in progress, to plan additional activities and to keep the project “on track.” It also served the function of beginning to integrate project activities with those of the local people, and vice versa.

The search for this range of information was motivated by the conviction that understanding existing forest and other resource uses would enhance cooperation and effective collaborative management with local people. Such knowledge and cooperation would prove valuable in trying to change any harmful practices and in promoting traditional practices with conservative effects.

### **Study Sites**

Because this chapter appears with a great deal of other research on the area, Very little introductory information about locale, beyond the introduction of main study

villages,<sup>1</sup> is presented here. Ng. Kedebu' is a small Malay fishing community of 108 people (Colfer's *de jure* census, 1992) in the heart of the DSNP (see Figure 1). It claims an area of 70.54 km<sup>2</sup>, including a protected area (Hutan Nung) shared with other communities (Dennis *et al.* 1998). Its inhabitants are formally registered as residents of the larger community, Selimbau, on the Kapuas River, from which there is a yearly inundation of additional fishers during the dry season (raising the *de facto* population in October 1992, to 199). They are Muslims, sharing significant common cultural features with related peoples described by Firth (1966), Harrison (1970), Furukawa (1994), and Scott (1985). Based on time series, remote sensing data (1973, 1990 and 1994), Dennis *et al.* (1998) concluded that local management of forest resources appeared to be sustainable (minimal change in forest cover);<sup>2</sup> their fisheries management, less so (see Dudley, this volume).

Wong Garai is an Iban longhouse to the northeast of DSNP. Its inhabitants have resided in the area for over one hundred and fifty years. Within a traditionally-defined territory of around 24 km<sup>2</sup>, they practice a complex agroforestry system based on swidden rice cultivation, forest gardens, hunting, fishing, and wages earned on trips across the border to Malaysia (described in detail in Wadley 1997a, 1997b, n.d.a; Wadley *et al.* 1997, n.d.; Colfer *et al.* 1997a). Their belief system includes a mixture of Christianity and traditional ancestor worship (Wadley n.d.b), and they share many characteristics with other Iban and Ibanic groups (as described by Freeman 1970; Padoch 1982; Sutlive 1988; Dove 1981; Drake 1982).

Bemban, site of a partial study, is an Iban longhouse of 15 households, including 71 people (village records, 1992) on the western edge of DSNP. Its territory comprises 67.28 km<sup>2</sup> (Dennis *et al.* 1998), and is adjacent to the lakes, making the community's resource use somewhat more similar to the Malay patterns than are the other Iban communities. Half of the community is Protestant, half Catholic, all with a considerable animist admixture.

Comparable remote sensing data are unavailable for Wong Garai, but their system includes rotating of fields with long forest fallows (see Colfer *et al.* 1997a; Wadley n.d.a). Bemban has a similar system. The ecologist, Peters (1993) comments, "All factors considered, the [Bemban] system comes very close to the ideal of sustainable forest utilization." (p. 35). The remote sensing data from Bemban (Dennis *et al.* 1998) suggest more forest change there than in Wong Garai, but the shifting patterns of forest type over the years (1974, 1990, and 1994) suggest a normal long rotation forest fallow system, with probable sustainability under recent conditions.<sup>3</sup>

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<sup>1</sup>We use pseudonyms throughout this chapter in order to protect the privacy and trust of the people whose lives we studied.

<sup>2</sup>Dudley points out, as counter-evidence, the increasing scarcity of *tembesu'* (*Fragraea fragrans*), the most popular local building material, and the presence of many large stumps throughout the area (an undetermined number deriving from previous authorized, large scale logging in the area). He acknowledges that much of the forest remains, but questions why, feeling that low demand, lack of valuable timber, and regular flooding are more important factors than good management.

<sup>3</sup>There is some evidence that with the current Indonesian financial problems, these conditions may worsen. There is renewed interest in establishing a huge 47,000 ha oil

## Methods

This study was conducted in Ng. Kedebu' and Wong Garai, and briefly in Bemban. In Ng. Kedebu', 8 to 10 families (20% of households) kept records; in Bemban, eight families (67%); and in Wong Garai, the entire longhouse of 13 families (100%). Each recordkeeping component (Fishing, Agriculture/ Agroforests, Forest Products, Wage Labor, and Food Consumption) had its own forms in the appropriate language: Malay or Iban.

Families filled in forms in booklets with multiple sheets for each month of the studies. Literate members of participating families recorded what their members caught, found, produced, sold, and ate, as fully as possible. If possible, they also specified producer, harvester, owner, and seller. They kept records every day for one month every quarter<sup>4</sup> resulting in four months of data during 1992-93, from Ng. Kedebu' and Wong Garai, and one month (December 1992) from Bemban.

In Ng. Kedebu', Colfer began the study and later supervised a village assistant, Sahar, after he took a lead role in monitoring the recordkeeping. Colfer resided there from August—October 1992; in a distant DSNP community from November 1992—February 1993; and at the DSNP headquarters, a short canoe ride from Ng. Kedebu', from March—July 1993. An attempt was made to reflect the limited community diversity by selecting half the respondents from “upriver” newcomers and half from “downriver” oldtimers, and by including one woman-headed household and one riverboat dweller. There was a slight change in cooperators over the year.

In Wong Garai, recordkeeping forms were modified by using the Iban language and adding a form on rice cultivation for use during the February rice harvest (See Colfer *et al.* 1993b; also Wadley 1997a for a fuller analysis of rice). This form included information on land use and ownership, and agricultural production. The entire community participated, under Wadley's resident supervision.

Colfer started supervising the study in Bemban but due to constraints on her time and low levels of literacy in the community, only one month of data collection was possible. The Wong Garai Iban forms were also used in Wong Garai.

Significant problems with the method included: difficulties finding sufficiently literate family members, people's fears about the confidentiality and use of the results, and difficulty reading people's handwriting, which became particularly acute during data entry.<sup>5</sup> This could be overcome by more regular supervision, which would also increase interaction with community members. Another difficulty was the rather amazing number of ways people measured things. As will be clear from the tables A-C and I-K, this problem was never satisfactorily resolved. A related problem was translation and

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palm plantation to the north of DSNP, and a transmigration settlement is apparently proceeding to the northeast as well as smaller oil palm projects along the middle and lower Leboyan river (see Wadley 1998).

<sup>4</sup>We paid participating families a nominal Rp. 15,000 per month for this work; this was roughly US\$7.50 at the exchange rate of the time, US\$1 = Rp. 2,000.

<sup>5</sup>This handwriting problem was compounded by language barriers as those who entered the data were from Java and unfamiliar with Malay and Iban. This resulted in numerous errors which we could only correct by returning to the original forms.

comparison of different Iban and Malay resource categories, particularly regarding forest use (see discussion on Agriculture/Agroforests and Forest Products below).

## Results of Recordkeeping

### *Fishing*

#### **Fish and Fishing Gear**

Many types of fish were recorded by local people (Appendices A-C). But it is important to note that their list by no means includes all fish species in these waters (cf. Dudley, this volume; Widjanarti 1995, for biological studies of local fish), but rather indicates those fish that local people consider important in their daily lives. There are inevitably some inconsistencies in identification of fish by local people (as well as some difficulty in linking common names to scientific names). However, these data, imperfect as they are, indicate the variety of fish people recognize and use, as well as the relative abundance of useful species.

Because project activities emphasized work in the park's lakes area, work to match scientific with Malay fish names has proceeded further than with Iban fish names. (Appendices A-C). It is almost certain that many of the same species recorded in the Malay data set are also in the Iban data set, but this match to local names has not yet been made. Nevertheless, species habitat preferences result in real differences between the fish fauna in the two areas. The Iban fish names are included to show the depth of indigenous knowledge of fish among that group and the comparative abundance of species, leaving for future researchers the task of matching the local and scientific names.

Differences between Iban and Malay emphases on fishing are related to the very different environments they inhabit. On one hand, Malay live in the lakes area which has been an extremely rich fishery for much of the year, while the Wong Garai Iban live in the headwaters of a Leboyan tributary. The people of Wong Garai have complained of increased fishing by communities downriver from them which they believe have decreased local yields. These factors no doubt contribute to some of the differences between Ng. Kedebu' and Wong Garai.

The lists of fish caught also show the significant differences in *amount* of fish caught in the three communities. Analysis of fishing records was complicated significantly by the fact that some fish were recorded by "tail" (*ekor* in Malay, *iko* in Iban, which refers to counts of individual fish) and some were recorded by kilogram (Appendices A-C). Ng. Kedebu' average total catches reported in kg were more than seven times those recorded in Wong Garai, and more than twice Bemban catches. The dominance of Ng. Kedebu' in fisheries was even more pronounced in the comparisons by "tails."

Malay fisherfolk are much more likely than Iban swidden cultivators to be comfortable making estimates in kilograms, because many Malay commercial transactions require sale by kg. There is considerably greater fishing success among the people of Ng. Kedebu', where they of course also put considerably greater effort into such activities.

The three communities employed a variety of gear to catch fish (Table 1). These data are important because of the varying efficiency of different fishing gear and their consequent potential impact on fish stocks. Again, the frequencies show the different importance and methods of fishing among the Malay *vis-à-vis* the Iban. Although 60% of the cases of gear use among the Iban coincided with Malay gear, five of the twelve Iban

methods were not mentioned by the Malay. The Malay identify at least 45 fishing gear types (Dudley 1996b) but recorded only 13 gear types (ignoring the unknown methods recorded by both ethnic groups).

**Table 1. Frequencies of Fishing Gear/Methods Recorded in Ng. Kedebu', Wong Garai and Bemban, 1992-93.**

Gear/Methods	Ng. Kedebu'		Wong Garai		Bemban	
	Freq.	%	Freq.	%	Freq.	%
Gillnet	1612	61.3	56	9.5	3	5.1
Flat liftnet	444	16.9				
Castnet	267	10.2	33	5.6		
Small trap	81	3.1				
Multiple hooks/long lines	59	2.2				
Individual hooks	59	2.2	40	6.8	4	6.8
Large meshed gillnet	41	1.6				
Speargun/diving	18	0.7	125	21.3		
Tube trap	15	0.6				
Larger trap	9	0.3				
Longline	7	0.3				
By hand	1	< 0.1	7	1.2		
Fish trap			191	32.5	48	81.4
Wide mesh basket			110	18.7		
Poison			11	1.9		
Bush knife			9	1.5		
Unknown	16	0.6	6	1.0	4	6.8
<b>Total</b>	<b>2629</b>	<b>100.0</b>	<b>588</b>	<b>100.0</b>	<b>59</b>	<b>100.0</b>

The fishing implements used by the Wong Garai Iban reflect their reliance on fast-moving streams and small rivers. The small number recorded in Bemban is due in part to the fact that the recordkeeping study only encompassed the month of December.

Despite the Iban reputation for using poisons in fishing, these data (supplemented by Wadley's long term, day to day exposure to life in Wong Garai) suggest limited use of natural poisons in fishing by these communities. Where commercial interests come into play poison may be more likely to be used (see Aglionby 1995).

#### **Fish and Money**

Ng. Kedebu' is comparatively more dependent on income derived from fish than the Iban communities (Table 2).

**Table 2. Income from Most Valuable Fish Sold in Ng. Kedebu' and Bemban.**

Local Names	Latin Names [Probable]	Total Money (Rp) Received During 4 mo.	
		Ng. Kedebu'	Bemban
Bilis	<i>Clupeichthys bleekeri</i>	1,444,270	
<b>Lais</b> [various kind]			
• Lais		1,004,450	
• Lais butu	<i>Ompok hypophthalmus</i>	133,500	
• Lais p		2,500	
• Lais banga	<i>Kryptopterus micronema</i>	81,500	
• Lais jungang	<i>Kryptopterus apogon</i>	2,500	
<b>Total Lais</b>		<b>1,224,450</b>	
<b>Patik/Baung</b>			
• Patik	<i>Mystus nemurus</i>	860,395	
• Baung	<i>Mystus planiceps</i>	96,350	
<b>Total Patik/Baung</b>		<b>1,053,095</b>	
<b>Toman</b> [various kinds]	<i>Channa spp.</i>		
• Toman	<i>Channa micropeltes</i>	178,600	
• Delak	<i>Channa striata</i>	71,400	
• Piyang	<i>Channa maruloides</i>	500	
<b>Total Toman</b>		<b>250,500</b>	
Lelabi	Soft shelled turtles		176,400
Ulang uli	<i>Botia macracanthus</i>	176,225	
Umpan	<i>Puntioplites wandersii</i>	86,350	
<b>Other fish</b>		<b>531,245</b>	
<b>Total</b>		<b>4,766,135</b>	<b>176,400</b>

Note: No fish were sold from Wong Garai.

The variety of valuable fish and the amount of selling evident in Ng. Kedebu' is in obvious contrast to the pattern in Wong Garai (where no fish were sold) and Bemban, where only the very valuable soft-shelled aquatic turtle was exported for a very good price, across the Malaysian border. This fairly large amount of money (Rp. 176,400) was obtained by one man from the sale of one or two large turtles.<sup>6</sup>

<sup>6</sup>In late 1993, Wadley recorded from only one of many such transactions in Lanjak, a boat-load of 111 hard-shelled turtles (*buko'* or *biuku'*)—1,191 kg. total—and nine soft-shelled turtles (*lelabi*)—87.5 kg. total. They sold for Rp. 800 per kg. and Rp. 2,750 per kg. respectively. A Nanga Badau merchant bought them for further marketing into Sarawak, where turtles are reportedly sold as far away as Miri at very good profit (Wadley 1998). The Iban who had caught the turtles (and bought some from others) came from a longhouse on the eastern edge of the Reserve. So, like the Malay, Iban living within easy access of the Lakes also rely on them to make money.

Fish as a contribution to normal family incomes is only important in Ng. Kedebu', where fishing forms the economic base for all families. Table 3 shows the monthly incomes from fishing by study families in Ng. Kedebu'. The wild fluctuations are clear, as is the low overall average income from fishing (See Figures 5 and 6, for the place of fishing in overall income).

One important point concerning the Bemban data is that they come from December, a month of typically high water, when people normally do not fish much. Given their proximity to the Lakes, Bemban fishing and income derived from fishing are likely to increase in the dry months. This is in contrast to the upriver Wong Garai Iban, who fish for household consumption only—reflected in their absence in these data.

**Table 3. Average cash received from fishing by family and month in Ng. Kedebu' (1992-93).**

Family	Month				Family Average (Rp)
	September 1992	December 1992	March 1993	June 1993	
C	109,400	112,035	381,000	91,750	173,546
H	49,400	37,200	120,350	124,540	82,873
L	16,170	1,200	9,000	59,900	21,568
M	NA	82,000	305,900	186,050	191,317
J	NA	123,375	120,550	54,850	99,592
F	NA	0	45,350	0	15,117
N	14,150	5,475	31,500	NA	17,042
E	NA	NA	192,150	163,500	177,825
G	NA	NA	157,850	169,145	163,498
D	53,650	NA	NA	NA	53,650
O	0	NA	NA	NA	0
B	0	NA	NA	NA	0
Q	0	NA	NA	NA	0
I	NA	35,645	NA	NA	35,645
P	NA	NA	713,100	NA	713,100
K	NA	NA	NA	992,200	992,200
A	NA	NA	NA	207,750	207,750
<b>Month average</b>	30,346	49,616	207,675	204,969	173,219

NA refers to months when that family was not included in the study.

The average monthly income from fishing is about Rp. 175,000, reasonably substantial for rural forest dwellers in Kalimantan. The problem for local people arises from the rather extreme variations in income. DSNP fisherfolk live with a high degree of uncertainty. Sometimes they catch fish of high value or in large quantities, while at other times they catch or are able to sell nothing. In addition to the perversities (from the human perspective) of fish reproduction and movements, there are uncertainties related to transport. During the dry season, trade boats have difficulty getting to many

communities, thus sometimes interfering with the sale of fish when fish are most easily caught.

In Ng. Kedebu', the average cash received per trip is Rp. 1800. In Wong Garai, it is nothing, and in Bemban it is Rp. 3000 (statistically significant differences, using Kruskal-Wallis nonparametric test,  $\chi^2 = 49.09$  with 2 d.f. ( $P < 0.001$ ). This yields an overall average of Rp. 1,800/trip. The fisheries related income in Ng. Kedebu', the lack of fisheries-related income in Wong Garai, and the dramatic (but more occasional) fisheries-related income in Bemban reflect local patterns of resource use. Malay rely for a low, marginal income, on fisheries. Iban experience occasional, windfall profits from fisheries, but they do not rely on fish for primary subsistence needs (except as part of one's own diet, see last "Results" section; also Wadley 1997a).

Ng. Kedebu', as the only location with recurring income from fisheries, provides the only opportunity to examine income data, disaggregated by gender. There, males earn an average of Rp. 1,500/trip and females, Rp. 1,200/trip, with mixed outings yielding an average of Rp. 3,900/trip. The overall average income per trip is Rp. 1,800. The lower female earnings may relate to their tendency to "fish for supper." The higher earnings for mixed groups cannot be disaggregated from the fact that a mixed group is, by definition, more than one person, where a single sex trip is often a single fisher. The amount of cash received by mixed gender groups is significantly greater than that received by single sex outings, whether male or female (Kruskal-Wallis nonparametric test,  $\chi^2 = 100.2$  with 2 df,  $P < 0.00$ ).

#### Level of effort

One simple indicator of level of efforts is the number of fishing trips undertaken. Tables 4 and 5 show these, disaggregated by gender, for Ng. Kedebu' and Wong Garai, respectively.

**Table 4. Number of Trips by Gender and Month—Ng. Kedebu' (1992-93).**

Gender	Month							
	September 1992		December 1992		March 1993		June 1993	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Male	156	63.1 %	377	70.3 %	710	72.5 %	649	76.1 %
Female	49	19.4 %	89	16.6 %	231	23.6 %	0	0 %
Mixed	44	17.5 %	70	13.1 %	38	3.9 %	204	23.9 %

$\chi^2 = 333.2$  with 6 df,  $P < 001$ .

**Table 5. Number of Trips by Gender and Month—Wong Garai (1992-93).**

Gender	Month							
	December 1992		March 1993		June 1993		September 1993	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Male	81	76.4 %	135	75.0 %	151	100.0 %	151	100.0 %
Female	25	23.6 %	45	25.0 %	0	0 %	0	0 %

$\chi^2 = 84.0$  with 3 df,  $P < 0.001$ .



In both Iban and Malay data sets, there is no statistically significant difference in length of trips by men and women, but among the Malay trips involving males and females together were significantly longer than single-sex ones.

Bemban is excluded from this comparison because the sample was too small. For the Malay, the predominance of mixed gender trips in June, a comparatively busy fishing season, is striking when contrasted with the other months, in which single-sex outings are more common. An increase in fishing by both genders during the dry season (typically June-August) was also demonstrated in a time allocation study conducted in Ng. Kedebu' (Colfer *et al.* forthcoming).

Among the Iban, the greater involvement of men in fishing contrasts with the greater involvement of women in subsistence agriculture (see Wadley 1997a). On the one hand, men fish more in the months when they must get fresh food to feed guests during post-harvest rituals (June) and after rice planting, their peak agricultural labor (September). Women, on the other hand, who are overwhelmingly more involved in rice cultivation, thus have less time for fishing. The months where there is no recorded female fishing reflect periods when women are busy preparing and attending post-harvest rituals (June) as well as weeding hill swiddens and planting swamp swiddens (September).

The much higher number of trips among the Malay also provides further confirmation that fishing is a major economic activity among these people. The larger number of trips undertaken in Ng. Kedebu' *vis-a-vis* Wong Garai is statistically significant ( $\chi^2 = 55.69$  with 2 d.f.,  $P < 0.001$ ).

The amount of time consumed in fishing differed significantly by community as well. In Ng. Kedebu' the mean number of hours per trip was 4.88; in Wong Garai, 1.64, and in Bemban, 1.51. Fishing trips made in Ng. Kedebu' are significantly longer than trips in the other two locations (Kruskall-Wallis nonparametric test,  $\chi^2 = 803.43$  with 2 d.f. ( $P < 0.001$ )).

A number of other researchers have noted the active involvement of women in Indonesia's inland fisheries (e.g., Upton and Susilowanti 1992; Polnac and Malvestuto 1992; Malvestuto 1989; C. Bailey *et al.* 1990; Colfer *et al.* forthcoming). These data confirm such involvement, though to a statistically significant lesser degree than male involvement (Tables 4 and 5).

Malay spend more time fishing, and they have access to much denser (seasonal) populations of fish. In all probability, Bemban patterns, were data available, would more closely parallel the Malay during the dry months.

### Fisheries and Management Issues

- Which fish are most commonly caught? Does this reflect abundance in the Reserve? What sorts of management considerations are needed to safeguard these fish, from both biodiversity and production points of view?
- How much fish do the various communities actually catch?
- What are the management implications of these kinds and amounts of gear? Are they likely to result in serious resource degradation? What regulatory regimes would best safeguard the fish while maintaining the people's livelihoods?

- Which fish are most important economically? Are these fish abundant in the area? How can we make sure they remain abundant? If they are abundant, how can we enhance the profitability of their use to local people?
- How do people's incomes vary over the course of the year? What is their standard of living, as measured by incomes? What management actions are feasible, given this level of income for local people?
- How do the different communities differ in their incomes from fishing? What sorts of management differentiation will these differences imply?
- Who fishes and who receives the cash from fishing? How do we ensure that those who benefit now from fishing do not lose out under new management regulations?
- How does the distribution of fishing effort by gender and ethnicity differ over the course of the year?
- How much time do people spend fishing? How does this differ among the different communities?

### **Agriculture/Agroforestry**

Almost as obvious as the Malay dependence on fisheries is the Iban dependence on agriculture. Their economic base is rice cultivation (*cf.* Wadley 1997a; Colfer *et al.* 1993b). Although Iban cultural, economic, and ritual dependence on rice is essential to understand, it is not a monocrop system. Instead rice cultivation is part of a larger agroforestry system. Rice fields themselves are really multicrop gardens with rice as the principal crop.

During data collection, an attempt was made to provide comparable categories for Malay and Iban. In doing so, Iban field, garden, and managed forest categories were collapsed into a broader category of "things that are tended or cultivated" (*utai ke dipara*). Thus in these data there are a number of products that might best be placed in the forest products section, and indeed there is considerable overlap with that section (see below). This shows that a neat division of cultivation and forest is a rather foreign concept to Iban, and results in the cumbersome category of "agriculture/agroforestry" used here.

### **Crops Harvested**

Comparing Iban rice fields and gardens to Malay gardens in the field, the greater diversity of crops is obvious at Wong Garai. In this data set, Wong Garai collaborators recorded 21 items, and Ng. Kedebu', 17 (Appendices D and E). Add to this, products from Iban agroforests (including the animals captured in agroforests and uncultivated plants collected), and Iban "crop" diversity is far higher.

For the Malay data, the Latin names were not determined on the basis of identified samples but rather on the basis of the best estimates of botanically trained fieldworkers in the Reserve. For the Wong Garai data, the Latin names were determined from the extensive ethnobotanical work of Hanne Christensen (n.d.b) at a closely related longhouse just across the border in Sarawak. The animals captured were identified by Wadley in the field.

In Bemban, in December, people reported a preponderance of corn, cucumbers and cassava. These are crops normally available at that time of the agricultural cycle.

### Crop Locations

The diversity of crop locations is among the Iban is in striking contrast to the Malay agricultural system. In Ng. Kedebu' only one source was listed, the *tayak*, or small fields located directly behind the village. Colfer measured a sample of nine (of 45) fields, and they ranged in size from 24 m<sup>2</sup> to 297 m<sup>2</sup>, with the mean being 117 m<sup>2</sup>. These fields were flooded most of the year, and the ability to bring a crop to fruition was greatly influenced by the timing of the annual flood. Table 6 shows the Wong Garai locations from which people harvested crops or collected/captured agroforest products. The much more complex agroforestry system of the Iban is reflected in the variety of locations listed below.

**Table 6. Sources of Agricultural/Agroforest Products, Wong Garai, 1992-93.**

English Names	Iban Names	Frequency	Percentage
Homegarden	Kebun/Redas	142	33.6
Forest reserve	Pulau	95	22.5
Old longhouse site	Tembawai	74	17.5
Floodplain	Emperan	63	14.9
Hill rice field	Umai bukit	21	5.0
Newly fallowed field	Temuda	11	2.6
Longhouse yard	Laman	7	1.7
Forest cemetery	Pendam	4	0.9
Fallow forest	Damun	3	0.7
Rubber grove	Kebun getah	1	0.2
Swamp rice field	Umai paya'	1	0.2

### Harvesting, Ownership and Gender

Besides crops and locations, the division of labor by sex in these two communities had potential management implications. Participating households recorded who harvested the crops recorded, shown in Table 7. The predominance of women harvesters is evident in both communities, though much more dramatically so in Ng. Kedebu'.

**Table 7. Gender of Harvester in Ng. Kedebu', Wong Garai and Bemban, 1992-1993.**

Gender	Villages						Total
	Ng. Kedebu'		Wong Garai		Bemban		
	Freq	N	Freq	N	Freq	N	
Male	42	18.0 %	159	37.7 %	7	7.4 %	208
Female	190	81.6 %	230	54.5 %	35	37.2 %	455
Mixed	0	0	23	5.5 %	51	54.3 %	74
Unspecified	1	0.4 %	10	2.4 %	1	1.1%	12
<b>Total</b>	233	100 %	422	100 %	94	100 %	749

$\chi^2 = 281.9$  with 4 d.f ( $P < 0.001$ ), there is a different gender pattern among three villages. In this table 12 observations are missing.

There is a significantly different gender pattern among the three villages. In Ng. Kedebu', women are very dominant, probably because of their emphasis on *tayak* cultivation. In contrast, among the Iban, men's and women's contributions are more evenly spread although women still dominate. Men's involvement in agroforest management is relevant here.

Given the importance of tenure considerations to sustainable forest management (e.g., Prabhu *et al.* 1996; Colfer *et al.* 1997b), recorders were asked to indicate who owned the land from which the crops were harvested.

**Table 8. Gender of Land Owners from Which Crops were Harvested, Ng. Kedebu' and Wong Garai, 1992-93.**

Gender	Ng. Kedebu'		Wong Garai	
	(N)	(%)	(N)	(%)
Female	230	98.7	28	6.6
Male	1	0.4	118	28
Mixed gender	2	0.9	182	43.1
Unspecified	0	0	94	22.3
<b>Totals</b>	<b>233</b>	<b>100</b>	<b>422</b>	<b>100</b>

In Ng. Kedebu', women were the primary land owners (though the land owned covers a remarkably small area),<sup>7</sup> (Table 8). In Wong Garai, the pattern shifts, from one slightly dominated by women to one where mixed gender ownership is predominant, with males having a significantly greater part in land ownership than women. The "unspecified" category is also likely to be mixed gender; it refers to "same household" and "kin in another household."

This pattern at Wong Garai is probably a product of the prevailing patrilocal residence, whereby a woman goes to live with her husband's family upon marriage. Consequently, men are more likely to be regarded as the formal heads of households and thus more likely to be listed as land owners. However, this oversimplifies the matter because among the Iban, households own land, not individuals (Wadley 1997a, 1997b).

Furthermore, in many areas of Borneo, crops can be owned on land belonging to someone else. Participants in the study therefore also indicated who owned the crops that were harvested (a separate issue from land ownership, in many cases). In Ng. Kedebu', the land owner and the crop owner were in all cases identical, i.e., women own the plants as well as the land.

This was not the case in Wong Garai where the largest category of plant ownership (almost 40%) came from land belonging to the unspecified category (i.e., "same household" or "kin in another household"). Women were the second largest category of plant owner (29%). Men were the least likely to own the plants (13%), in contrast to their more meaningful position in land ownership (28%). This represents evidence for local acceptance of the idea that allocating one's labor confers rights (sometimes called "sweat equity")—a commonly stated view in Borneo and other areas of Indonesia.

<sup>7</sup>Dennis *et al.* (1998) found a total of only 31 ha of cleared forest in their total territory of 7,054 ha, based on 1994 remote sensing data. The cultivated area behind the village was not more than 5 ha in 1992.

Again, however, for the Iban this conflates notions of ownership. Women are listed as “owners” for two reasons: (1) They were more likely to have planted the items in question, and (2) with high rates of male absence due to labor migration, women might have been listed as owning something because they were the effective household heads. The predominance of mixed gender (including “unspecified”) shows that gender is not a particularly important ownership issue in Iban households.

This pattern with women or mixed categories dominating suggests that efforts by conservation area managers to intensify agriculture, improve fallow management, or develop income generation projects related to agroforestry would do well to include local women. In the DSNP context, approaching formal male leaders is an important prelude to cooperation with communities. However, once such cooperation has been secured, planning, implementation and evaluation will need to involve women as well (cf. Colfer *et al.* 1997c). The complete dominance of women in Ng. Kedebu' agriculture makes it particularly important there. The wider distribution of responsibilities among the Iban suggests that both need to be involved, although women do dominate in rice cultivation (cf. Wadley 1997a).

#### **Agriculture/Agroforestry and Management Issues**

- What agroforestry products do the people in these communities grow and collect? In what quantities?
- Where do local people gather and grow these products? What management strategies might be useful in intensifying existing land uses, such as through fallow improvement in order to minimize expansion of agricultural areas?
- Who grows and collects these products? Who would be appropriate partners in efforts to improve or experiment with new management techniques?
- Whose permission will be needed to experiment with new management techniques on village lands?

#### **Forest Products**

The forest product portion of the recordkeeping study prompts some conclusions about people's dependence on the forest, forest culture interaction, and indigenous knowledge—all issues of relevance for sustainability (Colfer 1995).

Four issues emerge as important from this portion of the study:

1. The repertoire of items that were collected by people in the three communities. This indicates existing patterns of use, probable areas of indigenous knowledge, and hints about potential for expansion or need for reduction in harvesting.
2. The uses to which those items were put. If a large number of items was necessary for subsistence (food, fuel, building materials, etc.), this would suggest a strong dependence of local people on the forest. It could also, less directly, reflect indigenous knowledge of forest products usage, including possibly environmentally benign areas for income generation.

3. The locations from which the items were collected. The number of locations mentioned can provide an indication of the people's indigenous geographical knowledge—and provide useful hints to their use of space within the park.
4. The income derived from these products. This would reflect people's dependence on forests for cash, either as part of subsistence or as supplementary income.

### Repertoire of Forest Products

A variety of forest products are collected throughout the year in each of the three communities (Appendices F-H). The Wong Garai data set (Appendix G) is much more extensive than either of the other two, reflecting greater Iban forest use than Malay forest use; and also the longer research period, *vis-à-vis* Bemban (Appendix H). Again, as with the data on agriculture/agroforests, there is some overlap here with “cultivated” categories.

Although the Bemban data set is not comparable (because of the reduced period of time for which records were kept), the Bemban Iban represent an intermediate category. This is not surprising but nonetheless interesting because their community is located much closer to the Lakes than Wong Garai. One might therefore expect Bemban forest use to take an intermediate position between the Wong Garai forest use patterns and those of Ng. Kedebu'.

The data reveal a rather sharp (and not surprising) division between the pattern of forest use of the Malay, on the one hand, and the Iban, on the other. The 207 forest products recorded by the Malay were exclusively wood and rattan (with one exception). The Iban of Wong Garai, in sharp contrast, recorded primarily foods (556 items), with a few other forest products (60).

Our attempts to determine amounts of forest products collected have been somewhat confusing primarily because of the different “counters” (or units) used for different kinds of item (appendices I-K). The Malay recorded the fewest ways of measuring quantities of forest products (Appendix I), with three (sticks, canoesful, and sheets) standards.

A greater number of measurements for forest produce (eight) were used, as well as a greater variety of products collected from the forests of Wong Garai. The terms used to count items collected are stick (*batang*), seed (*igi'*), bundle (*tungkus*), tail (*iko'*), backpack (*ladong*), sheet (*keping*), basket (*raga'*), and stem (*tangkai*) (Appendix J).

The products, the amounts regularly used in all three communities, and the effort required (measured as number of trips) to search for them, varies between the communities.

### Uses of Forest Products

The uses for these forest products were also recorded. In Ng. Kedebu' people use forest products in three primary ways—as firewood (24.5%), for smoking fish (33.2%), and for sale (27.4%). In Bemban they use forest products for making mats (35.0%), boat construction (22.5%), and food (15.0%). In Wong Garai people use forest products for eating (92.3%) and cooking (5.9%). The Malay use forest products commercially although also for subsistence purposes.

Among the Iban, forest products are primarily foods or items used in subsistence. This reflects the Iban tendency to take for granted the many forest products that they use daily. Colfer had difficulty obtaining comparable information on non-food uses of forest

products from a similar group (the Uma' Jalan Kenyah of East Kalimantan). This was simply because the local people could not conceive of someone a) not knowing about these products and their uses already, or b) having any particular interest in something so common. The items, not typically in short supply, were used daily by the people themselves (see Colfer *et al.* 1997a).<sup>8</sup>

Certainly Iban dependence on forest fibres, firewood, and timber is more obvious when one is confronted with their lifestyle (housing, cooking and agricultural implements, binding materials, weaving materials for mats and containers of various kinds, furniture, boats, etc.) than is evident from these data. Their extensive ecological knowledge and lexicon for forest resources further support this view (e.g. Colfer *et al.* 1997b; Wadley n.d.a; Christensen n.d.a; Pearce *et al.* 1987).

The Bemban data, though minimal, again reflect an intermediate position between Ng. Kedebu' and Wong Garai, in the comparative dominance of wood products collected. Besides firewood, foods, and construction materials, the people of Bemban collect forest products for ceremonies. Again, in all three villages, the subsistence uses (or commercial uses which are then immediately converted to subsistence uses) of—and thus dependence on—the forest are clear.

#### **Locations from Which Forest Products were Collected**

The final analysis on this data sub-set revolves around the areas in which people collect forest products (appendices L-N). The fact that Bemban's data set is smaller than the others derives from the fact that data were only collected for one month there. However, as with the other results, Bemban seems to represent an intermediate situation between Ng. Kedebu' and Wong Garai.

The Wong Garai data sets includes a large number of items in a small number of locations; whereas the Ng. Kedebu' dataset includes a smaller number of items in a larger number of named locations. There are several possible interpretations to this observation. First, the terrestrial homeland of the Wong Garai Iban (lowland Dipterocarp forests) is richer in terms of the repertoire of forest products than the flooded forest areas which the Malay inhabit.<sup>9</sup> The Malay may require a more refined geographical knowledge base—Where do we find the few products available, during what periods of the year?—compared to the greater botanical and zoological knowledge base required in the Iban context—Which of the many products are useful/edible?

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<sup>8</sup>One other factor here may involve the method and its implementation at Wong Garai. Most data recorders were schoolchildren of various ages (none younger than 10 years), and they were less likely to be involved in collection of non-edible forest products. In addition and given their diligence at recording meals, they may have placed an over-emphasis on food items compared to the other entries. On several occasions Wadley had to ask them why they had not recorded certain things (e.g. lengths of bamboo for cooking) when it was obvious that members of their households had collected them.

<sup>9</sup>Numerous researchers have commented on the relative poverty of these flooded forests in terms of flora and fauna (Giesen 1987, 1996). In his surveys in upland and lowland areas of this area, Peters (1993:7) found 133 species in the upland areas compared to only 44 species in the lowlands. Its "claim to fame" is uniqueness rather than abundance or diversity.

The most probable interpretation, however, is related to the codes used: Malay codes represent specific named locations while Iban codes refer to categories of places, which have many specific names. For example, within Wong Garai territory, there are 26 (named) old longhouse sites and over 46 (named) forest or tree reserves (including sacred sites) (see Colfer *et al.* 1997b).

This difference is probably researcher-derived. In trying to produce comparable categories in the data collection, the Malay category of forest (*hutan*) encompasses a range of Iban forest types (managed forest, preserved forest, and fallow forest), each of which has its own set of sub-categories. In asking the Iban to record forest products, this range of location types had to be identified on the forms in order for all types to be included. Another result of this effort was the considerable overlap in items between agriculture/agroforests and forest data sets (see above).

### Income from Forest Products

One important issue conservation managers must understand in local contexts is the degree of market dependence among local people. Table 9 provides a clear indicator of the relative market involvement of the Malay and the Iban. Interestingly, the Malay often sell forest products in small amounts *vis-a-vis* the Iban who rarely sell forest products, but receive much larger amounts of money for them.

**Table 9. Totals and Mean Money Received from Forest Products, Ng. Kedebu' and Wong Garai, 1992-93.**

Villages	Total Rp. Received (Rp)	N	Mean Rp Received
Ng. Kedebu'	699,244	82	8,527
Wong Garai	330,950	17	19,500

(Here we have combined data from "forest" and "agroforest" sections.)

The sample families in Ng. Kedebu', taken together, earned Rp. 699,244 from the sale of forest products during the four recordkeeping months. This results in an average monthly income per family of Rp. 19,513 (Figure 5). Extrapolating from these data, one gets over Rp. 2,000,000 for a whole year for those families, or an estimated Rp. 10,500,000 village annual income from forest products.<sup>10</sup>

The Iban in Wong Garai, by contrast, recorded a total income from forest products of Rp. 330,950 (representing only 17 records of forest product sales, from seven households). Bemban families recorded no income from forest products, during the month they kept records. Both Iban and Malay are dependent on forest products for their livelihoods, but in very different ways.

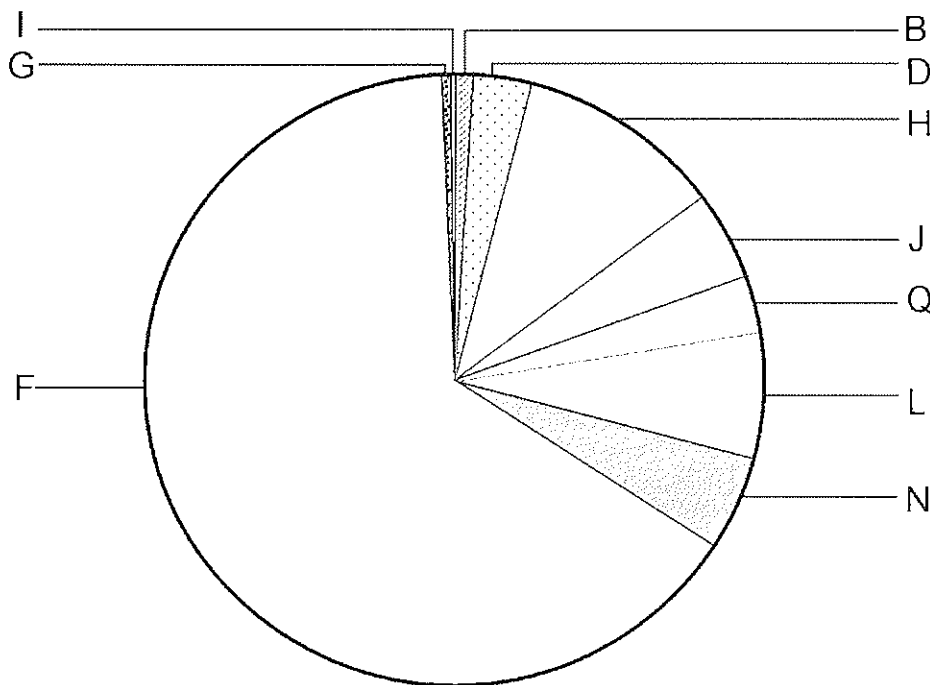
Looking more closely at the Ng. Kedebu' data set, where money is a more pervasive element in people's lives, there is an interesting pattern, with one family having a much

<sup>10</sup>These estimates were computed by multiplying the per family income by three (to reflect the unrecorded remainder of the year) and then multiplied again based on the proportion of the community's households included in the studies. The figures, of course, must be taken with a grain of salt, since many local products are truly seasonal, i.e., only available during a short period—so even though we tried to reflect seasonal variation, by scheduling our recordkeeping every three months, in tropical rain forests this kind of estimate is less reliable than it would be in many contexts.



larger income than the others (Figure 2). Colfer also found this pattern in a similar study of Kenyah income patterns in Tanah Merah and Long Segar, East Kalimantan (Colfer *et al.* 1997a).

A slightly different pattern exists in Wong Garai, where seven of the thirteen families sold forest products and with one household making Rp. 92,950 from one sale of illipe nuts and another, Rp. 130,000 from three such sales.



**Figure 2: Division of village income from forest products by family, Ng. Kedebu' (1992-93).**

There is a significant gender difference in the amount of income received for forest products in Ng. Kedebu' (Using Kruskal-Wallis nonparametric test,  $\chi^2 = 7.41$  with 2 d.f ( $P < 0.025$ ). There, men received an average of Rp. 8,100, while women only received an average of Rp. 3,600, with mixed gender outings averaging less than Rp. 1,000. The overall average income from these products was Rp. 6,300.

From the 17 records in Wong Garai, Iban women generate more cash from forest products than men. From only six records of selling illipe nuts, women earned Rp. 265,450—80% of the total earned and Rp. 44,000 for the average transaction. In contrast, men earned only Rp. 65,500 from the sale of rubber and palm wine; this was from 11 records of two households (only 20% of the total and only Rp. 5,900 for the average transaction).

### Forest Products and Management Issues

- What products do the local forests provide for local people? How intense is this use? How might forest management be improved to protect biodiversity while accommodating local people's needs?
- What quantities of which forest products are being harvested? Is this putting a strain on biodiversity or on the resources? How might these products be better managed, or protected?
- Where are local people finding the forest products they use? Are there areas that are over-harvested? Are there special niches for particular forest products?
- How important are forest products to the people's livelihoods and to their cash incomes? What effect would reduction in access bring? Could we increase revenues through processing or improved marketing of the same amount of produce?
- Who gains the income from sale of forest products? How much income do forest products provide to men and women?

### Wage Labor

Despite this source of income, people in all three communities are poor. The Malay are dependent on cash (from fishing, fish processing, and forest product collection) to buy their rice and other non-fish foods; and they are dependent on the forest to supply many of their daily subsistence needs (boats, houses, construction materials, etc.).

The Iban use less cash in daily life, though they may have access to more wealth than the Malay through remittances and goods brought back by the circular migrant men. Almost all of their food comes from the surrounding agroforests.

Conservation area managers have often devoted considerable effort to increasing incomes in conservation areas, as a means to enhance protection of local resources. Indeed, CIFOR has devoted one of its ten projects to trying to assess the truth of this widely held belief, in East Kalimantan. This issue was considered important enough to include in the recordkeeping study.

The jobs performed in Ng. Kedebu' included private chainsaw operator, carpenter, and fish processing (Table 10). One man served as a guide for the timber company (P.T. Mekanik) in transporting logs through the Reserve, another hired out himself and his canoe.

Wong Garai recordkeeping included very little wage labor. Of the three individuals recording any income from wage labor in Ng. Kedebu', two were outsiders who had come for the busy fishing season. All the recorded wage was from the months of September and October. The overall income recorded totaled Rp. 100,500. If extrapolated to the entire community of about 50 households, this would yield an annual village income from wage labor of roughly Rp. 1,500,000.

Five Ng. Kedebu' families reported earnings from fish processing (either sale of smoked, dried, or salted fish). The important fish are listed in Table 11, along with related income. The total fish processing income for the year for these five families was Rp. 315,050, which converts to an annual village income from this source of over Rp.

4,700,000<sup>11</sup>—considerably more important than wage labor, *per se*, which provided only Rp. 100,500 to four individuals.

**Table 10. Kinds of work performed in Ng. Kedebu and Wong Garai, 1992-1993.**

Work	Ng. Kedebu'		Wong Garai	
	Frequency	Percentage	Frequency	Percentage
Sale of dried fish	29	56.9	0	0
Carpenter	13	25.5	0	0
Sale of smoked fish	5	9.8	0	0
Operate boat (logging company)	2	3.9	0	0
Chainsaw operator	1	2.0	0	0
Escort/guide	1	2.0	1	12.5
Carry things	0	0	6	75.0
Logging fee	0	0	1	12.5

**Table 11. Average kilograms, prices, and income from fish sale by month, Ng. Kedebu' (1992-93).<sup>a</sup>**

Fish	September 1992			December 1992			March 1993		
	Kg.	Price	Income	Kg.	Price	Income	Kg.	Price	Income
Bilis	0	0	0	4.78	1362	6624	21.67	1267	26367
Lais	1.43	3625	6013	0	0	0	3.00	5167	15167
Landin	15.25	1000	15250	0	0	0	0	0	0
Patik	0	0	0	0	0	0	17	650	11050

<sup>a</sup>No fish sale from June 1993

No families recorded wage labor or fish processing income from Bemban. Although there is unquestionably income coming into this village from wage labor performed elsewhere, apparently none of the circular migrants returned during the period of recordkeeping. At Wong Garai, there were eight cases of locally-generated wage labor income—six cases of carrying lumber or other things, one case of escorting outsiders, and one of a village official receiving a fee of Rp. 36,000 from a local logging company (Table 10). The total income amounts to only Rp. 67,150 or Rp. 5,165 if averaged across households. Of the eight cases, three involved women while the majority (six) involved teenagers working for money primarily to pay for school supplies, though such money was also subject to use for other household expenses. Given the small amount of cash Iban appear to use for daily subsistence, the money earned here stands out as important.

<sup>11</sup>We get village total income during the periods of study by multiplying the total income that we got from survey by 5, to represent the sample of 20% of the community extrapolated to the whole community. Then we get the annual village income by multiply the village total income during the periods of study by 3 to represent the rest of the months that we extrapolated.

The income from wage labor is quite small, and even the fish processing income recorded in Ng. Kedebu' does not represent a particularly significant amount for an entire village. Ironically, the poverty of the people of Ng. Kedebu', who need cash every day for food and who do report some wage labor, is more observable than the poverty of the Iban, who recorded little involvement in wage labor, or income therefrom.

The explanation lies in regular circular labor migration to Malaysia and Brunei by Iban men. There they work in a range of jobs including logging and construction, and receive very high wages by Indonesian standards.<sup>12</sup> The average monthly wage ranges from US\$170 to US\$900, or Rp. 340,000 to Rp. 1,800,000 at early 1990s rates (US\$1 = Rp. 2,000). The amounts of money men remit to their families range from around US\$50 to US\$600 (or Rp. 100,000-1,200,000) (see Wadley 1997a for a full analysis).

However, no remittances were ever recorded in these data, nor is there any record of men's wages when they returned (as we would expect in the June recordkeeping when men regularly come home to visit). These omissions may have two causes: (1) People are extremely reticent to discuss money matters, particularly how much money they actually might have. Wadley was unable to get complete information on income from circular labor migration because of this. (2) The data recorders may have fallen into the habit of writing down things collected and produced by resident household members. Because people become so accustomed to male absence, they might have thought non-resident production beyond the scope of the study.

Figs. 3-6 provide an overview of incomes. The people of Ng. Kedebu' are much more dependent for subsistence on cash incomes than are those of Wong Garai; and substantial additional, unrecorded cash is available in Wong Garai from remittances (Figures 3 and 4).

Figures 5 and 6 are pie charts, showing the distribution of sources of family cash income recorded in the two communities. These data do clearly show the importance of natural resources are very important to these people, and are used in very different ways by the two ethnic groups (Figures 5 and 6).

#### Wage Labor and Management Issues

- What kinds of wage labor are available in the area? How involved are local people in wage labor?
- How reliable and how profitable are fisheries related work in the Reserve? Are there ways to stabilize incomes, or to increase incomes, without increasing harvesting, through better marketing or improved processing methods?
- Who are the wage laborers in and around the Reserve? How common is wage work?
- What is the dependence of these people on cash incomes? What is the distribution of sources of income in the various study communities?

<sup>12</sup>Wadley (1997a) found that in areas where smallholdings of rubber or pepper were profitable (i.e., stable prices and close markets), the incidence of labor migration was lower than in Wong Garai.

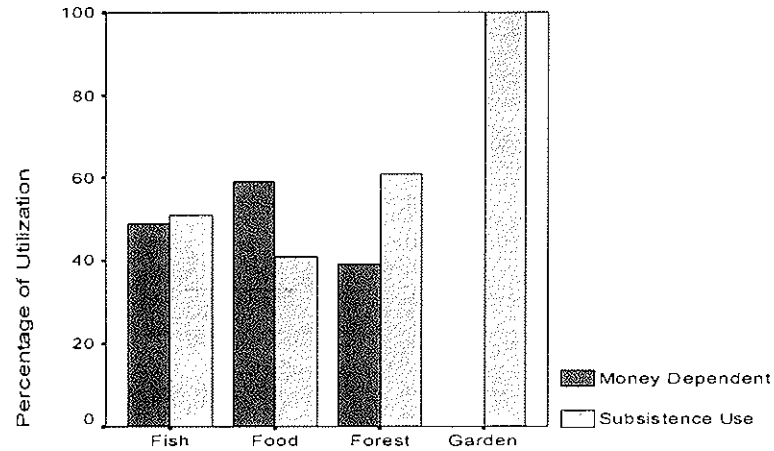


Figure 3. Percentages of recorded items sold (Fish, Forest and Garden Produce) or bought (Food) vs. subsistence in Ng. Kedebu', 1992-1993.

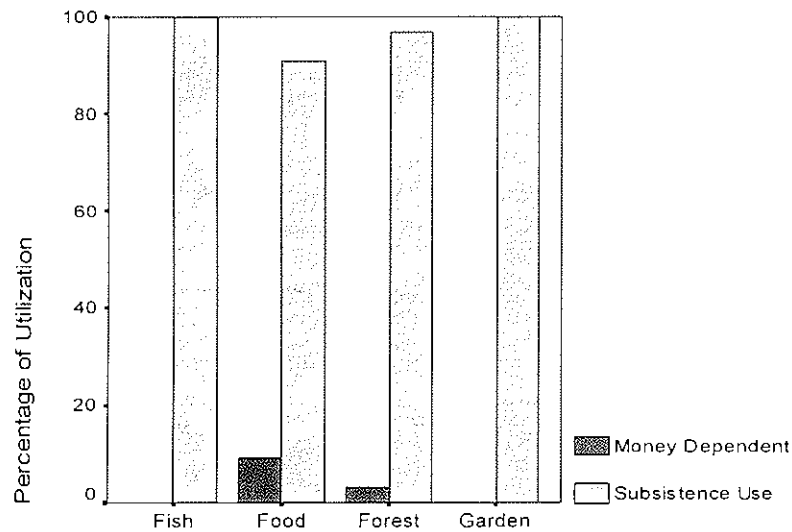


Figure 4. Percentages of recorded items sold (Fish, Forest and Garden Produce) and bought (Food) vs. subsistence in Wong Garai, 1992-1993.

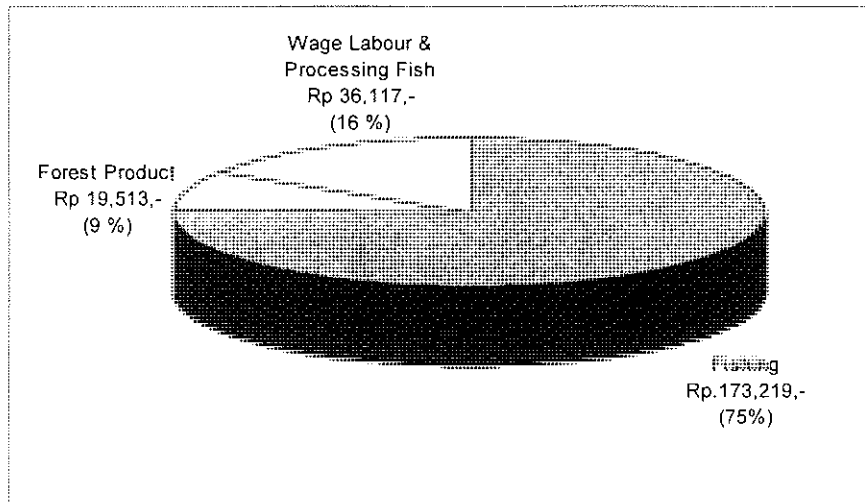


Figure 5. Pie chart showing the percentages of average monthly income per family from various sources in Ng. Kedebu' (Rp 228,849) during the study periods.

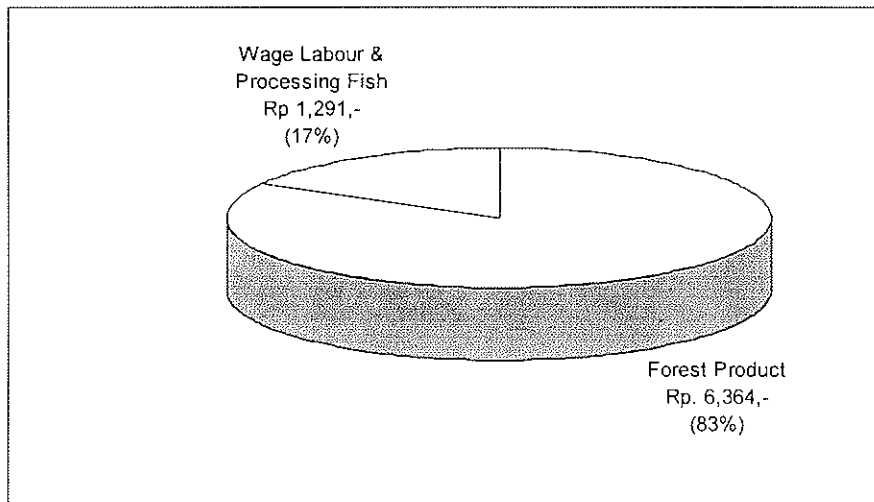


Figure 6. Pie chart showing the percentages of average monthly income per family from various sources in Wong Garai (Rp 7,655) during the study periods.

## **Foods**

The people of Danau Sentarum are poor by most outside standards. It is therefore especially important to be able to assess and monitor their nutritional situation. Food consumption recordkeeping gives a reasonably accurate portrayal of the kinds and distribution of foods available to people in the area. It also provides an indicator of people's dependence on local resources as well as hints on which local resources are critically important for subsistence.

## **Repertoire of Foods**

Overall, there were 127 types of foods listed in the data set. The most striking feature is the dominance of rice in the local diet. Mentioned 4,511 times, 1,582 of them come from Ng. Kedebu' and the rest come from Wong Garai. The second most frequently mentioned food item was cassava leaves, with 648 occurrences—127 come from Ng. Kedebu' and the rest come from Wong Garai.

There was a significantly different pattern of food consumption between the Malay fisherfolk and the Iban swidden cultivators. This can be seen in Appendices O and P, which show the frequencies of foods consumed by month for each ethnic group. One important difference between the two ethnic groups is the Iban preference for eating three times a day, and the Malay tendency to eat only twice.

This kind of information is important in attempts to work with local people. If certain animals, for instance, form a critical part of local diets, forbidding people to hunt them may be unrealistic. On the other hand, extended protection of old growth forest may serve to maintain populations of forest pig, which is prized by Iban and is not illegal to hunt outside the Reserve (see Wadley *et. al.* 1997). Similarly if people's most basic food item, rice, is rooted in swidden cultivation, attempts by conservation managers to persuade people not to cut forest lands are unlikely to succeed (without very attractive incentives and alternatives). However, efforts to work with farmers to improve fallow management in order to sustain the economically and ritually important swiddens may be met with a good deal of interest.

Timing is another issue that influences management. Certain foods may be abundant at certain times of the year, whereas there may be times of scarcity as well. Among the Iban, for example, green leafy foods and vegetables are more common from October to December when those crops are ripe in the hill swiddens. Thereafter they are increasingly scarce until the next farming year (see Figure 8).

## **Nutritional Categories of foods**

The distribution of foods among the different nutritional categories can give some hints (though not a definitive statement) about the nutritional status of local people. Again, there is a divergence of situations existing in Ng. Kedebu' and Wong Garai (Figures 7 and 8).

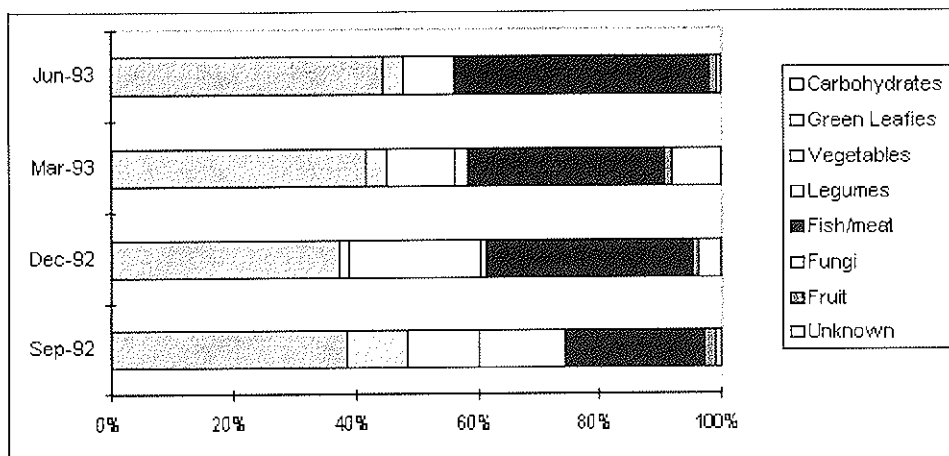


Figure 7. Nutritional Categories of Foods Consumed, Ng. Kedebu', 1992-93.

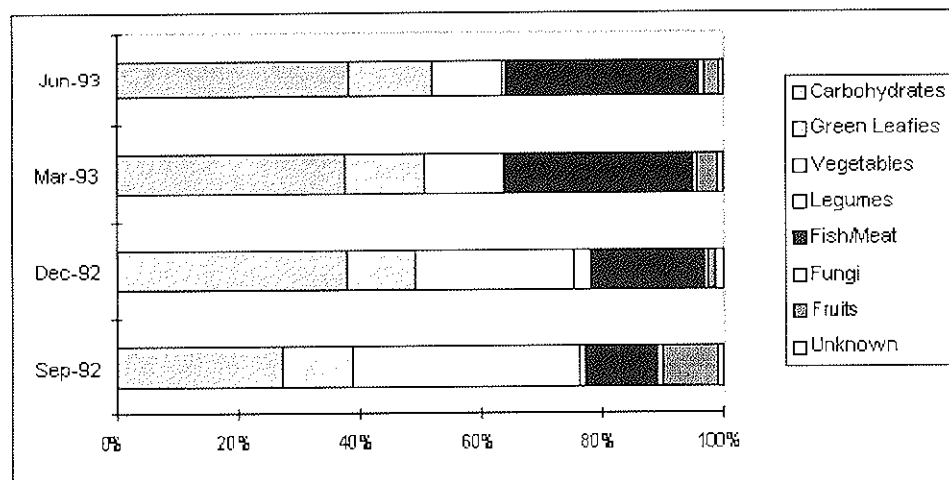


Figure 8. Nutritional Categories of Foods Consumed, Wong Garai, 1992-93.

The primary carbohydrate in both communities is rice—although in Ng. Kedebu' it is virtually all bought, and in Wong Garai it is all home grown. In previous analyses of comparable data from Dayaks, we deleted rice from our graphs and figures, because of its overwhelming dominance in the local diet (e.g., Colfer and Soedjito 1996; Colfer *et al.* 1997a). In this study we retain it, for local comparative purposes.

#### Sources of Foods

Another important, food-related issue for natural resource management is the source of people's foods. The degree to which people are integrated into a cash economy is important, and the proportion of their food that is bought represent two indicators of this integration (or its lack). The two ethnic groups differ dramatically in the amount of food



that they buy, with the Malay purchasing an average of 59 % of their food, and the Iban purchasing 9 %, during the four months of study periods (Figures 9 and 10).

In both Ng. Kedebu' and Wong Garai aquatic and bought sources of food are significant in their agroforestry systems. The people of Ng. Kedebu' are intimately integrated into a money economy, but at the bottom end of the economic hierarchy. The Iban, on the other hand, do not use their money for subsistence purposes; rather they are more likely to buy consumer goods and pay for their children's education (Wadley 1997a). Both communities' dependence on natural resources is equally clear (primarily rivers and lakes for the Malay; the forest for the Iban).

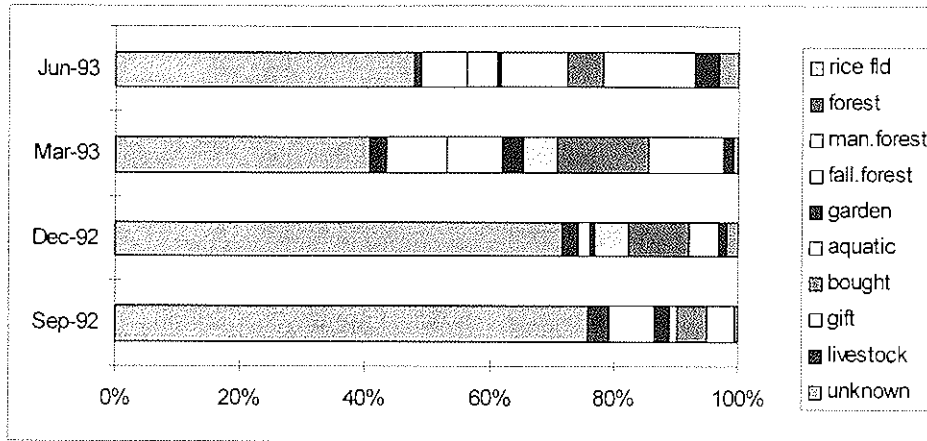


Figure 9. Sources of Food Reported in Ng. Kedebu', 1992-93.

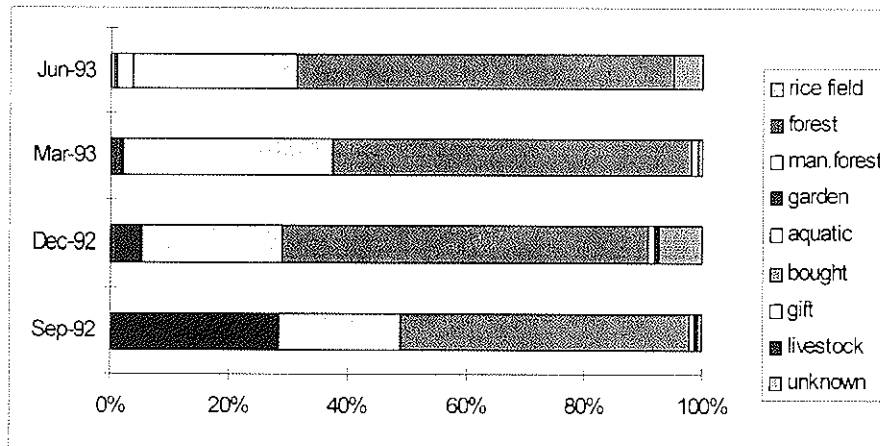


Figure 10. Sources of Food Reported in Wong Garai, 1992-93.

### Food and Management Issues

- What foods do people in the main study communities eat? How balanced is their diet, or how balanced could it be, given local resources? How does this vary over the course of a year?
- How nutritious is the diet available to local people?
- Where are the main sources of food for local people and how do these vary by ethnic group?

### Summary and Conclusion

What then is the use of all this information and its gathering process about local people, in the pursuit of better conservation area management?

First, and most simply, in the process of supervising data collection, a manager meets with the local people, ensuring continuing data entry and asking questions about records that are unclear. In this way, a holistic understanding of local people's constraints and opportunities critical to good co-management begins to emerge. The rapport building process, necessary in co-management, progresses.

Second, the specific results help the manager in the creative process of developing management strategies, where a variety of goals, assumptions, and practices by different stakeholders need to come together into an integrated and complementary whole.

Although a manager may quickly recognize that there are two ethnic groups in the area, the extent of their differences in resource use is not immediately obvious to most biophysical scientists whose attention is normally directed elsewhere. This recordkeeping provides the very specific kinds of information that are often needed to make links between, for instance, biodiversity and human use issues. Who uses what, and how much of it?

Knowing how dependent are particular groups on particular resources can help managers to accept or reject various management ideas they may have. A manager who knows how dependent local people are on a specific endangered species will have a much clearer idea of how much effort may be required to protect it. The level of integration into a monetary economy also may influence managers' decisions about various potential strategies (e.g., to develop income generating activities or not; to propose management actions that require monetary expenditures or financial sacrifice on the part of local people or not).

The recordkeeping also provides information on the division of labor within households and communities. This kind of information is crucial for a manager in trying to tap into and enhance local management practices. DSNP managers who may want to reduce agricultural activity within the Reserve, for example, need to know that women are the farmers there; managers need to address their efforts to them, whether the technique is encouraging floating gardens, income generation activities, or awareness campaigns.

Conversely, if DSNP management wants to focus on a particular habitat (like flooded forest or old growth), this kind of data can clarify what is taken from that habitat by whom and in what quantities. Patterns of resource use emerge quite clearly and,

combined with the biophysical knowledge of most managers, can be used to pinpoint problem areas, potential benign marketing strategies, and areas of useful indigenous knowledge and management (potential or extant).

Finally, these data, easily quantifiable, provide convenient material to support management's conclusions about appropriate "next steps" in local management. They can also help to explain problem areas (e.g., trying to protect an endangered otter in a community where fishing is a critical subsistence base). Very pragmatically, these data are useful in demonstrating to funding agencies, evaluators, and central planners, the reasons behind local management decision, in areas where the needs of local people are considered important.

### **Acknowledgments**

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**Appendix A. Fish Reported Captured, Ng. Kedebu', 1992-93.**

Malay Name	Probable Latin Name	No. times reported	Percent times reported	Amount reported in Kg	Amount reported in Ekor
Bilis	<i>Clupeichthys bleekeri</i>	552	21.2	3251.45	1
Lais	[various kinds]				
• Lais	<i>Pelteobagrus cf. ornatus</i>	344	13.2	284.00	18457
• Lais butu	<i>Ompok hypophthalmus</i>	79	3.0	23.00	4763
• Lais jungang	<i>Kryptopterus apogon</i>	42	1.6	4.00	775
• Lais p	?	21	0.8	0	1222
• Lais banga	<i>Kryptopterus micronema</i>	19	0.7	7.00	123
• Lais sengro	?	1	0.1	0	10
• Lais panak	?	3	0.1	0	90
<b>Total Lais [various kinds]</b>		<b>509</b>	<b>19.5</b>	<b>318.00</b>	<b>25440</b>
Patik/Baug					
• Patik	<i>Mystus nemurus</i>	469	18.0	1680.30	238
• Baug	<i>Mystus planiceps</i>	39	1.5	69.70	92
<b>Total Patik/Baug</b>		<b>508</b>	<b>19.5</b>	<b>1750.00</b>	<b>330</b>
<b>Total Recorded as Lais or Patik/ Baug<sup>1</sup></b>		<b>1029</b>	<b>39.5</b>	<b>2132.00</b>	<b>26658</b>
Umpan	<i>Puntioptiles waandersii</i>	176	6.8	292.25	424
Kelabau	<i>Osteochilus melanopleura</i>	99	3.8	93.40	228
Landin	<i>Mystus nigriceps</i>	51	2.0	427.00	79
Jelawat	<i>Leptobarbus hoevenii</i>	41	1.6	0	770
Kapas	<i>Rohteichthys microlepis</i>	39	1.5	70.00	139
Buin	<i>Cyclocheilichthys sp.</i>	38	1.4	56.00	88
Genus					
<i>Channa</i>					
• Toman	<i>Channa micropeltes</i>	20	0.7	129.50	16
• Delak	<i>Channa striata</i>	16	0.6	78.50	8
• Runtuk	<i>Channa sp.</i>	2	0.1	1.00	2
• Piyang	<i>Channa maruloides</i>	1	0.1	1.00	0
<b>Total for Genus Channa</b>		<b>39</b>	<b>1.5</b>	<b>210.00</b>	
Kelompok	<i>Parachela oxygastroides</i>	37	1.4	8.00	452
Tengku-lan	?	33	1.3	72.50	36
Nuayang	<i>Pseudeutropius sp.</i>	31	1.2	43.80	350
Juara	<i>Pangasius polyuranodon</i>	30	1.1	22.50	46
Belantau	<i>Macrochirichthys macrochirus</i>	23	0.9	11.00	75
Palau	<i>Osteochilus kahajanensis</i>	22	0.8	24.00	24
Emperas	<i>Cyclocheilichthys apogon</i>	22	0.8	18.50	100
Patung	<i>Pristolepis fasciata</i>	21	0.8	22.50	87
Belida	<i>Chitala lopis</i>	20	0.8	64.00	7
Ulang uli	<i>Botta macracanthus macracanthus</i>	20	0.8	0	2004
Entukan	<i>Thynnichthys thynnoides</i>	19	0.7	75.00	57
Kebali	<i>Osteochilus schlegelti</i>	17	0.6	22.50	39
Tebirin	<i>Belodontichthys dinema</i>	16	0.6	27.50	38



Senara	<i>Paradoxcodacna piratica</i>	15	0.6	1.00	96
Butug	?	14	0.5	0	658
Bauk	[various kinds]				
• Bauk	?	7	0.3	60.00	0
• Bauk ketup	<i>Thynnichthys polylepis</i>	3	0.1	32.00	0
• Bauk tuduy	?	1	0.1	4.00	0
<b>Total Bauk</b>		11	0.4	96.00	0
Tilan	<i>Macragnathus maculatus</i>	11	0.4	15.50	6
Kenyyuar	<i>Luciosoma trinema</i>	10	0.4	7.50	37
Bundong	?	10	0.4	0	330
Tapah	<i>Wallago leeri</i>	8	0.3	10.50	5
Biawan	<i>Helostoma temminckii</i>	8	0.3	18.50	0
Tengalan	<i>Puntioplites bulu</i>	8	0.3	11.00	17
Siluari	<i>Lycotrissa crocodilus</i>	7	0.3	0	27
Kelik	<i>Clarias sp.</i>	6	0.2	0	29
Lipi	<i>Parachela spp.</i>	6	0.2	0.13	17
<b>Other fishes</b>	[various kinds, reported less than 5 times]	32	1.8	45.50	1247
Undifferentiated Species					
• BK	[large fish]	25	1.0	134.00	4
• BT	[medium size]	17	0.6	72.00	127
• BTK	[med. Large]	5	0.2	16.00	0
• Ikan barang	[junk fish]	28	1.1	74.30	441
• Ikan campur	[mixed fish]	3	0.1	9.00	0
<b>Total Undifferentiated species</b>		78	3.0	305.3	572
<b>Total</b>		<b>2599</b>	<b>100.0</b>	<b>7462.33</b>	<b>34759</b>

<sup>1</sup> These are trips where *lais* or *patik/baung*, or both *lais* and *patik/baung* together were caught.

\*Names of fish which were reported less than 5 times, in Ng. Kedebu', 1992-93: Seluang (*Rasbora sp.*), Temunit (*Labeo chrysophekadion*), Ketutuk (*Oxyeleotris marmorata*), Tamban (?), Tengadak (*Barbodes schwanenfeldii*), Keroyak (?), Langkung (*Hampala macrolepitoda*), Kujam (*Labiobarbus spp.*), Buntal (*Tetraodon spp.*), Kedukul (*Amblyrhynchthys truncatus*), Kchukoi, Ringau (*Datnoides microlepis*), Tawang (?), Piyam (*Leptobarbus melanopterus*).

## Appendix B. Fish Reported Captured, Wong Garai, 1992-93.

Iban Name	Probable Latin Name	No. times reported	Percent times reported	Amount in Kg	Amount in "Iko"
Lais [various kinds]					
• Lais	<i>Pelteobagrus cf. Ornatus</i>	1	0.2	0	0
• Lais	<i>Kryptopterus micronema</i>	24	4.2	4.00	41
banga					
• Lelipai	<i>Silurichthys spp.</i>	13	2.2	3.00	20
<b>Total Lais</b> [various kind]		38	6.6	7.00	61
Patik/ Baung					
• Baung	<i>Mystus planiceps</i>	68	11.7	12.00	134
<b>Total Patik/Baung</b>		68	11.7	12.00	134
<b>Total Recorded as Lais or Patik/ Baung</b> <sup>1</sup>		106	18.3	19.00	195
Banta'	<i>Osteochilus microcephalus</i>	74	12.8	21.00	100
Undai	[shrimp]	59	10.2	11.55	63
Ensenuai	<i>Rasbora sp.</i>	53	9.3	8.00	135
Keli'	<i>Clarias sp.</i>	43	7.4	7.00	110
Geregit	<i>Leiocassis cf. Stenomus</i>	29	5.0	6.50	85
Pansik	<i>Botia hymenophysa</i>	25	4.3	1.50	39
Palau	<i>Osteochilus kahajanensis</i>	20	3.5	4.50	16
Kujam	<i>Labiobarbus spp.</i>	16	2.8	3.50	14
Kemujuk	?	14	2.4	0.50	14
Gerama'	<i>Gecarcinus spp.</i>	13	2.2	0	42
Tekuyong	[snails]	12	2.1	4.00	0
Genus <i>Channa</i>					
• Toman	<i>Channa micropeltes</i>	1	0.2	0	0
• Delak	<i>Channa striata</i>	10	1.8	11.00	10
<b>Total for Genus Channa</b>		11	2.0	11.00	10
Buing	<i>Cyclocheilichthys sp.</i>	11	1.9	0	115
?	<i>Macrognathus maculatus</i>	8	1.4	1.00	4
Gerang	?	8	1.4	0	17
Adong	<i>Hampala macrolepitoda</i>	7	1.2	0.50	3
Buntal	<i>Tetraodon sp.</i>	6	1.0	5.00	28
Unknown		6	1.0	0	8
<b>Other</b>	[various kinds, reported less than 5 times]	56	4.9	15.00	205
<b>Fishes*</b>					
<b>Total</b>		<b>577</b>	<b>100.0</b>	<b>121.05</b>	<b>1247</b>

<sup>1</sup>These are trips where *lais* or *patik/baung*, or both *lais* and *patik/baung* together were caught.

\*Names of fish which were reported less than 5 times, in Wong Garai, 1992-93: Nyenyuar (*Luciosoma trinema*), Lelabi [soft-shelled turtles], Kerimpok (?), Patong (*Pristolepis fasciata*), Engkarit (*Puntius eugrammus*), Lelekat (?), Bauk (?), Pama [frogs], Ngewai (?), Runto' (*Ophiocephalus sp.*), Keyulong (*Xenentodon canciloides*), Memuri' [tadpoles], Riu' (*Pangasius macronema*), Leladin (*Mystus nigriceps*), Rusit (?), Anak beluh (?), Bah (?), Belau (*Ophiocephalus sp.*), Buntat (?), Empelasi' (*Betta spp.*), Entebali (?), Gerau (?), Keripalu (?), Memayut (?), Empelung (?), Peranak (?), Petok (?), Surik (?).

**Appendix C. Fish Reported Captured, Bemban, 1992.**

Iban Name	Probable Latin Name	No. times reported	Percent times reported	Amount in Kg	Amount in "Iko"
Baung	<i>Mystus planiceps</i>	14	25.5	13.50	157
Leladin	<i>Mystus nigriceps</i>	13	23.6	7.00	81
Runto'	<i>Ophiocephalus sp.</i>	7	12.7	0.10	5
Bawan	<i>Helostoma temminckii</i>	6	10.9	1.00	95
Lais	<i>Pelteobagrus cf. Ornatus</i>	4	7.3	0	0
Patong	<i>Pristolepis fasciata</i>	2	3.6	0	0
Kerimang	?	2	3.6	1.00	15
Ni'	?	2	3.6	3.00	40
Delak	<i>Channa striata</i>	1	1.8	0	0
Lelabi	[Soft-shelled turtles]	1	1.8	49.00	4
Gerinung	?	1	1.8	0	0
Kerandung	<i>Ophiocephalus pleurothakmus</i>	1	1.8	0	0
Padi	?	1	1.8	0	0
<b>Total</b>		<b>55</b>	<b>100.0</b>	<b>74.60</b>	<b>397</b>

**Appendix D: Crops Harvested in Ng. Kedebu', 1992-93.**

Local Names	Probable Latin Names	Frequency	Percentage
Retak	[Green beans]	52	22.3
Buah perenggi	[Squash]	46	19.7
Daun ubi	<i>Manihot esculenta</i> [cassava leaves]	31	13.3
Retak panjang	<i>Vigna sinensis</i> [longbeans]	31	13.3
Jagung	<i>Zea mays</i> [corn]	23	9.9
Daun retak panjang	<i>Vigna sinensis</i> [longbean leaves]	8	3.4
Daun retak	[Green beans leaves]	7	3.0
Ubi	<i>Manihot esculenta</i> [cassava]	6	2.6
Entimun	<i>Cucumis sativus</i> [cucumber]	6	2.6
Daun perenggi	[Squash leaves]	5	2.1
Kacang duduk	[peanuts]	4	1.7
Buah kusut (Gambas)	?	4	1.7
Daun cangkok	<i>Sauropus spp.</i>	4	1.7
Terong china	[Chinese eggplant]	2	0.9
Daun timun	<i>Cucumis sativus</i> [cucumber leaves]	2	0.9
Daun kangkung	<i>Ipomoea aquatica</i> [swamp cabbage]	1	0.4
Paku' manis	[fern]	1	0.4

### Appendix E: Agricultural/Agroforest Products in Wong Garai, 1992-93.

#### • Field and Garden Products

Local Names	Probable Latin Names	Frequency	Percentage
Cangkok	<i>Sauropus spp.</i>	36	8.5
Daun empasa'	<i>Manihot esculenta</i> [cassava leaves]	27	6.4
Daun ensabi	<i>Allantospermum borneensis</i>	21	5.0
Kebari'	Bittermelon?	20	4.7
Tebu	<i>Saccharum officinarum</i> [sugarcane]	16	3.8
Retak	[Green beans]	16	3.8
Empusut	<i>Luffa aegyptica</i>	11	2.6
Terong	<i>Solanum spp.</i> [eggplant]	10	2.4
Daun subung	[ <i>Xanthosoma mafaffa</i> leaves]	4	0.9
Terong pipit	<i>Solanum torvum</i>	4	1.0
Lia'	<i>Zingiber spp.</i> [ginger]	3	0.7
Kacang (Cabe)	<i>Capsicum frutescens</i> [chillie]	3	0.7
Terong cina	Chinese eggplant	1	0.2
Buah rampo'	<i>Cucumis sativus</i> [cucumber]	1	0.2
Buah empasa'	<i>Manihot esculenta</i> [cassava]	1	0.2
Pisang	<i>Musa spp.</i> [banana]	1	0.2
Daun entaban	<i>Poikilospernum spp.</i>	1	0.2
Daun jebuk	<i>Celosia argentea</i>	1	0.2
Pako' & Cangkok		1	0.2

#### • Agroforests Products

Local Names	Probable Latin Names	Frequency	Percentage
Ai' ijuk	[Wine of] <i>Arenga pinnata</i>	48	11.4
Buah rian	<i>Durio zibethinus</i> [durian]	32	7.6
Buah sibau	<i>Nephelium reticulatum</i>	17	4.0
Buah pedalai	<i>Artocarpus sericicarpus</i>	15	3.6
Dedabai	<i>Canarium odontophyllum</i>	13	3.1
Kayo' api	[Firewood, various kinds]	13	3.0
Bukoh	<i>Artocarpus integer</i>	13	3.0
Engkabang	<i>Shorea macrophylla</i>	9	2.1
Ketuntum		8	1.8
Kulat	[mushroom]	6	1.4
*Kemiding	<i>Stenochlaena spp.</i>	6	1.4
Upa' panto'	<i>Eugeissonia utilis</i>	6	1.4
Engkala	<i>Litsea garciae</i>	5	1.2
Buah asam	<i>Mangifera decandra</i>	5	1.2
Rembai	<i>Baccaurea motleyana</i>	4	0.9
Tubo'	[Bamboo shoots]	4	0.9
Karet/getah	<i>Harvea braziliensis</i>	3	0.7
*Kayo' engkelong	<i>Shorea quadrinervis</i>	3	0.7
Daun koko	<i>Theobroma cacao</i>	3	0.7
Asam pauh	<i>Mangifera petandra</i>	2	0.5
Nangka	<i>Artocarpus heterophyllus</i>	2	0.5
Buah rungan	<i>Carica papaya</i>	2	0.5
*Tucung kecala'	<i>Etlingera elatior</i>	2	0.5
*Daun sabong	<i>Gnetum gnemon</i>	2	0.5

Petai	<i>Parkia speciosa</i>	2	0.5
*Wj	[various species of rattan].	2	0.5
*Kulat mata jane'	<i>Calostoma spp.</i>	1	0.2
Inyak	<i>Cocos nucifera</i>	1	0.2
Belimbing	<i>Averrhoa bilimbing</i> [starfruit]	1	0.2
**Kijang	<i>Muntiacus spp.</i>	1	0.2
**Pelandok	<i>Tragulus spp.</i>	1	0.2
**Jane'	<i>Sus barbatus</i> [wild pig]	1	0.2
*Upa' encala		1	0.2
Mawang	<i>Mangifera pajang</i>	1	0.2
Engkeranje'	<i>Dialium indum</i>	1	0.2
Purur	<i>Artocarpus communis</i>	1	0.2
Ruas	[Lengths of Bamboo]	1	0.2
Upa' payau		1	0.2
*Uncultivated plants			
**Game animal			

**Appendix F. Forest Products with Number of Collecting Trips Recorded in Ng. Kedebu' (1992-93).**

Species (Local Name)	Latin/English Name	Number of Trips	Yearly estimate*
Kayu api/bakar	[various kinds, firewood]	62	248
Rotan antu	<i>Calamus sp</i> [Rattan]	61	244
Kayu Ntangis	<i>Randia sp</i>	28	112
Kayu kefansau	<i>Dryobalanops abnormis</i>	11	44
Kayu mengkupas	wood?	9	36
Kayu limut	<i>Casaeria sp. nov.</i>	6	24
Kayu putat	<i>Barringtonia acutangula</i>	6	24
Kayu tahun	<i>Garcinia sp</i>	5	20
Kayu jijap	<i>Eugenia sp</i>	4	16
Kayu ngkurung	<i>Grewia spp</i>	2	8
Atap emang	<i>Hopea griffithii</i>	2	8
Atap sirap	[various kinds, shingles]	2	8
Kayu sikop	<i>Garcinia celebica</i>	1	4
Kayu kebesi	<i>Memecylon edule</i>	1	4
Kayu ngkunik	<i>Antidesma stipulare</i>	1	4
Kayu merandap	wood	1	4
Kayu tembesuk	<i>Fragraea fragrans</i>	1	4
Kayu kemarauan	<i>Shorea platycarpa</i>	1	4
Kayu ngkelopak	wood	1	4
Papan pukul	<i>Shorea virescens</i>	1	4
Kayu belanti	<i>Baccaurea bracteata</i>	1	4
Unknown		1	4

\*The results from the four months of recordkeeping (number of trips) were multiplied by 3 to estimate the yearly number of trips.

This estimate must be taken with a grain of salt, since there are a number of species marked by real seasonality (i.e., likely to occur only once a year).

### Appendix G. Forest Products with Number of Collecting Trips Recorded in Wong Garai (1992-93)

Species (Local Name)	Latin / English Names	Number of Trips	Yearly Estimate~
*Daun empasa'	Cassava leaves	101	404
Kayo' api	Firewood [various kind]	64	256
Tubo'	Bamboo shoots	46	184
*Buah empasa'	Cassava roots	39	156
Pako'	<i>Fern</i>	31	124
Kemiding	<i>Stenochlaena spp.</i>	28	112
*Daun subong	<i>Xanthosoma mafaffa</i> leaves	25	100
Terong	<i>Solanum spp.</i>	25	100
Kulat	Mushroom [general]	22	88
Upa' panto'	<i>Eugeissonia utilis</i>	20	80
*Tebu	<i>Saccharum officinarum</i>	16	64
Pako' ikan	<i>Diplazium esculentum</i>	11	44
Entaban	<i>Poikilospernum spp.</i>	11	44
*Empusut	<i>Luffa aegyptica</i>	11	44
Daun rebung	<i>Callaria spp.?</i>	9	36
Ai' ijuk	<i>Arenga pinnata</i>	8	32
Buah pedalai	<i>Artocarpus sericicarpus</i>	8	32
Pako' kero'	<i>Nephrolepis bisserata</i>	7	28
Dedabai	<i>Canarium odontophyllum</i>	7	28
*Kacang (cabe)	<i>Capsisum frutescens</i>	7	28
**Munsang	Various species of civet	6	24
Upa' entibap	<i>Arenga saccharifera</i>	6	24
Buah rian	<i>Durio zibethinus</i>	6	24
Buloh	<i>Bambusa vulgaris</i>	6	24
Tubo' hetong	<i>Gigantochloa latifolia</i>	5	20
Buah bukoh	<i>Artocarpus integer</i>	5	20
Kulat mata jane'	<i>Calostoma spp.</i>	5	20
Daun daup	<i>Bauhinia spp.</i>	5	20
**Janc'	<i>Sus barbatus</i>	5	20
Kulat buah	<i>Hygrocybe sp.</i>	4	16
Kulat bulu	<i>Panus rudia</i>	4	16
Kulat ikan	<i>Pleurotus sp.</i>	4	16
Daun gelabak	<i>Pseuderanthemum borneense</i>	4	16
**Kijang	<i>Muntiacus spp.</i>	4	16
Daun	Various kind of leaves	4	16
Buah asam kecala	<i>Etilingera elatior</i>	4	16
Ramo'papan	Lumber [various kind]	4	16
Upa' encala	?	3	12
Kulat kerop	[mushroom]	3	12
Kulat lepit	<i>Auricularia auricula-judae</i>	3	12
Buah asam	<i>Mangifera decandra</i>	3	12
Kulat dilah kepayang	<i>Pleurotus sp.</i>	3	12
Asam pauh	<i>Mangifera petandra</i>	3	12
Kulat jalong	<i>Cookeina sulcipes</i>	2	8

Kulat gelos	<i>Lentinus sp</i>	2	8
**Nyumboh	<i>Macaca nemestrina</i>	2	8
*Cangkok	<i>Sauropus spp.</i>	2	8
Kayo' jijap	<i>Eugenia sp</i>	2	8
Kayo' engkelong	<i>Shorea quadrinervis</i>	1	4
**Empeliau	<i>Hylobates muelleri</i>	1	4
Daun arak	<i>Ficus oleaefolia?</i>	1	4
Inyak	<i>Cocos nucifera</i>	1	4
*Kebari'	bittermelon?	1	4
Buah sibau	<i>Nephelium reticulatum</i>	1	4
Kulat buruk	Gerronema and other	1	4
Kulit pukul	Tree bark for house siding	1	4
Kulan	<i>Pandanus spp.</i>	1	4
Kayo' limut	<i>Casaeria sp. nov.</i>	1	4
Kayo' belanti	<i>Baccaurea bracteata</i>	1	4
Unknown	?	33	

~The results from the four months of recordkeeping (number of trips) were multiplied by 3 to estimate the yearly number of trips.

\*Cultivated plants

\*\*Game animal

#### Appendix H. Forest Products with Number of Collecting Trips, Bemban (December 1992).

Local Names	Latin /English Names	Number of Trips
Empukung	Termite nest	14
Senggang	<i>Hornstedtia scyphifera</i>	5
Tubo'	Bamboo shoots	4
Kulan	<i>Pandanus spp.</i>	4
Papan	Board [various kinds]	3
Kulit pukul	Tree bark for siding of houses	2
Buloh	<i>Bambusa vulgaris</i>	2
Kayu api	Firewood [various kinds]	2
Daun daup	<i>Bauhinia spp.</i>	1
*Babi	<i>Sus barbatus</i>	1
Kayu ntangis	<i>Randia sp.</i>	1

\*Game animal

### Appendix I. Quantities of Forest Products Gathered in Ng. Kedebu' (1992-93).

Species (Local Name)	Latin Names	Measures		
		Stick	Canoeiful	Sheet
Kayu ntangis	<i>Randia sp</i>	178	16	0
Rotan antu*	<i>Calamus sp</i>	0	0	8429
Kayu bakar	[various kind]	500	43	0
Kayu belanti	<i>Baccaurea bracteata</i>	2	0	0
Papan pukul	<i>Shorea virescens</i>	0	0	10
Atap sirap	[various kind]	0	0	600
Atap emang	<i>Hopea griffithii</i>	0	0	750
Kayu ngkelopak	wood?	0	0	15
Kayu kemarauan	<i>Shorea platycarpa</i>	15	0	0
Kayu tembesuk	<i>Fragraea fragrans</i>	7	0	0
Kayu mengkupas	wood?	2	0	0
Kayu merandang	wood?	10	0	0
Kayu kelansau	<i>Dryobalanops abnormis</i>	416	0	496
Kayu ngkunik	<i>Antidesma stipulare</i>	100	0	0
Kayu jijap	<i>Eugenia sp</i>	0	4	0
Kayu tahun	<i>Garcinia sp</i>	0	4	0
Kayu putat	<i>Barringtonia acutangula</i>	0	3	0
Kayu limut	<i>Casaeria sp. nov.</i>	0	5	0
Kayu ngkurung	<i>Grewia spp</i>	0	2	0
Kayu kebesi	<i>Memecylon edule</i>	0	2	0
Kayu sikop	<i>Garcinia celebica</i>	0	1	0

\*We find it rather odd that the people measure rattan in "sheets," but that is how they recorded it.



**Appendix J. Quantities of Forest Products Gathered in Wong Garai (1992-93).**

Species (Local Name)	Latin Names	Measures							
		Stick	Seed	Bundle	Tails	Back- pack	Sheet	Basket	Stem
Kayo' belanti	<i>Baccaurea bracteata</i>				6				
Kayo' jijap	<i>Eugenia sp</i>				2				
Kayo' limut	<i>Casaeria sp. nov.</i>							1	
Kayo' api	<i>firewood</i> [various kinds]			4		61		2	
Kulan	<i>Pandanus sp</i>			2					
Ramo'/ papan	<i>Beam</i> [various kinds]			2		1		3	
Buloh	<i>Bambusa vulgaris</i>					6		1	
Tubo'	Bamboo shoots		22	8	24	5		28.10	
Kulit pukul	Tree bark for siding of houses							1	
Jane'	<i>Sus barbatus</i>				3	2			
Daun	[various kinds]					3		2	
Daun Daup	<i>Bauhinia sp</i>							5	
Kemiding	<i>Stenoch- laena spp.</i>				4			20.63	
Kacang (cabe)	<i>Capsicum frutescens</i>			5	1	2		3	
Terong	<i>Solanum spp.</i>		6	13	10	5		11.20	
Asam pauh	<i>Mangifera petandra</i>			2		1		1	
Daun empasa'	<i>cassava leaves</i>	5		6	30	26	2	57.95	
Buah empasa'	<i>cassava roots</i>		18	4	11	21		16	
Buah rian	<i>Durio zibethinus</i>					6			
Kulat mata jane'	<i>Calostoma spp.</i>							3.50	
Kulat burak	<i>Gerronema and other</i>							0.25	
Kulat	<i>Pleurotus</i>			2		1		0.50	



Tubo' betung	<i>esculentum</i> <i>Giganto- chloa</i>	5		2	1.05
Daun gelabak	<i>latifolia</i> <i>Pseuderan- thenum</i>		6		3
Kulat ikan	<i>borneense</i> <i>Pleurotus</i>			3	0.26
Munsang	<i>sp.</i> Various species of civet		6	1	
Kulat lepit	<i>Auricularia</i> <i>auricula- judae</i>				0.31
Kulat bulu	<i>Panus</i> <i>rudia</i>		8		2.13
Empe-liau	<i>Hylobates</i> <i>muelleri</i>			1	
Kulat gelos	<i>Lentinus sp</i>				2.13
Kulat jalong	<i>Cookeina</i> <i>sulcipes</i>				1.50
Pako' kero'	<i>Nephrolepi- s biserrata</i>	1		5	6
Kulat kerop	<i>a mush- room</i>			1	2.05
Kulat buah	<i>Hygrocybe</i> <i>sp.</i>				4
Upa' encala	?			2	1
Kayo' engke- long	<i>Shorea</i> <i>quadri- nervis</i>			9	
Tebu	<i>Saccharum</i> <i>officinarum</i>	6	15		5
Unknown	?		13	9	10
					9.10

**Appendix K. Quantities of Forest Products Gathered in Bemban (December 1992).**

Species (Local Names)	Latin/Engl ish Name	Measures					
		Stick	Seed	Canoe/ful	Bundle	Back- pack	Sheet
Kayu	<i>Randia sp</i>	0	0	0	0	1	0
Ntangis							
Kayu api	Firewood [various kind]	7	0	3	0	0	0
Empukung	Termite nest	0	80	0	0	16	0
Kulan	<i>Pandanus spp.</i>	0	0	0	6	0	0
Senggang	<i>Hornstedtia scyphifera</i>	0	0	0	8	0	0
Papan	Board [various kind]	49	0	0	0	0	0
Buloh	<i>Bambusa vulgaris</i>	4	0	0	0	0	0
Tubo'	Bamboo shoots	5	30	0	0	0	0
Kulit pukul	Trec bark for siding of houses	20	0	0	0	0	0
Babi	<i>Sus barbatus</i>	1	0	0	0	0	0
Daun daup	<i>Bauhinia spp.</i>	1	0	0	0	0	0



1 = Kayu ntangis (wood)	8 = Kayu ngkelopak (wood)	15 = Kayu jijap (wood)
2 = Rotan antu' (rattan)	9 = Kayu kemarauan (wood)	16 = Kayu tahun (wood)
3 = Kayu bakar (firewood)	10 = Kayu tembesuk (wood)	17 = Kayu putat (wood)
4 = Kayu belanti (wood)	11 = Kayu mengkupas (wood)	18 = Kayu limut (wood)
5 = Papan pukui (wood)	12 = Kayu merandang (wood)	19 = Kayu ngkurung (wood)
6 = Atap sirap (shingles)	13 = Kayu kelansau (wood)	20 = Kayu kebesi (wood)
7 = Atap emang	14 = Kayu ngkunik (wood)	21 = kayu sikop (wood)

**Appendix M. Frequency of forest product collected in Bemban, December 1992 , by location.**

Location	Forest Product										
	<i>kayu api</i>	<i>em- pu- kung</i>	<i>kula- an</i>	<i>seng- gang</i>	<i>papan</i>	<i>buluh</i>	<i>tubu</i>	<i>kulit pukul</i>	<i>babi</i>	<i>daun</i>	<i>daun dacip</i>
Babas (forest)	1	13	4	5				1		1	1
Bangkal begetah Danau	1										1
Danau Pegah (lake)									1		
Emperan (floodplain)						2	1	6			
Lubuk Mensidang	1										
Ng. Santik/ Lengkong Santik Ngkuran	6										
Penyelawat	4										
Pintas Jenat	3										
Seberang kampung	4		1						4	1	
Sepandan Kerinan						1					
Sg. Empaik	1	1				1			2		
Sg. Lebak Langkan											
Tembawai (ex- housesite)							1	4			



Kulat jalong		2			
Pako kero	3	3			
Kulat kerop		3			
Kulat buah		2	1	1	
Upa' encala				2	
Kayo engklong	1				
Tebu	7	4	1	4	
Unknown	11	12	1	3	3

1 = Lake (Danau)

2 = Forest (Babas)

3 = Floodplain (Emperan)

4 = Housegarden  
(Redas/Kebun)

5 = Tree reserve (Pulau)

6 = Rubber grove (Kebun)

7 = Old longhouse site  
(Tembawai)

8 = Hill field (Umai bukit)

9 = Fallowed forest (Damun)

10 = Swamp (Paya')

11 = Unknown



**Appendix O Frequencies of foods consumed by month, Ng. Kedebu' (1992-93)**

Food Category/ Local Names	Latin/ English Names	Sept. 92 Freq/%		Dec. 92 Freq/%		Mar. 93 Freq/%		June 93 Freq/%	
<b>Carbohydrates</b>		<b>441</b>	<b>38.5</b>	<b>326</b>	<b>37.0</b>	<b>334</b>	<b>41.3</b>	<b>638</b>	<b>44.2</b>
Nasi	<i>Oryza sativa</i>	414	36.2	295	33.5	296	36.6	577	40.0
Ubi	<i>Manihot esculenta</i>	10	0.9	21	2.4	6	0.7	38	2.6
Mie	Noodles	7	0.6	4	0.5	13	1.6	16	1.1
Kerupuk ikan	Belida chips	5	0.4	2	0.2	15	1.9	4	0.3
Kentang	<i>Solanum spp.</i>	3	0.3	1	0.1	3	0.4	3	0.2
Keladi	Taro	1	0.1	3	0.3	1	0.1		
<b>Green Leaves</b>		<b>111</b>	<b>9.7</b>	<b>14</b>	<b>1.6</b>	<b>28</b>	<b>3.5</b>	<b>48</b>	<b>3.3</b>
Daun ubi	Cassava leaves	73	6.4	9	1.0	16	2.0	29	2.0
Daun perenggi	Squash leaves	15	1.3					1	0.1
Perenggi									
Daun retak panjang	Long-bean leaves	13	1.1						
Panjang									
Daun entimun	<i>Cucumis sativus</i> leaves	4	0.3			48	5.9		
Sawi	?	4	0.3			2	0.2		
Kangkung	<i>Ipomoea aquatica</i>	3	0.3	1	0.1	1	0.1	2	0.1
Daun	<i>Sauropus spp.</i>			2	0.2			1	0.1
Cangkok									
Paku' kemiding	fern [general]			2	0.2	2	0.2	3	0.2
Paku' kubuk	?				.2			8	0.6
Paku' keruk	<i>Nephrolepis biserrata</i>							2	0.1
Paku' ikan	<i>Diplazium esculentum</i>							1	0.1
Bayam	<i>Amaranthus spp.</i>					2	0.2	1	0.1
Kuca'i	<i>Allium tuberosum</i>					3	0.4		
Kantu rungan	Papaya leaves					1	0.1		

<b>Vegetables</b>		<b>134</b>	<b>11.7</b>	<b>190</b>	<b>21.6</b>	<b>89</b>	<b>11.0</b>	<b>1,206</b>	<b>8.3</b>
Entimun	<i>Cucumis sativus</i>	42	3.7	66	7.5	48	5.9	8	0.6
Kacang/cabe	<i>Capsicum frutescens</i>	23	2.0	40	4.6	21	2.6	32	2.2
Lungkang jeli'	Baby corn	18	1.6					1	0.1
Buah perenggi perenggi	Squash	9	0.8	65	7.4	10	1.2	1	0.1
Terong	<i>Solanum spp.</i>	8	0.7			3	0.4	45	3.1
Jagung	<i>Zea mays</i>	7	0.6						
Nangka	<i>Artocarpus integer</i>	6	0.5	7	0.8	2	0.2	10	0.7
Kol	Cabbage	4	0.3	1	0.1				
Terong Cina	Chinese Eggplant	4	0.3					3	0.2
Empusut	<i>Luffa aegyptica</i>	2	0.1						
Kepare	Bittermelon	2	0.2	1	0.1				
Labu	Gourd	1	0.1			4	0.5	1	0.1
Rebung	Bamboo shoots	1	0.1	7	0.8			15	1.0
Tomat	Tomato	1	0.1						
	Chinese Cucumber							1	0.1
Cangkok	<i>Sauropus spp.</i>			3	0.3				
Jantung pisang	banana flower							1	0.1
Lia'	<i>Zingiber sp</i>					1	0.1		
<b>Legumes</b>		<b>166</b>	<b>14.5</b>	<b>8</b>	<b>0.9</b>	<b>18</b>	<b>2.2</b>	<b>1</b>	<b>0.1</b>
Retak panjang	Green bcans	163	14.2						
Jengkol	<i>Pithecellobium jiringa</i>	2	0.2	7	0.8	18	2.2		
Kacang duduk	?	1	0.1	1	0.1			1	0.1
<b>Fish/Meat</b>		<b>263</b>	<b>23.0</b>	<b>301</b>	<b>34.2</b>	<b>264</b>	<b>32.7</b>	<b>603</b>	<b>41.8</b>
Patik/Baung	<i>Mystus spp.</i>	67	5.9	33	3.8	84	10.4	98	6.8

Lais	[various kind]	46	4.0	15	1.7	58	7.2	64	4.4
Ikan asin	Salt-Dried fish	43	3.8	12	1.4	33	4.1	89	6.2
Landin	<i>Mystus nigriceps</i>	29	2.5			7	0.9	6	0.4
Belida	<i>Chitala lopis</i>	16	1.4	3	0.3	10	1.2	5	0.3
Ringau	<i>Datnooides microlepis</i>	10	0.9			3	0.4	6	0.4
Ikan	Fish [general]	8	0.7	15	1.7	6	0.7	125	8.7
Telor ayam	Chicken egg	6	0.5	3	0.3	5	0.6	8	0.6
Bauk	[various kind]	6	0.5	44	5.0	3	0.4	37	2.6
<b>Genus <i>Channa</i></b>		5	0.4	24	2.7	11	1.3	37	2.5
• Toman	<i>Channa micropeltes</i>	4	0.3	23	2.6	11		31	2.1
• Delak	<i>Channa striata</i>	1	0.1	1	0.1			6	0.4
Tapah	<i>Wallago leeri</i>	4	0.3	1	0.1	1	0.1		
Bawan	<i>Helostoma temminckii</i>	4	0.3			2	0.2	5	0.3
Bangah	?	4	0.3	3	0.3	2	0.2	17	1.2
Telor Ikan	Fish egg	4	0.3			1	0.1		
Juara	<i>Pangasius polyuranodon</i>	3	0.2	10	1.1	7	0.9	22	1.5
Tengalan	<i>Puntioplites bulu</i>	2	0.2	1	0.1			8	0.6
Patung	<i>Pristolepis fasciata</i>	2	0.2	1	0.1			2	0.1
Kenyuar	<i>Luciosoma trinema</i>	2	0.2					1	0.1
Kelabau	<i>Osteochilus melanopleura</i>	2	0.2	2	0.2			1	0.1
Sarden	Sardines	1	0.1	3	0.3	6	0.7	3	0.2
Kaloi	<i>Osphron</i>	1	0.1						

	<i>emus</i>								
Bantak	<i>goramy</i>	1	0.1						
	<i>Osteo-</i>								
	<i>chilus</i>								
	<i>micro-</i>								
	<i>cephalus</i>								
	Salai fish	1	0.1			3	0.4	49	3.4
Jukut	Fermen-	1	0.1			1	0.1		
	ted fish								
Tebirin	<i>Belon-</i>	1	0.1					7	0.5
	<i>dotich-</i>								
	<i>thys</i>								
	<i>dinema</i>								
Bilis	<i>Chu-</i>			86	9.8	15	1.9	9	0.6
	<i>peichthys</i>								
	<i>bleekeri</i>								
Keli'	<i>Clarias</i>			2	0.2			2	0.1
	<i>sp.</i>								
Ayam	Chicken			5	0.6			1	0.1
Kijang	<i>Munti-</i>			38	4.3	6	0.7		
	<i>acus sp.</i>								
Bayak	?							1	0.1
<b>Fungi</b>								<b>5</b>	<b>0.3</b>
Kulat	Mush-							5	0.3
	room								
<b>Fruits</b>		<b>19</b>	<b>1.7</b>	<b>7</b>	<b>0.8</b>	<b>10</b>	<b>1.2</b>	<b>17</b>	<b>1.2</b>
Tempoyak	<i>Durio</i>	14	1.2			9	1.1		
	<i>zibethi-</i>								
	<i>nus</i>								
Nyur	<i>Cocos</i>	4	0.3			1	0.1		
	<i>nucifera</i>								
Asam kandis	?	1	0.1						
Pisang	<i>Musa</i>			1	0.1			7	0.5
	<i>spp.</i>								
Nenas	<i>Ananas</i>			6	0.7			9	0.6
	<i>comosus</i>								
Rampai								1	0.1
<b>Unknown</b>		<b>11</b>	<b>0.9</b>	<b>33</b>	<b>3.7</b>	<b>65</b>	<b>8.0</b>	<b>11</b>	<b>0.7</b>
<b>Total Record</b>		<b>1145</b>	<b>100.0</b>	<b>879</b>	<b>100.0</b>	<b>808</b>	<b>100.0</b>	<b>1434</b>	<b>100.0</b>

**Appendix P** Frequencies of Foods consumed by month, Wong Garai (1992-93)

Food/ Category/ Local Names	Latin/ English Names	Dec. 92 Freq/%		Mar. 93 Freq/%		June 93 Freq/%		Sep. 93 Freq/%	
<b>Carbo- hydrates</b>		<b>355</b>	<b>27.1</b>	<b>511</b>	<b>40.6</b>	<b>810</b>	<b>37.2</b>	<b>1412</b>	<b>37.8</b>
Asi'	<i>Oryza sativa</i>	350	26.7	434	34.5	770	35.4	1347	36.1
Buah empasa'	<i>Manihot esculenta</i>	3	0.2	27	2.1	17	0.7	30	0.8
Mie	Noodles	1	0.1			6	0.3	24	0.6
Kerupuk ikan	Belida chips			1	0.1				
Buah subong	<i>Colocasia esculenta</i>	1	0.1	49	3.9	17	0.8	11	0.3
<b>Green Leaves</b>		<b>150</b>	<b>11.4</b>	<b>154</b>	<b>12.2</b>	<b>289</b>	<b>13.3</b>	<b>511</b>	<b>13.7</b>
Daun empasa'	Cassava leaves	13	1.0	104	8.3	177	8.2	227	6.1
Daun entekai	Squah leaves	2	0.2	3	0.2	3	0.1	129	3.5
Daun rampo'	<i>Cucumis sativus</i>	103	7.9	1	0.1				
Ensabi	<i>Allantospermum spp.</i>							1	0.03
Daun cangkok	<i>Sauropus spp.</i>	4	0.3	3	0.2	21	1.0	32	0.9
Pako' [general]	ferns [general]	4	0.3	8	0.6	8	0.4	21	0.6
Pako' kemiding	<i>Stenochlaena spp.</i>	8	0.6	4	0.3	19	0.9	35	0.9
Pako' kubuk						3	0.1	1	0.03
Pako' kero'	<i>Nephrolepis biserrata</i>			1	0.1				
Pako' ikan	<i>Diplazium esculentum</i>			1	0.1	2	0.1		
Bayam	<i>Amaranthus spp.</i>	2	0.2					7	0.2
Kuca'i	<i>Allium tuberosum</i>	2	0.2	19	1.5	12	0.6	6	0.2
Kantok rungan	Papaya leaves							12	0.3
Daun entaban	<i>Poikilospernum</i>	2	0.2			2	0.1	6	0.2

Daun sabong	<i>spp.</i> <i>Gnetum gnemon</i>	7	0.5	2	0.2	32	1.5	6	0.2
Daun subung	<i>Xanthosoma mafaffa</i>	2	0.2			4	0.2	15	0.4
Kantok lekan	?	1	0.1	4	0.3	1	0.1	2	0.1
Kantok remat	<i>Lygodium spp.?</i>			4	0.3				
Ketuntum	?					5	0.2	10	0.3
Kantok mawan	?							1	0.03
<b>Vegetables</b>		<b>496</b>	<b>37.8</b>	<b>358</b>	<b>20.5</b>	<b>292</b>	<b>13.5</b>	<b>445</b>	<b>12.0</b>
Buah rampo'	<i>Cucumis sativus</i>			99	7.9	2	0.1	8	0.2
Kacang/cabe	<i>Capsicum frutescens</i>			2	0.2	9	0.5	3	0.1
Kelapong	Baby corn	4	0.3						
Lingkau Buah entekai	Squash	96	7.3	86	6.8	2	0.1	83	2.2
Terong	<i>Solanum spp.</i>	176	13.4			100	4.6	43	1.2
Lingkau	<i>Zea mays</i>	85	6.5	23	1.8	1	0.1	1	0.03
Upa'	Palm cabbages							5	0.1
Terong Cina	Chinese					1	0.1	1	0.03
Empusut	eggplant <i>Luffa aegyptica</i>	4	0.3					1	0.03
Kebari'	Bittermelon	6	0.5			1	0.1	176	4.7
Genok	Gourd	72	5.5	5	0.4			2	0.1
Tabo'	Bamboo shoots	20	1.5	18	1.4	86	4.1	58	1.6
Tomat	Tomato	7	0.5						
Tungkul pisang	Banana flower			1	0.1				
pisang									
Lia'	<i>Zingiber sp</i>			10	0.8	2	0.1	2	0.1
Bungai entekai	Squash flower	19	1.4						



Jukat	fish Pickled fish	1	0.1	20	1.6	6	0.3	208	5.6
Undai Bilis	shrimp <i>Clu- peichthys bleekeri</i>	6	0.5	18	1.4	47 1	2.2 0.1	11	0.3
Keli'	<i>Clarias sp.</i>			14	1.1	1	0.1	5	0.1
Manok Kijang	Chicken <i>Muntia- cus spp.</i>	8	0.6	2	0.2	34 37	1.6 1.7	53 8	1.4 0.2
Buing	<i>Cyclo- chei- lichthys sp.</i>							1	0.03
Gerama'	<i>Gegar- cinus spp.</i>	2	0.2	3	0.2	6	0.3		
Pama' Jane'	Frog <i>Sus barbatus</i>	1 29	0.1 2.2	2 14	0.2 1.1	12 36	0.6 1.7	2 312	0.1 8.4
Kesa' Capi Lelabi	Ant nest Cow Soft- shelled turtle	1 4	0.1 0.3					1 10	0.03 0.3
Empeliau	<i>Hylo- bates muelleri</i>			1	0.1			17	0.5
Rusit	Dried fish					48	2.2	10	0.3
Burong	Birds [general]							7	0.2
Rasong	<i>Nasalis larvatus</i>							3	0.1
<b>Fungi</b>		<b>13</b>	<b>1.0</b>	<b>9</b>	<b>0.7</b>	<b>14</b>	<b>0.6</b>	<b>38</b>	<b>1.0</b>
Kulat	[mush- room]	7	0.5	9	0.7	12	0.6	23	0.6
Kulat burak	<i>Gerro- nema</i> and other	2	0.2			1	0.1	12	0.3
Kulat mata jane'	<i>Calo- stoma spp.</i>	2	0.2					2	0.1
Kulat dilah	<i>Pleuro- tus spp.</i>	1	0.1						
Kepayang Kulat muyong Kulat risik	? ? ?	1	0.1			1	0.1	1	0.1
<b>Fruits</b>		<b>120</b>	<b>9.2</b>	<b>17</b>	<b>1.3</b>	<b>76</b>	<b>3.5</b>	<b>88</b>	<b>2.3</b>



Empikau/ tempoyak	<i>Durio zibethi- nus</i>	5	0.4					21	0.5
Inyak	<i>Cocos nucifera</i>	31	2.4			12	0.6		
Pisang	<i>Musa sp.</i>	1	0.1	3	0.2	4	0.2	2	0.1
Buah brunei	<i>Ananas comosus</i>			9	0.7	1	0.1		
Buah pedalai	<i>Arto- carpus spp.</i>	55	4.2			29	1.3		
Buah rembai	<i>Baccau- rea motle- yana</i>					5	0.2		
Buah asam	<i>Mangi- fera decandra</i>	1	0.1			10	0.5	15	0.4
Buah punsut	?	12	0.9			2	0.1	23	0.6
Buah purur	<i>Artocar- pus commu- nis</i>	3	0.2	1	0.1	3	0.1		
Buah dedabai	<i>Canari- um odonto- phyllum</i>	9	0.7			1	0.1		
Buah bukoh	<i>Arto- carpus integer</i>	3	0.2	4	0.3	7	0.3	24	0.6
Buah senggang	<i>Horn- stedtia scyphi- fera</i>					1	0.1		
Buah sibau	<i>Nephe- lium reticu- latum</i>					1	0.1		
Limau	<i>Citrus spp.</i>							1	0.03
Tebu	<i>Saccha- rum offici- narum</i>							2	0.1
<b>Unknown</b>		<b>12</b>	<b>0.9</b>	<b>15</b>	<b>1.2</b>	<b>18</b>	<b>0.8</b>	<b>29</b>	<b>0.8</b>
<b>Total Record</b>		<b>1,312</b>	<b>100.0</b>	<b>1,358</b>	<b>100.0</b>	<b>2,174</b>	<b>100.0</b>	<b>3,727</b>	<b>100.0</b>

## FLORA AND VEGETATION OF DANAU SENTARUM: UNIQUE LAKE AND SWAMP FOREST ECOSYSTEM OF WEST KALIMANTAN

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Danau Sentarum National Park is characterized by lakes and a variety of swamp forests that are unique, and unlike comparable habitats in Indonesia or Southeast Asia. Structurally, it was once very similar to the Mahakam Lakes in East Kalimantan, but the latter area is severely degraded. Three main swamp forest types are recognized on the basis of structure: dwarf swamp forest, stunted swamp forest, and tall swamp forest. Within each of these, various vegetation types are recognized on the basis of dominant species. Basic structural types are closely linked with depth and duration of flooding. Aquatic vegetation is virtually absent, due to a combination of severe fluctuation in water levels and low nutrient levels in lake waters. Plant species diversity of each habitat is low, but due to diversity in habitat types, overall plant diversity is relatively high and 262 species are recorded for swamp forests. DSNP harbors 30-40 endemics or restricted range species. The most serious immediate threats to the integrity of these forests are fires and illegal logging, while swidden cultivation on levees forms the main threat to the riparian habitat.

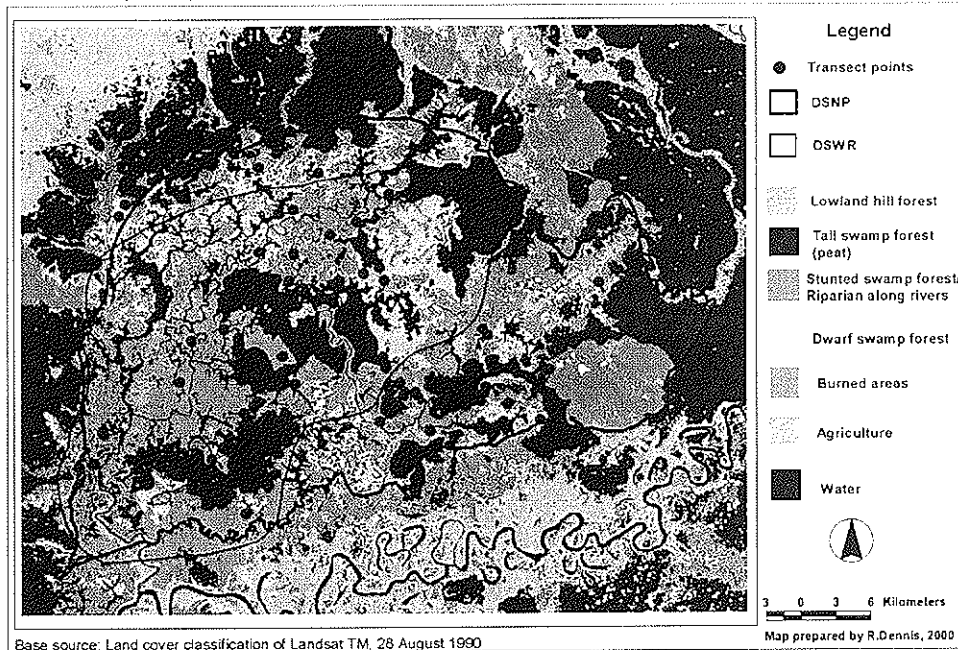
### **BACKGROUND**

#### **Swamp habitats in Indonesia**

Large areas of non-marine swamp occur in the lowlands of Sumatra, Borneo, and Papua, extending over a total area of 23-35 million hectares (Euroconsult, 1984; Silvius *et al.*, 1987; RePPPProT, 1990; IIED, 1994), and form one of the largest areas of tropical swamp world-wide outside of Amazonia (WCMC, 1992; Maltby, 1997). These swamps consist of two main types, namely peat swamp forest and freshwater swamp forest. The former is characterized by peat soils, which by definition have an organic matter content of at least 65 percent, while the latter occurs on predominantly mineral soils. More than three-quarters of all peat land in Southeast Asia occurs in Indonesia, and with a total area of 17-27 million hectares, it accounts for more than half of the world's total of tropical peat land (Maltby, 1997).

Most of Indonesia's non-marine swamps are near coastal areas and were forested before the advent of large-scale commercial logging in the 1980s and 1990s. Isolated swamps further inland, in the middle or upper basins of larger rivers, are far less common. Papua's very extensive swamp forests are broad, inland extensions of coastal freshwater swamp forests, and due to the rugged, mountainous nature of the interior, inland swamps are either absent or consist of medium to high altitude bogs (Paaijmans, 1976; Petocz, 1989). Most swamps of Sumatra follow a similar pattern: peat- and freshwater swamp forests are found along most of the east coast and extend far inland, with wooded medium to high altitude bogs found in the central mountain range (Scholz,

1983; Silvius *et al.*, 1987). Due to a flat topography, lowland swamps have developed far inland on Borneo and are well-developed in the middle-upper reaches of the island's longest rivers, especially along the Mahakam and Kapuas (Silvius *et al.*, 1987). While forested swamps along the Mahakam have largely deteriorated over the past decades, those in the upper Kapuas basin are relatively intact, and a significant area is protected in the Danau (=lake) Sentarum National Park.



**Figure 1. Major habitats of Danau Sentarum National Park (map produced by R.A. Dennis for UK-ITFMP)**

### Danau Sentarum National Park

The Danau Sentarum National Park (further referred to as DSNP or the Park) covers an area of 132,000 hectares, and is located in the floodplain of the upper Kapuas River in West Kalimantan (see Giesen and Aglionby, 2000). The Park lies between the Kapuas River and the border with Sarawak, and is located between 0°40'–0°55' N and 112°00'–112°25' E at an average elevation of 35 meters. DSNP consists of a series of interconnected seasonal lakes, interspersed with swamp forest, peat swamp forest, and dry lowland forest on isolated hills. It was gazetted a Wildlife Reserve (*Suaka Margasatwa*) in 1982, and its status was upgraded to National Park (*Taman Nasional*) in 1999.

### Physical factors

Annual rainfall in the Park fluctuates around 3,900 mm per year, while the surrounding hills and mountainous catchment area receive 4,500–6,000 mm. Because of high precipitation levels, most of the low-lying areas in the basin—including Danau Sentarum—are flooded in the wetter months. Water levels of the lakes and streams may rise and fall up to 12 meters during an average year. During about nine months of the year the lake system

is flooded, with an average maximum depth of 6.5 meters, though levels may fluctuate substantially. During the remainder of the year (usually late June-early September) waters usually retreat to the deepest channels and the lakes dry out entirely in two out of three years.

Isolated waterholes or *kerinan* may remain in the swamp forest or otherwise dry lake bed, while deeper parts of otherwise dry streams may remain as pools or *lubuk*. Lakes and stream waters are colored by tannins, very mineral-deficient and acidic, with a pH of 4.5-5.5. Light penetration in water is about one meter, while conductivity averages at 16  $\mu$ S (range 9-24  $\mu$ S). Dissolved oxygen levels are fairly low, averaging at 4.4 mg/l, while surface temperatures are high (30.4°C). The geology of Danau Sentarum consists largely of recent deposits with some arkosic sandstone outcroppings. Recent deposits consist of illite and kaolin clays in the lake basin, with pockets of shallow to moderately deep topogenic peat occurring locally. Soils on slopes consist mainly of highly weathered and nutrient poor loams and sands, while those on the flat ridge tops consist of fine to moderately fine sands and loamy sands. In general, soils throughout the area have a low to very low nutrient status and are infertile. The flat topography is relieved by several isolated hills in the Park, and hill ranges to the west, northeast, and east.

#### METHODOLOGY

Botanical studies were initially carried out in the area by the author in 1986 (Giesen, 1987). These included the collection of voucher specimens (numbered 1-200), which were deposited at Bogor, Leiden and (partly at) Kew herbariums. During the UK-Indonesia Tropical Forest Management Program (UK-ITFMP) project at DSNP (1992-97), further collections were made of both ferns and seed plants. Voucher specimens (numbered Zulkarnain and Giesen 300-580, dated 1993-94) were deposited at and identified by Bogor and Leiden herbariums, with duplicates held at the Park's Bukit Tekenang Field Center. Kew Herbarium provided identifications of collected palm specimens. Local plant names and uses were recorded for each species. Plant specimens were also identified in the field using *Flora Malesiana*, *Tree Flora of Malaya*, Airy Shaw (1975), Backer and Poshumus (1939), Bakhuizen van den Brink (1943-45), Corner (1988), Danser (1927-28, 1931, 1936-37, 1940) and Piggott (1988). Whitmore *et al.* (1990) was used to convert local names to scientific names; the latter were subsequently cross-referenced by comparing plant material with literature references.

To assess the composition and structure of DSNP vegetation, surveys included transects, whereby vegetation along a discrete line is described. Transects of DSNP swamp forest vegetation were carried out on a stratified random basis (Mueller-Dombois and Ellenberg, 1974), using a 1990 Landsat TM image of the area and 1:50,000 scale base maps created by the UK-ITFMP team, as a basis for site selection. Points were located in the field using a Magellan 5000 Global Positioning System. Each transect measured 10 by 100 meters, within which all plants were recorded, and height/diameter records were made of woody species with a dbh of more than five centimeters. In addition to plant species and location, water depths were measured in the flooded forest, along with soil type and peat depth. In all, 66 transects were carried out between 7 March and 11 June 1994. Ten transects were on peat soil, half of which (transects 24,26,37,43,61) were shallow (< 50 cm deep), while others were up to 4.05 meters deep. Transect data was entered into a spreadsheet, and analyzed for species presence and relative abundance. Habitat surveys also included: a) short surveys in 27 burnt areas,

whereby species occurrence and condition was noted (June 1994); b) a phenology study of 29 plant species occurring along the jetty at Bukit Tekenang (every 1-2 weeks, January 1994-January 1995); and c) a study of the phenology of 40 common plant species at DSNP, every 2-3 weeks (January 1994-January 1995).

## RESULTS

### Flora

#### Plant diversity

Study of the flora of DSNP began with Beccari in 1867, when he collected about 30-35 type specimens (Beccari, 1904), which are held by the herbarium of Florence. Subsequent collections were made in the lake area by Teysmann (1875), Hallier (1895), Polak (1949) and Giesen (1987). Altogether, 504 plant species were recorded in the Danau Sentarum area, representing 99 families (see Appendix I), of which 57 percent were identified to species level and 35 percent to genus level. The ten best-represented plant families are *Dipterocarpaceae*, with 40 species, *Euphorbiaceae* 36 species, *Rubiaceae* 35 species, *Myrtaceae* 26 species, *Fabaceae* 21 species, *Lauraceae* 20 species, *Melastomataceae* 20 species, *Guttiferae* 19 species, *Moraceae* 14 species, and *Areaceae* 14 species.

Of these 504 species, just over half (262) are found in the Danau Sentarum swamp forests, where plant collecting efforts by the author were concentrated. Most of the remainder are found in dryland habitats such as lowland forest, heath forest and sites of former shifting cultivation. Aquatic herbaceous species are uncommon, probably because of the significant annual fluctuations in water levels, and are generally limited to more permanent bodies of water near the Kapuas River. Almost three-quarters (73%) of the 504 species are trees and shrubs.

#### Taxonomic rarities

The Danau Sentarum area harbors novel and interesting plant species. *Dichilanthe borneensis* (known locally as *berus*), was first collected at Danau Sentarum by Beccari in 1867, and has never been collected elsewhere. This unique species represents a link between the *Rubiaceae* (to which it has been assigned) and the *Scrophulariaceae*, incorporating characteristics from both families. A new species of *Rhodoleia* (*insang dungan*) was collected in 1993 and identified by Vink (Leiden Herbarium). This species belongs to the *Hamamelidaceae*, a family poorly represented in Asia, with only seven genera occurring in the Malesian realm, each represented by only one species. The only other species of this family found on Borneo is *Sycopsis dunnii*, which is endemic to Mt. Kinabalu, Sabah (Vink, 1957). The small tree *Dicoelia beccariana* (*belat*), the sedge *Hypolytrum capitulatum*, the stemless palm *Eugeissona ambigua* (*ransa*) and the rattan *Plectocomiopsis triquetra* (*rotan udang*) are rare species that are locally common at DSNP (Airy-Shaw, 1975; Kern, 1972; Dransfield, pers. comm. 1986 and 1994).

#### Endemics/restricted range species

In the absence of comparable floristic data from much of Borneo, the number of plant species with a restricted range or endemic to Danau Sentarum can only be approximated. Many of the 35 species collected by Beccari in the Danau Sentarum area in 1867 (Beccari, 1904) are likely to have a restricted range, as he focused on novel species, and had already been active in neighboring Sarawak for many years before visiting the

Kapuas lakes. Species that are endemic to DSNP or at least have a restricted range number 30-40, and include the new *Rhodoleia* species, *Dichilanthe borneensis* and *Eugeissona ambigua* mentioned above. Danau Sentarum is the type locality for all three species. Seven other species likely to be restricted to the Danau Sentarum area are new species collected by Giesen (1987) and Zulkarnain and Giesen (Giesen, 1996). These include *Casaeria* sp. nov. (*Flacourtiaceae*; *limut*), *Croton* cf. *ensifolius* (*Euphorbiaceae*; *melayak*), *Helicia* cf. *petiolaris* (*Proteaceae*; *putat rimba*), *Korthalsella* cf. *germinans* (*Loranthaceae*; *paha buntak*), *Microcos* cf. *stylocarpus* (*Tiliaceae*; *tengkuring asam*), *Ternstroemia* cf. *toгуian* (*Theaceae*), and *Vatica* cf. *umbronata* (*Dipterocarpaceae*; *menungau*).

#### Flowering and fruiting

A number of plant species tend to flower and set fruit intermittently throughout the year, without any apparent cue by either rainfall or water depth. These species include *Crudia teysmannia* (*timba tawang*), *Fagraea fragrans* (*tembesu*), *Ficus heterophylla* (*luwak*), *Psychotria montensis* (*akar engkerabang*), and *Xanthophyllum flavescens* (*tengkuring*). If these five species are omitted from the phenology study of 29 species, there is a good correlation between flowering/fruiting and flooding regime. Of the 24 species that display seasonality, only 3 flower/fruit in the dry months of April to August, while the remainder flower or set fruit throughout the October-March wet season (with 6-18 flowering/fruiting at any given time in this period).

#### Exotics

Relatively few exotic plant species have been introduced to DSNP; these include *Ageratum conyzoides*, *Cassia alata*, *Eichhornia crassipes*, *Hyptis brevipes*, *Ludwigia hyssopifolia*, *Mimosa pigra* and *Passiflora foetida*. All are from tropical South America except for *H. brevipes*, which originates from Mexico. Waterhyacinth *Eichhornia crassipes* and Giant Mimosa *Mimosa pigra* are highly invasive noxious weed species (Miller *et al.*, 1981; Soerjani *et al.*, 1987; Finlayson, 1998), but fortunately for the Park, both remain uncommon at DSNP (see below).

#### Vegetation and habitats

Major habitat types at DSNP are indicated in Table 1 and a map is provided in Figure 1. Based on physiognomy, three major types of swamp forest can be identified: tall, stunted, and dwarf swamp forest, which have average canopy heights of 22-30, 8-15(-22) and 5-8 meters, respectively. Dwarf swamp forest develops in deeply flooded areas that may be flooded with 4-5.5 meters of water for 8-12 months per year. Tall swamp forest is flooded for 2-3 months annually by 1-2.5 meters of water, and some areas are characterized by peat soils with a depth of 0.5-4 meters. Stunted swamp forest is intermediate between tall- and dwarf swamp forest in terms of flooding depth and duration, and does not have any peat. Both dwarf and stunted swamp forests are prone to fires (see below, and Dennis *et al.*, 2000). Heath forests are characterized by uniform, fairly small stunted trees (average up to 20-25 meters), an open canopy, large numbers of myrmecophytes, and usually occur on very poor, leached sandy soils. In the DSNP area heath forests occur on the top of sandstone ridges. Lowland forest is found on the low hills and ridges around the lake basin, and consists of tall to very tall tree, with emergents attaining 35-45(-55) meters.

**Table 1. Habitat types of Danau Sentarum.**

Habitat type	80,000 ha Wildlife Reserve e (gazetted 1982)		132,000 ha National Park (gazetted 1999)	
	Area (ha)	%	Area (ha)	%
Lowland forest (on hills)	102	0.13	6,767	5.17
Heath forest	0	0	201	0.15
Tall swamp forest	8,962	11.00	21,915	16.76
Stunted swamp forest	30,824	38.19	39,469	30.18
Dwarf swamp forest	2,170	2.69	2,362	1.81
Regenerated after fire(s)	10,952	13.57	16,930	12.95
Recently burnt	3,680	4.56	6,154	4.71
Clearings/shifting cultivation	1,848	2.29	4,603	3.52
Settlements	27	0.03	32	0.02
Open water (lakes and rivers)	21,728	26.92	30,095	23.01
Floating grass mats	0	0	257	0.20

Note: Data obtained from the ODA/PHPA Remote Sensing/GIS Unit; based on Landsat TM (1990), airborne radar imagery and 1994 aerial photographs.

#### Herbaceous aquatic vegetation

Herbaceous aquatic vegetation is rare at DSNP. The extreme annual fluctuation of water levels limits the growth of many species, and both submerged and emergent aquatic herbs are usually absent. Incoming floodwaters bring floating mats of waterhyacinth *Eichhornia crassipes*, but these do not proliferate. Most waterhyacinth remain small, gradually turning brown and withering, except in villages and in waters near the Kapuas River. Other free-floating species such as Nile Cabbage *Pistia stratiotes* are rare, and occur only near villages and streams near the Kapuas River. When the lakes dry out—which occurs in two out of three years—dry lake bottoms are rapidly colonized by a carpet of small annual herbs, dominated by grasses such as *Isachne globosa*, sedges such as *Fimbristylis dipsacea*, *F. miliacea*, and diminutive herbs such as *Lindnera* species.

Emergent herbs—especially sedges—are found in swamp forests, but rarely occur as discrete vegetation types. An exception to this general pattern is formed by floating mats of herbaceous vegetation called *kumpai*, which occurs locally in the southern part of DSNP, especially at several oxbow lakes near the Kapuas River, and along the Mbaloh Leboyan River. *Kumpai* consists of thick mats of mainly perennial herbs, dominated by grasses such as *Digitaria* species, *Echinochloa colonum*, *Leersia hexandra*, *Leptochloa chinensis*, *Panicum conjugatum*, *P. repens*, *Phragmites karka* and *Saccharum spontaneum*, along with the climbers *Aniseia martinicensis* and *Merremia hederacea*, and the large herbs *Polygonum barbatum* and *Polygonum celebicum*.

#### Swamp forest vegetation

Three swamp forest vegetation types can be recognized at DSNP, namely dwarf swamp forest, stunted swamp forest and tall swamp forest. Tall swamp forest is found in areas that are shallowly flooded for shorter periods, and is locally called *hutan pepah*. Depending on the locally common species, an appropriate suffix is added, for example *hutan pepah kelansau* or *hutan pepah emang*. Stunted swamp forest is termed *hutan rawa* or *gelgah*, and similarly, one may for example have *gelgah menungau*, *gelgah kamsia* or

*gelgah kenarin* depending on local conditions and dominant tree species. Dwarf forest of any type is called *rampak*, and dwarf swamp forest is called *rampak gelgah*. A fourth type that is very similar to stunted swamp forest is riparian forest, which occurs on levees of larger rivers in the Park.

Dwarf swamp forest is characterized by trees and shrubs 5-8 meters tall, and may be flooded more than 11 months per year (average 9.5 months). At times this vegetation is almost entirely submerged, as waters may be 5.5 meters deep. Common species are *Barringtonia acutangula* (*putat*), *Carallia bracteata* (*kayu tahun*), *Croton* cf. *ensifolius* (*melayak*), *Garcinia borneensis* (*empanak*), *Gardenia tentaculata* (*landak*), *Ixora mentanggis* (*mentangis*), *Pternandra teysmanniana* (*gelagan*), *Memecylon edule* (*kebesi*), *Syzygium claviflora* (*masung*) and *Timonius salicifolius* (*kerminit*). Some species may be locally dominant, to the virtual exclusion of all other species.

Stunted swamp forest is characterized by small to medium-sized trees 8-15(-22) meters tall. It is flooded 4-8 months annually (average 6 months), with waters of up to 3.5 meters deep. This habitat is highly fire-prone and subjected to regular burning in the dry season. It is estimated that about a quarter of this habitat has been burnt over the past decades. Based on species composition, two main stunted swamp forest vegetation types may be recognized, namely Kenarin-Menungau-Kamsia vegetation, and Kawi-Kamsia vegetation.

Kenarin-Menungau-Kamsia stunted swamp forest is probably the most widespread, and is characterized by *Diospyros coriacea* (*kenarin*), *Vatica* cf. *umbronata* (*menungau*) and *Mesua hexapetalum* (*kamsia*), along with many other species including *Cleistanthus sumatranus* (*kertik*), *Crudia teysmannii* (*timba tawang*), *Fordia splendissima* (*limau antu*), *Garcinia bancana* (*sikup*), *Homalium caryophyllaceum* (*pekeras*), *Ilex cymosa* (*kayu telor*), *Microcos* cf. *stylocarpa* (*tengkurung asam*) and *Xanthophyllum affine* (*merbemban*).

Kawi-Kamsia stunted swamp forest is characterized by the same species as the previous type, but includes the dipterocarp *Shorea balangeran* (*kawi*), which may dominate locally. Occasionally *kawi* trees may attain a height of over 30 meters, but on average they are usually 15-22 meters and are often gnarled. This vegetation type is possibly derived from the Kenarin-Menungau-Kamsia type by the influence of fire, as *Shorea balangeran* appears to be a relatively fire-tolerant species (see below; Mackinnon *et al.*, 1983; Giesen, 1987; Dennis *et al.*, 2000).

Climbers such as various rattans *Calamus schistoacanthus* (*duri antu*), *Calamus tapa* (*duri tapah*), *Ceratolobus hallierianus*, (*duri pelanduk*), *Psychotria montensis* (*akar engkerabang*), *Ficus heterophylla* (*luwak*), *Fagraea* cf. *ceilanica* (*akar seraya*) and *akar tulang salai* (Annonaceae) are also common to locally very common in the stunted swamp forest (for rattans, see Peters and Giesen, 2000).

Tall swamp forest is dominated by the occurrence of tall (25-30(-35) meter) straight stemmed trees, in areas that are flooded for 2-3 months annually by 1-2.5 meters of water. Peat, with depths of up to four meters may occur locally, but is often absent. Two main vegetation types may be recognized, namely the Kelansau-Emang-Melaban type and the Ramin-Mentangur Kunyit vegetation type.

Kelansau-Emang-Melaban tall swamp forest, characterized by the occurrence of *Dryobalanops abnormis* (*kelansau*), *Hopea mengerawan* (*emang*) and *Tristaniaopsis obovata* (*melaban*) is the most common type of tall swamp forest. Additional species



found in this habitat include *Calophyllum* species (*mentangur*), *Dichilanthe borneensis* (*berus*), *Gluta pubescens* (*kebaca*), *Gluta wallichii* (*rengas manuk*), *Ilex cymosa* (*kayu telor*), *Shorea balangeran* (*kawi*), *Teysmanniodendron sarawakanum* (*mutun*) and *Vatica ressak* (*resak*).

Ramin-Mentangur kunyit tall swamp forest may formerly have been more widespread, but as *Gonystylus bancanus* (*ramin*) is much sought after by commercial timber companies; it is now uncommon and occurs only very locally. It is characterized by a very open canopy, and an undergrowth characterized by the tall sedge *Tetradlea borneensis* (*lembang*). Dominant tree species are Ramin and *Calophyllum sclerophyllum* (*mentangur kunyit*), along with *Dichilanthe borneensis* (*berus*), *Garcinia rostrata* (*sikap rimba*), *Shorea balangeran* (*kawi*), *Syzygium durifolium* (*ubah*) and *Tristaniopsis obovata* (*melaban*).

Riparian forest in much of the area appears to have many of the same species as the Kenarin-Menungau-Kamsia stunted swamp forest, but is characterized by the presence of typical riparian species such as *Gluta renghas* (*rengas*) and *Lagerstroemia speciosa* (*bungur*), along with *Antidesma stipulare* (*engkunik*), *Artocarpus teysmannii* (*cempedak air*), *Dillenia excelsa* (*ringin*), *Elaeocarpus cf. sphaerocarpa* (*menyawai*), *Excoecaria indica* (*kebauu*), *Ficus microcarpa* (*jabai*), *Hopea dasyrrhachis* (*tekam air*), *Mallotus sumatranus* (*belantik*), and *Pternandra galeata* (*kelusuk bijang*). This vegetation type occurs on levees of the larger rivers in the Park (e.g. Tawang, Belitung, Empanang), and has a flooding regime similar to that of the stunted swamp forest.

### Dryland forests

Dryland habitats at DSNP occur on the isolated hills scattered throughout the area (Pegah, Semanggit, Sempadan, Semujan, Tekenang), and the low ranges to the west, northeast, and east of the Park. Because this habitat formed only a minor element in the original 80,000 hectare reserve, it has not received much emphasis in the habitat studies to date. Based on physiognomy, two main dryland primary vegetation types can be recognized, namely hill forest and heath forest. In addition, various secondary vegetation types occur, mainly as a result of clearing and burning of these primary vegetation types.

Hill forests are dominated by dipterocarp species such as *Anisoptera grossivenia* (*penyau*), *Dipterocarpus gracilis* (*tempurau*), *Shorea leprosula* (*rup*) and *S. seminis* (*kerintak*). These trees are tall to very tall, with emergents attaining 35-45 meters. Hill forests occur on the slopes of isolated hills and along ranges, where soils are moister and less sandy (i.e. with significant clay content). In some areas, for example at Bukit Semanggit, Dayak forest gardens (*tembawang*) occur where certain dipterocarps such as *tempurau* are nurtured for the periodic harvesting of the oil-containing nuts. Heath forest—also known as *kerangas*—is a stunted forest with trees of (20)22-26 meters. The canopy is open, while the trees have slender trunks and are pole-like. This vegetation type occurs on sandy soils west of the Park, on top of Bukit Semujan and on the flat tops of hills in the Menyukung range to the southeast of the Park. Small areas of a wetter type of heath forest known as *kerapah* occurs on leached, sandy soil at the base of hills to the west of the Park. Common heath forest species include *Baeckia frutescens*, *Koompassia malaccensis* (*menggeris*), *Lithocarpus* species (*kempilik*), *Lycopodium cernuum*, *Nepenthes ampullaria*, *N. mirabilis*, *Shorea laevis* (*masang*), *S. seminis* (*kerintak*), *Syzygium* species, *Tristaniopsis obovata* and *Vatica cinerea* (*resak padi*). Secondary scrub occurs on abandoned former sites of shifting cultivation (*ladang*) and areas

formerly cleared for settlements. These patches are small and constitute only a minor element, as these infertile hills have generally not been cultivated. Secondary scrub vegetation is characterized by a profusion of ferns (esp. *Pteridium aquilinum*), shrublets *Melastoma malabathricum* and *Rhodomyrtus tormentosa*, various *Macaranga* species and a hill variety of *Fagraea fragrans* (*tembesu*).

### Fires

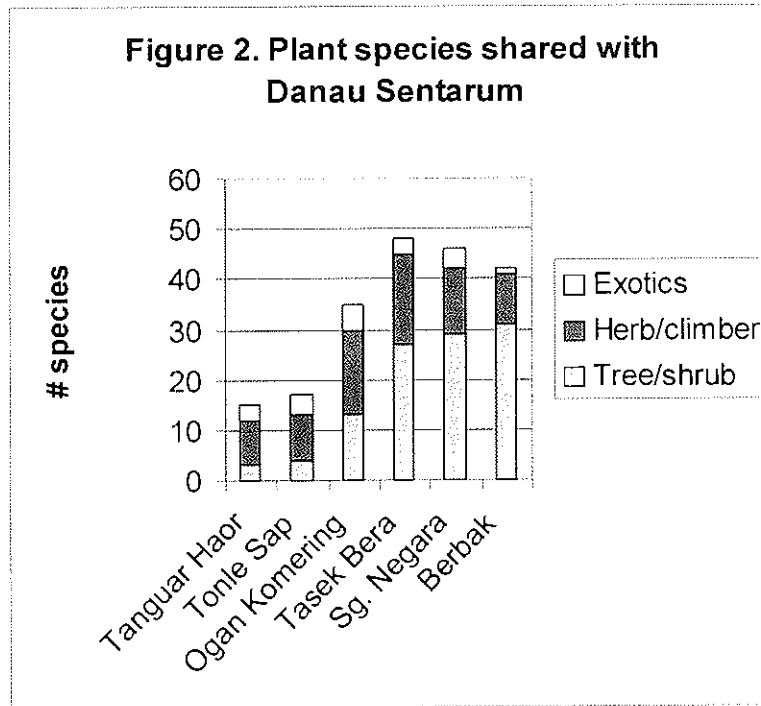
Fire is an all-important factor controlling vegetation patterns at DSNP. From studies of remote sensing imagery, combined with ground truthing, it is apparent that 18 percent of the 80,000 hectare reserve (= 24.8% of reserve forests) have been affected by fire over the past decades (see Dennis *et al.*, 2000). Vegetation studies of 27 formerly forested areas that had been burnt during the past decade showed that the species that most often survive a fire are: *Shorea balangeran* (*kawi*; in 80% of fires), *Crudia teysmannia* (*timba tawang*; 65%), *Mesua hexapetalum* (*kamsia*; 51%) and *Syzygium* sp. 120 (*tengelam*; 51%). This does not mean that many trees survive a fire: for a given fire survival may vary between 0-25 percent of all trees. On average, however, about 1-3 percent of all trees appear to survive a typical fire. Survival is important for recruitment, and relatively fire-tolerant species such as the aforementioned four are most likely to form an important element in the recovering vegetation. Of these four species, *kawi* survives in the greatest numbers. A second important element in areas recovering from fires are the pioneer species; i.e. those species that newly establish themselves from propagules (seeds, fruit). The most important pioneer species observed at burnt sites at DSNP are shrubs *Croton* cf. *ensifolius* (*melayak*), *Ixora mentanggis* (*mentangis*) and *Timonius salicifolius* (*kerminit*), and the herbs *Polygonum* spp. *lembung* and *kumpai* (various grasses).

## DISCUSSION

### *Plant diversity*

Dwarf swamp forests are very low in plant diversity, having an average of only 10 species per transect of 10 by 100 meters (0.1 ha), and a maximum of 15 species. Stunted swamp forest is somewhat richer, with an average of 17-18 species per transect and a total of 60 species. Most diverse among the wetland habitats is tall swamp forest, with an average of 20-29 species and a total of 127 species. Riparian forests are of intermediate diversity, having about 20 species on average, and a total of 35 species. Plant diversity in the various wetland habitat types is low compared to Malesian lowland forest, where 120-180 species may be found in a one hectare plot (Whitmore, 1984). It is comparable to Southeast Asian peat swamp forests such as in Peninsular Malaysia, where tree species diversity of 0.4-1.0 hectare plots may range from 54 (Shamsudin and Chong, 1992) to 132 (Ibrahim, 1997), and more than 150 plant species have been recorded by Latiff (1997). Peat swamp forests of Sarawak appear to be more diverse, and Anderson (1963) recorded 242 tree species alone in this habitat. The variety of habitat types in the Danau Sentarum area contributes to overall diversity. The total of 262 plant species recorded in the swamp forests of Danau Sentarum is almost identical to that of the swamp forests of Berbak National Park in Jambi, Sumatra, where Giesen (1991) recorded a total of 261 plant species. At DSNP 73 percent are trees and shrubs, while at Berbak this figure is 67 percent. This figure for DSNP (191) is intermediate between Pensinsular Malaysia and Sarawak.

Endert (1927) describes similar forests from the lake district of the Mahakam River in East Kalimantan, but these forests have now largely disappeared, and the Mahakam lakes have subsequently become choked with floating aquatic weeds, especially waterhyacinth *Eichhornia crassipes* (pers. comm. Head of Provincial Planning Bureau, "Bappeda," East Kalimantan, 1993). In addition, formerly forested areas around the Mahakam lakes have become infested with the exotic Giant Mimosa *Mimosa pigra*. Swamp forests along the east coast of Sumatra are taller and of a quite different species composition, perhaps owing to the higher nutrient levels of waters. Lakes and swamp forests along the Siak Kecil River in Riau, Sumatra, occur on deep to very deep peat, and few species are shared with DSNP (Giesen and van Balen, 1992).



Source of data: Sungai Negara (Giesen, 1989), Ogan-Komerling (Giesen and Sukotjo, 1991), Berbak (Giesen, 1991), Tasek Bera (Giesen, 1998b), Tonle Sap (Davies and Mundkur, 1994; Giesen, 1998a) and Tanguar Haor (Giesen and Rashid, 1997).

Plant species shared between Danau Sentarum and a number of key freshwater wetlands in South and Southeast Asia are summarized in Figure 2. Floristically, DSNP is most similar to the swamp forests of Berbak (Jambi, Sumatra), Sungai Negara (South Kalimantan) and Tasek Bera (Peninsular Malaysia), with which it shares 42, 46 and 48 species, respectively. If easily dispersed (and often "weedy") herbaceous species and exotics are excluded, Danau Sentarum is most similar to Berbak, with which it shares 31 trees and shrubs. 13 tree and shrub species are shared with the Ogan Komerling lebaks in South Sumatra; this low figure is probably due to the long history of logging and burning, which has impoverished the woody vegetation in this part of South Sumatra. Only 3-4 non-exotic tree and shrub species are shared with Tonle Sap (Cambodia) and Tanguar

Haor (Bangladesh), namely *Barringtonia acutangula*, *Crateva religiosa*, *Ficus heterophylla* and *Melastoma malabathricum*. Forests around Tonle Sap are highly disturbed and few mature stands remain. *Barringtonia*-dominated swamp forest vegetation occurs westward up to Afghanistan and India (Heyne, 1950), but these forests are invariably greatly disturbed and poor in species. In Bangladesh last vestiges of depleted swamp forest remain in the *haor* region in the northeastern part of the country (Giesen and Rashid, 1997).

#### **Aquatic vegetation**

Although once very similar to Danau Sentarum, the Mahakam lakes have changed significantly, as most of the forests have disappeared or are greatly disturbed, lake waters are choked with waterhyacinth, and fisheries have declined dramatically (Dunn and Otte, 1983; Bappeda, pers. comm. 1993). As waterhyacinth was already present in the Mahakam in 1925, the more recent proliferation of this weed species in the lakes is probably due to changes in nutrient status of the waters. This appears to be linked with changes in the catchment, as Dunn and Otte (1983) show that the decline in Mahakam lakes fisheries (from late 1960s onwards) coincided with increased logging in the Mahakam River basin. At Danau Sentarum, water acidity and nutrient status appear to be limiting waterhyacinth growth. According to Oki *et al.* (1978) and Carlander (1980), the threshold level of  $\text{Ca}^{2+}$  for waterhyacinth growth is 120  $\mu\text{Mol/liter}$  (= 4.8 mg/l), which is 4.5-24 times the average  $\text{Ca}^{2+}$  concentration found in the Kapuas lakes (Giesen, 1987). This also explains why waterhyacinth survives in village waters and near the Kapuas River, as nutrient levels are higher in these locations.

#### **Flooding and habitat types**

The single most important factor governing the distribution of the different vegetation types is depth and duration of flooding, and structurally, the stunted swamp forest of Danau Sentarum is very similar to the *Várzea* swamp forests of Amazonia (Richards, 1972), where similar flooding regimes occur. Dwarf swamp forest is flooded on average for a period of 9.5 months per year, by water depths with an average maximum of 5.5 meters. During some years, such as 1995, flooding is year-round, and this vegetation may be (partly-) submerged for up to 21 months at a time. Stunted swamp forest is flooded for an average of 6 months per year, with waters of up to 3.5 meters deep, while for tall swamp forest these figures are 2-3 months and 1-2.5 meters. The flooding regime appears to have a greater effect on vegetation structure (dwarf, stunted, tall forest) than on floristic composition, as there is no apparent correlation with the latter. All tree species examined in Danau Sentarum's swamp forests appear to have growth rings. These may be associated with the flooding regime, as annual floods lead to a period of relative dormancy, and the drier period is a time of growth.

Flowering and fruiting of trees and shrubs at Danau Sentarum show a degree of synchronicity linked with flooding. Although there are always a number of trees and shrubs that flower or bear fruit, there is a marked increase as floodwaters rise. This has not gone unnoticed, as local fishermen are well aware that the arrival of the migratory bees (*Apis dorsata*) that form the basis of the local honey industry (Rouquette, 1995), occurs simultaneously with the rise of the floodwaters. There is an ecological advantage for flowering and fruiting in the wet season, as the fruits of many species float and are dispersed by flood waters. An interesting characteristic is that many local swamp forest

fruits are sour, even when fully ripe, probably due to high levels of citric and ascorbic acids (Vitamin C). This is possibly parallel to the situation in Amazonia, where many fruits are dispersed by fish that are attracted by sour fruit. This response is selected upon, as fish are unable to produce these essential compounds (pers. comm. C. Peters, 1994).

### Soils and habitat types

Differences between soil types appear to be less important in determining vegetation patterns than the flooding regime. Tall swamp forest occurs both on peat and mineral soil, but the two types of tall swamp forest recognized, *Kelansau-Emang-Melaban* and *Ramin-Mentangur*, are not strongly linked with either soil type. The distinction between hill forest and heath forest is strongly determined by soil type and geomorphology. Hill forest at DSNP occurs on slopes where the soil has a large fraction of clay minerals and where soil moisture is higher, whereas heath forest occurs on areas with leached, dry, sandy soils.

### Clearing and logging

Both the Malay and Dayak ethnic groups of the region traditionally practice swidden or *ladang*. Dayak generally practice *ladang* in dryland areas, while Malay cultivate the levees of larger rivers. As most of the hills in and immediately adjacent the Park have highly infertile soils, there are few Dayak *ladang* and their impact is small. Dayak *ladang* are significant only on the hills near Lanjak, around Gunung Kenepai south-west of the Park, and in the Lempai range west of DSNP. *Ladang* practices of the Malay probably have a greater effect on DSNP, as it leads to direct loss of riparian habitat. This habitat is small in area, and it is estimated that already more than half of the Park's riparian forests had been lost to shifting cultivation by 1994, especially along the Tawang, Tengkidap and Belitung/Ketam rivers. Where fields have been abandoned for a long time, a secondary vegetation type appears dominated mainly by a few shrubby species rather than taller trees characteristic of the original vegetation. The clearing of sites for settlements has a very localized direct effect, and only a small area (35 ha) has been cleared to date for this purpose. However, as settlements are located on the levees of the major streams, this contributes to pressures on vulnerable riparian habitat.

Commercial logging commenced in the Danau Sentarum area south of the Menyukung range to the southeast of the Park in 1978. In the 1980s, four logging concessions bordered on the Park and concentrated on selective logging of tall swamp forest. By the mid-1990s these companies had stopped or were on the verge of closing down, as most tall swamp forests in and around the Park had been logged. There is evidence that (illegal) logging has commenced again since 1997 (Wadley *et al.*, 2000). Logging occurred in a number of tall swamp forest areas within the 80,000-hectare reserve prior to gazettal in 1982, including 200 hectares at Danau Pemera and 150 hectares south of Bukit Pegah. Most of these selectively logged forests are regenerating well, and are expected to have retained most plant species. Fast growing tree species such as *Calophyllum* Mentangur species tend to dominate these regenerating swamp forests. The lack of commercially interesting timber in the dwarf and stunted swamp forests of Danau Sentarum protected these areas from logging. A more insidious type of logging is the small scale felling of trees that takes place within the Park by local inhabitants. Much of this concentrates on timber for local use, and specifically targets *Shorea balangeran* and *Fagraea fragrans*, and large specimens of the latter are becoming rare (Peters, 1994).

## Fires

Reports of forest fires in the Danau Sentarum area date back to the last century. Ida Pfeiffer (1856) observed extensive areas of burnt stumps, while Gerlach (1881) reports of extensive fires in the forests in the northwestern part of the current park, near Pulau Majang. Molengraaff (1900) records fisherfolk igniting the forest during the dry season, but Polak (1949) could not find traces of burnt forest in spite of specifically looking for them. Vaas (1952) suggested that the latter may be explained by a lack of fishing during the Second World War. Studies carried out by UK-ITFMP show that the incidence of burning has increased significantly since 1990, but causes remain speculative (see Dennis *et al.*, 2000).

Both dwarf and stunted swamp forests at Danau Sentarum are prone to fires, possibly due to the accumulation of large amounts of organic matter in the wet months, in combination with desiccation in the dry season. As van Steenis (1957) pointed out, "Fire is one of the greatest enemies of the swamp forest ... this type of forest is definitely flammable and is attacked by fishermen." Most fires are caused by human activities, and the more pronounced a dry season, the higher the number of fires and extent of burning (Aglionby, 1997). Studies of pioneer and surviving plant species in burnt areas at DSNP strongly suggest that forests subjected to (infrequent) fires are characterized by fire-tolerant surviving species such as *kawi*, *kamsia*, *timba tawang* and *tengelam*. This indicates that *Shorea balangeran*-dominated stunted swamp forest may be derived from the more diverse Kenarin-Menungau-Kamsia stunted swamp forest by irregular burning. This supports the hypothesis by MacKinnon (1983) about the origin of *Shorea balangeran*-dominated forests in the Tanjung Puting National Park in Central Kalimantan.

Areas that are more frequently burnt are likely to be dominated by rapidly colonizing, shrubby pioneer species such as *kerminit*, *melayak* and *mentangis* shrubs, which are dominant species of the dwarf swamp forest. Large areas of this dwarf swamp forest occur in the northern and northwestern part of the Park, in areas where stunted swamp forest is to be expected on the basis of flooding depth and duration. While this habitat appears to be linked with deep and prolonged flooding, it is apparently also connected with repeated burning. A similar pattern was found by Giesen (1989) in the Sungai Negara swamp forests of South Kalimantan, where infrequent fires lead to domination by *Shorea balangeran* and *Combretocarpus rotundifolius*, while more frequently burnt areas were dominated by *Melaleuca cajuputi* (*gelam*).

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## APPENDIX I: PLANTS OF DANAU SENTARUM NATIONAL PARK

#	Family	Species	Number	Identification	Local name(s)	Habitat
1	Acanthaceae	<i>Pseuderanthemum</i> sp.	520	Bogor	?	C
2	Amaranthaceae	<i>Alternanthera sessilis</i>	---	WoR	Lembu seluang	D
3	Anacardiaceae	<i>Camposperma auriculata</i>	---	WTM	Beringin	Ci
4		<i>Gluta pubescens</i>	---	FM	Kebacar	Ci
5		<i>Gluta renghas</i>	40	Leiden	Rengas	D
6		<i>Gluta wallichii</i>	---	FM	Rengas manuk	Ci
7		<i>Gluta</i> sp.	393	---	Rengas manuk	Ci
8		<i>Mangifera</i> sp.	377	Bogor	Rabu	Bi
9		<i>Semecarpus glaucus</i>	56	Leiden	Temelak	Ci
10		<i>Swintonia</i> sp.	---	FM	Kerintah, Kerintak	C(E)
11		?	---	---	Ubal	F
12	Annonaceae	<i>Polyalthia</i> sp.	137	Leiden	Lada	F
13		<i>Xylopia</i> sp.	---	WTM	Jankar/ Jangkang	Ci
14		?	489	---	Akar tuiang salai	D
15	Apocynaceae	<i>Dyera ?polyphylla</i>	---	WTM	Jelutung	Cii
16		<i>Tabernaemontana</i> sp.	135a	Leiden	Lada (Iban)	F
17		?	72	---	?	E
18	Aquifoliaceae	<i>Ilex cymosa</i>	444/ 012	Bogor, Leiden	Telur	B, Ci
19	Araceae	<i>Aglaeonema minus</i>	565	Bogor	Keladi rimba	E
20		<i>Aglaeonema simplex</i>	76	Leiden	Rumput ilung	E
21		<i>Pistia stratiotes</i>	---	---	Rumpur tempu-rung penuh	lake
22	Araliaceae	<i>Schefflera avensis</i> (Miq.) Harms	541	Bogor	?	E
23		<i>Schefflera</i> sp.	130	Leiden	?	Bii
24	Arecaceae	<i>Calamus myriacanthus</i> Becc.	111	Drans-field	Rotan makup	Ci, E
25		<i>Calamus schistoacanthus</i> Bl.	449	Dransfield	Rotan duri antu	B, C
26		<i>Calamus zonatus</i> Becc.	134	Dransfield	Rotan duri antu kerangas	F
27		<i>Calamus</i> sp.	---	---	Rotan duri maram	E
28		<i>Calamus tapa</i> Becc.	---	Dransfield	Rotan tapah	B, Ci, E
29		<i>Calamus</i> sp.	---	---	Rotan tunggal	Ci, E
30		<i>Ceratobus hallierianus</i> Dransfield	---	Dransfield	Rotan pelanduk	B,C, (E)
31		<i>Daemonorops hystrix</i>	359	Dransfield	Rotan duri	E

		<i>(Griff.) Mart. Var.</i>			seni	
32		<i>exulans</i> Becc.				
		<i>Eugeissonia ambigua</i>	---	Beccari, Polak	Ransa	E
33		<i>Korthalsia</i> sp.	---	---	Rotan tikus	C
34		<i>Licuala</i> sp.	---	---	Gernis	C
35		<i>Oncosperma horrida</i> Scheff.	---	Polak	?	E
36		<i>Plectocomiopsis triquetra</i> (Becc.) J. Dransf.	135b	Dransfield	Rotan udang	(C), F
37		?	---	---	Rotan telian	C, E
38	Asclepiadaceae	<i>Dischidia nummularia</i>	---	---	Akar kancing	B, C
39		<i>Dischidia</i> sp.	504	---	?	Ci
40		<i>Hoya macrophylla</i> Bl.	465	Bogor	Litap	B, C
41	Asteraceae	<i>Ageratum conyzoides</i> L.	327	Bogor	?	H
42		<i>Vernonia arborea</i> Buch.- Ham.	322	Bogor	Bungkok	E, H
43	Bambusoideae	?	---	---	Bambu	E, H
44	Begoniaceae	<i>Begonia</i> sp.	566	Bogor	?	E
45	Bombaceae	<i>Durio kutejensis</i>	---	WTM	Empe-kung	E
46		<i>Durio</i> sp. (? <i>excelsus</i> )	---	WTM	Durian bukit	E
47		<i>Durio</i> sp.	---	---	Durian burung	E
48	Burmanniaceae	<i>Burmannia lutescens</i>	---	FM	?	E
49	Burseraceae	<i>Dacryoides laxa</i>	78	---	Tulang salai	E
50		<i>Dacryoides rostrata</i> (Bl.) <i>H.J.L. f. rostrata</i>	369	Bogor	Kema-yau	Bii, Ci, D
51		<i>Santiria ?griffithii</i>	---	FM	Bunyau	C
52	Capparaceae	<i>Crateva religiosa</i> Forst. F.	350/19	Bogor	Punggu	A, D
53	Casuarinaceae	<i>Gymnostoma sumatrana</i> (Jungb. Ex de Vriese) L.J.	47	Bogor	Embun	Cii
54	Coniferae	<i>Dacrydium beccari</i>	---	WTM	Embun	E
55	Connaraceae	<i>Connarus monocarpus</i> L. ssp. <i>Malayana</i> Leenh.	490	Bogor	Akar libang	Ci, D
56		<i>Connarus villosus</i> Jack.	506	Bogor	Tunjuk maias	C
57	Convolvulaceae	<i>Aniseia martinicensis</i> (Jacq.) Choisy	473	Bogor	Akar ginta	G, H
58		<i>Merremia hederacea</i>	---	FM	Akar kermibit	D, G, H
59	Cyperaceae	<i>Cyperus brevifolia</i> (Rottb.) Hassk	333	Bogor	Rumput terisit	G, H
60		<i>Cyperus trialatus</i> (Boeck.) Kern	334	Bogor	Rumput terisit	G, H
61		<i>Fimbristylis dichotoma</i> (L.) Vahl	326/125	Bogor	Rumput pulum	D, G, H
62		<i>Fimbristylis dipsacea</i>	---	FM	Semperai, Padi hantu	A, B
63		<i>Fimbristylis miliacea</i> (L.) Vahl	---	Bogor	Rumput terisit	B
64		<i>Hypolytrum capitulatum</i> Valck. Sur. Ex Clarke	330/126	Bogor, Leiden	Rumput musi	B, C
65		<i>Hypolytrum nemorum</i>	105/110	Leiden	Rumput	B, C

66		<i>Mapania cuspidata</i> var. <i>cuspidata</i>	---	FM	musi ?	Ci
67		<i>Rhynchospora aurea</i>	---	Polak	?	B,C
68		<i>Scleria ciliaris</i>	104/109	Bogor	Rumput terisit	B,C
69		<i>Scleria purpurescens</i>	---	FM	Terisit	B,C
70		<i>Scleria sumatrensis</i>	---	FM	Lembang	C
71		<i>Tetraria borneensis</i>	485	FM	Lembang	C
72		<i>Thoracostachyum bancanum</i>	105	Leiden	Rumput musi	B,C
73	Datisceae	<i>Octomele sumatrana</i>	---	---	Benuang kunit	B,D
74	Dilleniaceae	<i>Dillenia beccariana</i>	6	Bogor	Ringin, Juin(g)	D
75		<i>Dillenia excelsa</i>	---	WTM	Ringin, Juin(g)	C,D
76		<i>Dillenia</i> sp.	---	---	Juing rimba	C
77	Dioscoreaceae	<i>Dioscorea</i> sp.	---	Polak	?	G
78	Dipterocar- paccae	<i>Anisoptera grossivenia</i>	---	FM	Penyau	E
79		<i>Cotylelobium burkii</i>	---	FM	Pukul kawi	E
80		<i>Dipterocarpus crinitus</i>	---	---	Resak (k)emperas, r. empelas	E
81		<i>Dipterocarpus gracilis</i>	---	FM	Tempurau	Ci,E
82		<i>Dipterocarpus nudus</i>	---	FM	Tenkabang tikus	Ci
83		<i>Dipterocarpus tempehes</i>	---	FM	Ran	E
84		<i>Dipterocarpus validus</i> Bl.	---	Polak	Tempurau	Ci,E
85		<i>Dryobalanops abnormis</i> Gaertn.f.	---	Teysmann	Kelansau, Keladan	Ci
86		<i>Dryobalanops rappa</i> Becc.	---	FM	Kelansau, Kemerauan	C
87		<i>Dryobalanops oblongifolia</i> Dyer	---	FM	Kelansau bukit	E
88		<i>Hopea dasyrrhachis</i> Ashton	---	Bogor	Tekam air	Ci,D
89		<i>Hopea mengerawan</i> Miq.	---	De Mol	Emang	Ci
90		<i>Hopea rudiformis</i>	---	FM	Emang bahau	Cii
91		<i>Parashorea</i> ? sp.	---	FM	Resak barah	E
92		<i>Shorea balangeran</i> (Korth.) Burck	141	Leiden	Kawi	Bii,Ci
93		<i>Shorea</i> ? <i>beccariana</i>	---	FM	Teng- kawang rambai	C
94		<i>Shorea laevis</i>	---	---	Masang	F
95		<i>Shorea leprosula</i>	---	---	Rup, Penge- rawan lampung	Ci,E,F
96		<i>Shorea multiflora</i>	---	---	Barit	E
97		<i>Shorea pachyphylla</i>	---	---	Tegelung	Ci,E
98		<i>Shorea palembanica</i>	---	---	Majau	E
99		<i>Shorea pauciflora</i>	---	---	Balik	F
100		<i>Shorea quadrinervis</i>	---	---	Tengka-	F

101		<i>Shorea seminis</i>	422/390	Bogor	wang tikus	
102		<i>Shorea smithiana</i> Sym.	357	Bogor	Kerintak	Ci,D,E
103		<i>Shorea uliginosa</i>	---	---	Teng-kawang	E
104		<i>Shorea</i> sp.	---	---	Penge-rawan	
105		<i>Shorea</i> sp.	---	---	buaya	Ci
106		<i>Shorea</i> sp.	---	---	Emang melapi	E
107		<i>Vatica cinerea</i>	---	---	Kerintak	E
108		<i>Vatica micrantha</i> Hook.	356	Bogor	patung	
109		<i>Vatica cf. unbronata</i>	450,416, 340	FM, Bogor	Meranti	E
110		<i>Vatica venulosa</i>	---	FM	bunga, M. timbul, Keme-rauan	
111		<i>Vatica</i> sp.	---	---	Resak padi	F
112		?	---	---	?	D,E
113		?	---	---	Menu-ngau	B
114		?	---	---	Resak	B,Ci
115		?	---	---	seluang	
116		?	---	---	Meng-gung	E
117		?	---	---	resak	
118	Ebenaceae	<i>Diospyros coriacea</i> Hiern.	445, 342, 66	Leiden, Bogor	Resak bukit	E,H
119		<i>Diospyros maritima</i> Bl.	535	Bogor	Resak	C
120		<i>Diospyros</i> sp.	---	---	danau	
121	Elaeocarpaceae	<i>Elaeocarpus mastersii</i> King	560	Bogor	Resak jabai	C
122		<i>Elaeocarpus sphaerocarpa</i>	330	---	Resak labu	C
123		<i>Elaeocarpus submonoceras</i> Miq.	303	Bogor	Tekam	C
124		<i>Elaeocarpus</i> sp.	565	Bogor	beruk	
125	Ericaceae	<i>Rhododendron longiflorum</i>	410	Argent	Tekam	C
126		<i>Vaccinium bigibbum</i> JJS	042n	Bogor	tembaga	
127		<i>Vaccinium clementis</i> Merr.	549	Bogor	Kenarin,	B
128		<i>Vaccinium</i> sp.	065	Leiden	Mengku	
129		<i>Vaccinium</i> sp.	425	---	?	Ci
130	Euphorbiaceae	<i>Antidesma bunius</i>	354	Bogor	Malam	C,E
131		<i>Antidesma stipulare</i>	55/58	Leiden	Ensubal	E
132		<i>Antidesma venenosum</i> F. Mey ex Tul.	368	Bogor	Menyawai	(B),D
133		<i>Antidesma</i> sp.	---	---	Menyawai	(B),D
134		<i>Aporosa confusa</i> Gage.	362	Bogor	Engkunik	E

135		<i>Aporosa lunata</i> (Miq)Kurz	365	Bogor	?	E
136		<i>Aporosa</i> sp.	518/ 518B	Bogor	Keranjik tikus	C
137		<i>Baccaurea bracteata</i> MA	557	Bogor	?	E
138		<i>Baccaurea javanica</i> (Bl.) M.A.	341	Bogor	Engkunik	Bi
139		<i>Baccaurea racemosa</i> (Reinw. Ex.Bl.)Muell.Arg	019n	Bogor	Engkunik	Bi
140		<i>Baccaurea reticulata</i> (Ptychopyxix javanica (JJS) Croizet)	---	Airy Shaw (de Mol)	Suluh, Menu- ngan, Engkupa	B
141		<i>Breynia microphylla</i> (Kurz. Ex. T&B)M.A.	325	Bogor	Tarum buaya	D
142		<i>Cheilosa malayana</i>	---	---	Gurak	F
143		<i>Cleistanthus sumatranus</i> (Miq) M.A.	435, 315, 344	Bogor	Keretih	B,D
144		<i>Cleistanthus</i> sp.	---	---	Keretih bukit	E
145		<i>Cleistanthus</i> sp.	397	---	Punan	D
146		<i>Croton cf. ensifolius</i>	81, 314	Bogor	Melayak	A
147		<i>Dicoelia beccariana</i>	71, 378	Leiden	Kemelat, Belat	A,B
148		<i>Excoecaria indica</i> ( <i>Sapium indicum</i> )	---	WTM	Kebuau	D
149		<i>Galaeria fulva</i>	97	Leiden	Manyam rimba	Ci
150		<i>Glochidion borneense</i> (M.A.) Boerl.	499	Bogor	Manyam	D,H
151		<i>Glochidion</i> sp.	487	---	Manyam	Bi,Ci
152		<i>Glochidion</i> sp.	400	---	?	D,H
153		<i>Glochidion</i> sp.	---	---	Rambai	D
154		<i>Homalanthus populneus</i> (Geisel) Pax	364	Bogor	?	E,H
155		<i>Macaranga denticulata</i>	012	---	Ketali	E,H
156		<i>Macaranga gigantosa</i>	---	WTM	Merku- bung	E,H
157		<i>Macaranga triloba</i> f. <i>cornuta</i>	---	WTM	Garong	E,H
158		<i>Macaranga</i> sp.	---	WTM	Merpuah	E
159		<i>Macaranga</i> sp.	364	---	Purang	E,H
160		<i>Macaranga</i> sp.	---	---	Purang bukit	E,H
161		<i>Macaranga</i> sp.	073	---	Purang garong	E,H
162		<i>Macaranga</i> sp.	099	---	Purang tikus	E,H
163		<i>Mallotus sumatranus</i>	087,392, 433	Bogor, Leiden	Belantik	(B)D
164		<i>Neoscortechimia</i> sp.	147	Leiden	Teluk	E
165		<i>Sapium discolor</i>	---	---	Sengka- yang	E,F
166	Fabaceae	<i>Bauhinia</i> sp.	131	Leiden	Akar entalang	F
167		<i>Cassia alata</i>	---	---	Scrugan	D,H
168		<i>Crudia teysmannii</i>	064,306	Bogor, Leiden	Timba tawang	B,D



169		<i>Desmodium capitatum</i> (Burm.f.)DC.	332	Bogor	?	(E),H
170		<i>Dialium</i> sp.	375,434	Bogor	Keranjik madu	E
171		<i>Dialium</i> sp.	---	---	Keranjik tikus	E
172		<i>Erythrina</i> sp.	---	---	Dadap hutan	C
173		<i>Fordia splendissima</i>	446	Bogor	Limau antu	B
174		<i>Intsia ?palembanica</i>	---	WTM	Senah	C
175		<i>Kingiodendron</i> sp.	---	---	Sempetir	E
176		<i>Koompassia malaccensis</i>	---	WTM	Menggeris	E
177		<i>Mimosa pigra</i>	---	---	Putri malu	D,H
178		<i>Mucuna</i> sp.	048	Leiden	Akar limbai	D
179		? <i>Ormosia</i> sp.	396	---	Telempi Kelempi	B,D
180		<i>Phanera</i> sp.	131	Leiden	Entalang	F
181		<i>Pterocarpus</i> sp.	---	WTM	Senah	E,F
182		<i>Sindora leiocarpa</i>	---	WTM	Sindur	Ci
183		<i>Sindora</i> sp.	---	WTM	Sempetir	Ci
184		<i>Sindora</i> sp.	---	---	Tampar hantu	E
185		?	---	---	Kacang pelanduk	C
186		?	571	---	Leceng kera	B,D
187	Fagaceae	<i>Castanopsis</i> sp.	567	FM	?	E
188		<i>Lithocarpus curtisii</i> (King Hk.f.)A. Camus	544, 546	Bogor	(K)empe- lik (-babi)	E,F
189		<i>Lithocarpus</i> sp.	401, 402	FM	Kempilik	E,F
190		<i>Lithocarpus</i> sp.	---	---	Kempilik babi	E,F
191		<i>Lithocarpus</i> sp.	---	---	Kempilik batu	E,F
192		<i>Lithocarpus</i> sp.	394	---	Kenual babi	D
193	Flacourtiaceae	<i>Casearia</i> sp. nov.	Coll.	FM	Limut	B,C,D
194		<i>Flacourtia rukam</i> Z&M	367	Bogor	Rukam	D
195		? <i>Flacourtia</i> sp.	---	---	Mandin	D
196		<i>Homalium</i> <i>caryophyllaceum</i>	115,309, 431	Leiden	Perkeras, Empalinas	B,Ci
197		<i>Homalium</i> sp.	---	---	Perkeras bukit	E
198		<i>Hydnocarpus polypetala</i>	088	FM	Cugut	(B),D
199	Flagellariaceae	<i>Flagellaria indica</i> L.	---	WG, Polak	Rotan tikus	D,E
200		<i>Hanguana malayana</i>	---	Ross	?	Lake
201	Gesneriaceae	<i>Aeschynanthes</i> sp.	523	---	?	Ci
202		<i>Cyrtandra oblongifolia</i>	084	Leiden	Kumis kucing	G,H
203		<i>Didymocarpus</i> sp.	525	Bogor	?	E
204		<i>Didymocarpus</i> sp.	070	---	Rumput ilung	E
205	Gnetaceae	<i>Gnetum ?neglecta</i>	108	Leiden	Akar bunsoi	Ci
206	Guttiferac	<i>Calophyllum</i> <i>macrocarpum</i>	---	---	Bunan	F
207		<i>Calophyllum</i> <i>sclerophyllum</i> Vesque	537	Bogor	Mentangur kunyit	C

208		<i>Calophyllum</i> sp.	---	WTM	Bereng- kajang	Ci
209		<i>Calophyllum</i> sp.	---	WTM	Kacang	C
210		<i>Calophyllum</i> sp.	---	---	Mentangur batu	Ci,E
211		<i>Calophyllum</i> sp.	---	---	Mentangur bukit	E
212		<i>Calophyllum</i> sp.	---	---	Mentangur umut	C
213		<i>Calophyllum</i> sp.	491	---	Timbung	Ci
214		<i>Garcinia bancana</i>	339	Bogor	Sikup	B, C
215		<i>Garcinia borneensis</i> <i>Pierre.</i>	374	Bogor	Empanak	A,B
216		<i>Garcinia parvifolia</i> Miq.	338,358	Bogor	Kandis, Kundong	E,H
217		<i>Garcinia rostrata</i> ( <i>Hassk.</i> ) Miq	024, 480, 533	Bogor	Sikup rimba (Tulang ular)	C
218		<i>Garcinia</i> sp.	---	---	Kerat dila	Ci
219		<i>Garcinia</i> sp.	513	---	Kerin timah	C
220		<i>Garcinia</i> sp.	---	---	Ransi, Dila berkatak, Krupuk, Merkunyt	D
221		<i>Garcinia</i> sp.	---	---	Sikup ruai	F
222		<i>Mesua congestiflora</i> <i>P.V.Stevens</i>	517	Bogor	Kamsia rawa	Ci
223		<i>Mesua hexapetalum</i> ( <i>Hook.f.</i> ) <i>P.F.S.</i>	139, 345, 386, 452	Bogor	Kamsia	B
224		<i>Mesua</i> sp.	---	De Mol	Melanyan	C,F
225	Hamameli- daceae	<i>Rhodoleia</i> sp. <i>nov.</i>	381	Vink, Leiden	Isang dungan	B,D
226	Hypericaceae	<i>Cratoxylon arborescens</i>	---	---	Temau	C
227		<i>Cratoxylon glaucum</i> <i>Korth.</i>	550	Bogor	Temau	E
228	Lamiaceae	<i>Hyptis brevipes</i> <i>Poit.</i>	329	Bogor	?	G,H
229	Lauraceae	<i>Actinodaphne</i> sp.	---	Polak	?	E
230		<i>Cassytha filiformis</i>	496	Leiden	?	A
231		<i>Cinnamomum</i> sp.	---	WTM	Cendana	C
232		<i>Cinnamomum</i> sp.	---	---	Kulit lawang	Ci
233		<i>Cinnamomum</i> sp.	---	Teysmann	Sinduk, Sicntok	C,E
234		<i>Litsea</i> sp.	576	Bogor	Lilin	B,D
235		<i>Litsea</i> sp.	---	---	Medang bukit	E
236		<i>Litsea</i> sp.	---	---	Medang danau	C
237		?	---	---	Medang burung	C
238		?	---	---	Medang kalah	C
239		?	---	---	Medang keladi	C
240		?	---	---	Medang kerapah	C

241		?	---	---	Medang	C
242		?	---	---	kumbang Medang	C
243		?	---	---	lampung Medang	C
244		?	---	---	lebar daun Medang	C
245		?	---	---	libas Medang	C
246		?	---	---	meningkat Medang	C
247		?	---	---	patung Medang	C
248		?	---	---	perawas Medang	C
249	Lecythidaceae	<i>Barringtonia acutangula</i> <i>ssp. Acutangula</i>	011, 129	Leiden	Putat	A,D
250		<i>Barringtonia reticulata</i> (Bl.) Miq.	471	Bogor	Putat rimba	Ci
251		<i>Barringtonia</i> sp.	360	Bogor	Karut	E,H
252	Leeaceae	<i>Leea indica</i>	050	Leiden	Temali	D
253	Loganiaceae	<i>Fagraea ceilanica</i>	124	Leiden	?	D
254		<i>Fagraea cf. ceilanica</i>	418,438	Leiden	Akar seraya	Bi
255		<i>Fagraea elliptica</i> Roxb.	335	Bogor	Tembesu	E,H
256		<i>Fagraea fragrans</i> Roxb.	148,301, 306	Bogor, Leiden	Tembesu, Tembesu liin, Tembesu rebung	B
257		<i>Fragraea racemosa</i> Jack ex Wall.	085, 361	Bogor	Tapak labi	D,E
258	Loranthaceae	<i>Amyema</i> sp.	138	Leiden	Akar serang	B
259		<i>Dendrophthoe falcata</i>	122a	Leiden	Akar bentak	B
260		<i>Dendrophthoe pentandra</i> (L) Miq.	573	Bogor	Akar bentak	A,B
261		<i>Elytranthe</i> sp.	122b	Leiden	Akar bentak	B
262		<i>Helixanthera</i> sp.	004, 441	Leiden	Akar serang	Bi, D
263		<i>Korthalsella cf.</i> <i>germinata</i>	10b, 474	Leiden	Paha buntak	A
264		<i>Lepeostegeres</i> sp.	132	Leiden	Akar serang	F
265		<i>Lepidaria forbesii</i>	---	WG, Danser	Akar serang	C
266		<i>Lepidaria</i> sp.	090	Leiden	Akar serang	D
267		<i>Macrosolen cochinchinensis</i> (Lour.) Tiegh.	469	Bogor	Akar serang	A,B
268		<i>Macrosolen</i> sp.	555	Bogor	Akar serang	B
269		<i>Scurrula fusca</i> (Bl) GDon	459	Bogor	Akar serang	A,B
270		<i>Viscum ovalifolium</i> Wall. ex DC	554	Bogor	Akar serang	B

271	Lythraceae	<i>Lagerstroemia speciosa</i>	366	WTM	Bungur	D
272	Malvaceae	<i>Hibiscus tiliaceus</i>	---	WTM	Waru	D,H
273	Marantaceae	<i>Donax canaeformis</i>	044	Leiden	Akar bemban	D,H
274	Melastomaceae	<i>Bellucia axinanthera</i>	015	Leiden	Jembu	E,H
275		<i>Blastus</i> sp.	075a	Leiden	pestor Akar	E
276		<i>Diplectria</i> sp.	069	Leiden	tebentak Kelemun- ting bukit	E
277		<i>Medinilla motleyi</i> <i>Hook.f.ex Triana</i>	492	Bogor	?	D
278		<i>Medinilla</i> sp.	100	Leiden	?	Ci
279		<i>Medinilla</i> sp.	547	Bogor	?	E
280		<i>Melastoma affine</i> D. Don.	320	Bogor	Kelemun- ting	E,H
281		<i>Melastoma</i> <i>malabathricum</i> L.	336	Bogor	Kelemun- ting	E,H
282		<i>Memecylon edule</i> Roxb.	004,351, 352	Bogor	(Ke)besi	A,B
283		<i>Memecylon laurinum</i> Bl.	020	Bogor	?	B
284		<i>Memecylon</i> sp.	---	---	Besi danau	Ci
285		<i>Oxy-spora</i> sp.	077	---	Akar kelempi	E
286		<i>Pachycentria constricta</i> Bl.	451	Bogor	Akar serang	A,B,C
287		<i>Pachycentria</i> sp.	075b, 096	Leiden	Akar tebentak	E
288		<i>Pogonantha</i> <i>pulverulantha</i>	468	Bogor	Asam riang	B,C
289		<i>Pternandra coerulescens</i> <i>Jack var. jackiana</i> C.B.C.	353, 502	Bogor	Kebesi rimba, Sang	B, Ci
290		<i>Pternandra galeata</i>	118	Leiden	Kelusuk bujang, Piuluk, Engklusuk	B,C,D
291		<i>Pternandra teysmanniana</i> (Cogn.) Ohwi	009, 458	Bogor	Gelagan	A, (D)
292		<i>Pternandra</i> sp.	---	---	Kelukuk bukit	E
293		?	---	---	Sebaipau	C
294	Meliaceae	<i>Aglaiia odoratissima</i>	061	Leiden	Pasak	D
295		<i>Aglaiia</i> sp.	527, 528	Bogor	Pinanga kenyala	E
296		<i>Chisocheton patens</i> Bl.	531	Bogor	?	C
297		<i>Dysoxylum</i> sp.	---	---	Ensunut	F
298		<i>Dysoxylum</i> sp.	---	---	Mengungan lemah	F
299		<i>Dysoxylum</i> sp.	---	---	?	Ci
300		<i>Sandoricum emarginatum</i>	---	---	Kapas	E
301	Moraceae	<i>Artocarpus kemando</i>	---	WTM	Puduk	Ci
302		<i>Artocarpus teysmannii</i>	443	WTM	Cempedak air	D
303		<i>Ficus consociata</i> Bl. Var. <i>murtoni</i> King	346	Bogor	Ara nasi	B
304		<i>Ficus deltoidea</i> Jack	z015	Bogor	?	B
305		<i>Ficus grossivenis</i> Miq.	312	Bogor	Lengkan besar	E,H

306		<i>Ficus grossularioides</i> Burm.f.	113, 313	Bogor	Lengkan kecil	E,H
307		<i>Ficus heterophylla</i> L.f.	324	Bogor	Luwak	B,D
308		<i>Ficus microcarpa</i>	083	Leiden	Jabai, Beringin	D
309		<i>Ficus obscura</i> var. <i>Borneensis</i> (Miq.) Corner	363	---	Karak	E,H
310		<i>Ficus punctata</i> Thunb.	529	Bogor	?	C
311		<i>Ficus</i> sp.	387	---	Ara	A
312		<i>Ficus</i> sp.	074	Leiden	Ara	E
313		<i>Ficus</i> sp.	---	---	Ara kiarak burung	B
314		<i>Ficus</i> sp.	---	---	Ara nakit	B
315	Myristicaceae	<i>Myristica glabra</i> Bl.	534	Bogor	Kumpang	Ci
316		?	---	---	Kumpang kiong	F
317	Myrsinaceae	<i>Ardisia colorata</i> Roxb. (? <i>Ardisia blumei</i> )	051, 080, 317, 376	Bogor	Sabar bubu, Tampoh bubu	B
318		<i>Labisia pumilis</i> (Bl.) F. Vill	503	Bogor	?	C
319		<i>Maesa ramentacea</i> (Roxb.) Wall.	466	Bogor	?	Cii
320		<i>Rapanea porteriana</i> Wall. ex A.DC.	540	Bogor	?	Cii
321		<i>Rapanea umbellulata</i>	484	Bogor	?	Cii
322	Myrtaceae	<i>Baeckia frutescens</i>	403	WTM	?	E,F
323		<i>Eugenia bankanensis</i> Backer	478	Bogor	Embun, Engkerabu	C
324		<i>Eugenia ?densiflora</i>	420	WTM	Jembu air	D
325		<i>Eugenia costulata</i> Elmer	481, 510	Bogor	Ensubal babi, ubah rimba	Cii
326		<i>Eugenia</i> sp.	558	Bogor	?	E
327		<i>Rhodomyrtus tormentosa</i> (W.Ait) Hassk.	319, 337	Bogor	Kelemuntin g jawa	E,H
328		<i>Syzygium claviflora</i> Roxb.	304, 442	Bogor	Masung	A,(B)
329		<i>Syzygium durifolium</i> Merr. & Perry	305, 373, 378	Bogor	Ubah	B
330		<i>Syzygium</i> sp.	476	---	Mata siluk	A,Bi
331		<i>Syzygium</i> sp.	002, 383, 384	---	Ramut, Jijap	A,B,D
332		<i>Syzygium</i> sp.	372	---	Samak	B
333		<i>Syzygium</i> sp.	---	---	Samak pepah	C
334		<i>Syzygium</i> sp.	120, 308	---	Tengelam	A,B
335		<i>Syzygium</i> sp.	018	---	Ubah putih	B
336		<i>Syzygium</i> sp.	493	---	Ubah bornean	D
337		<i>Syzygium</i> sp.	---	---	Ubah ketingan	D
338		<i>Syzygium</i> sp.	349	Bogor	?	Bi
339		<i>Tristaniopsis obovata</i>	---	WTM	Melaban	C,F
340		<i>Tristaniopsis</i> sp.	382	---	Adau	B,C
341		?	---	---	Ubah jambu	C
342		?	---	---	Ubah	C

343		?	---	---	kelumuh	
344		?	---	---	Ubah lilin	C
345		?	---	---	Ubah merah	
346		?	---	---	Ubah paya	C
347		?	---	---	Ubah ribu	C
					Ubah ternilas, ubah sempilas	
348	Nepenthaceae	<i>Nepenthes ampullaria</i>	---	Danser	Entuyuk	Cii,F
349		<i>Nepenthes gracilis</i> Korth.	509,539	Bogor	Entuyuk	C
350		<i>Nepenthes cf. gracilis</i> Ridl.	543	Bogor	Entuyuk	E
351		<i>Nepenthes mirabilis</i>	136	Leiden	Entuyuk	C,E,F, H
352		<i>Nepenthes rafflesiana</i> Jack.	562	Bogor	Entuyuk	E
353	Ochnaceae	<i>Brackenridgea palustris</i>	092	Leiden	?	Cii
354		<i>Brackenridgea serrulata</i>	---	Beccari	?	C
355		<i>Euthemis minor</i> Jack.	482, 548	Bogor	Jinta	Cii, E
356	Olacaceae	<i>Scorodocarpus borneensis</i>	---	FM	Kesinduk	E
357	Oleaceae	<i>Chionanthus laxiflorus</i> Bl.	559	Bogor	Ensubal	E
358	Onagraceae	<i>Ludwigia hyssopifolia</i>	328	WoR	?	G,H
359	Orchidaceae	<i>Apostaria</i> sp.	---	Polak	Anggrek	E
360		<i>Appendicula</i> sp.	063	Leiden	Anggrek	B
361		<i>Bromheadia finlaysoniana</i> (Lindl.) Rehb.f.	536	Bogor	Anggrek	C
362		<i>Dendrobium crumenatum</i> Swartz.	574	Bogor	Anggrek	B,C
363		<i>Dendrobium lamellatum</i>	067	Leiden	Anggrek	B,D
364		<i>Dendrobium</i> sp.	119	Leiden	Anggrek	D
365		<i>Dendrobium</i> sp.	455	---	Anggrek	Bi
366		<i>Dendrobium</i> sp.	551	Bogor	Anggrek	E
367		<i>Eria</i> sp.	---	Polak	Anggrek	E
368		<i>Grammatophyllum speciosum</i> Bl.	---	Teysmann, Polak	Anggrek	B,D
369		<i>Macrostylis</i> sp.	---	Polak	Anggrek	E
370		<i>Taeniophyllum obtusum</i>	460	---	Anggrek	A,B
371	Pandanaceae	<i>Freycinetia</i> sp.	---	---	?	C
372		<i>Pandanus helicopus</i>	---	---	Rasau	D
373		<i>Pandanus</i> sp.	477, 515, 545	Bogor	Kulan	Cii
374		<i>Pandanus</i> sp.	428	---	Kulan bukit	E
375		<i>Pandanus</i> sp.	---	---	Mengkuang	B,C,D
376		<i>Pandanus</i> sp.	---	---	Ngerin	C
377	Passifloraceae	<i>Passiflora foetida</i>	---	FM	Akar selasi dani	G,H
378	Piperaceae	<i>Piper</i> sp.	---	---	?	(E)H
379	Poaceae	<i>Digitaria</i> sp.	---	WoR	Sepit udang	D,G,H
380		<i>Echinochloa colomum</i>	---	WoR	Padi hantu, Padi pengalui	D,G,H
381		<i>Ischaemum intermedium</i>	---	WoR	Kumpai	D,G,H
382		<i>Leersia hexandra</i>	---	WoR	Kumpai	D,G,H

383		<i>Leptochloa chinensis</i>	---	WoR	Kumpai	D,G,H
384		<i>Ottachloa</i> sp.	---	WoR	Kumpai	D,G,H
385		<i>Panicum repens</i>	---	WoR	Kumpai berbulu	D,G,H
386		<i>Paspalum conjugatum</i>	---	WoR	Kumpai sepit udang	D,G,H
387		<i>Phragmites karka</i>	---	WoR	Keberuk	D,G,H
388		<i>Saccharum spontaneum</i>	---	WoR	Keberuk, Tebu air	D,G,H
389		<i>Sorghum oropinquium</i>	---	WoR	Kumpai	D,G,H
390	Podocarpaceae	<i>Dacrydium beccarii</i>	---	FM	?	E,F
391	Polygalaceae	<i>Xanthophyllum affine</i> <i>Miq.</i>	021, 079, 436, 440	Bogor	Merbemban	B
392		<i>Xanthophyllum</i> <i>flavescens</i> Roxb.	371, 453, 472	Bogor	Tengkurun g jelawat	B
393		<i>Xanthophyllum vitellinum</i> (Bl.) Dietr.	2022	Bogor	Lilin	B,D
394		<i>Xanthophyllum</i> sp.	---	---	Rinja	B,D
395	Polygonaceae	<i>Polygonum barbatum</i>	127	Danser	Rumput lembu seluang	G,H
396		<i>Polygonum celebicum</i>	091	Danser	Rumput lembu	G,H
397	Pontederiaceae	<i>Eichhornia crassipes</i>	---	---	Rumput piambang	G
398	Proteaceae	<i>Helicia cf. petiolaris</i>	432	FM	Putat rimba	Bi
399	Rhizophoraceae	<i>Carallia bracteata</i> (Lour.) Merr.	007, 031, 310, 512	Bogor	Tahun (Tulang ular)	A,B,C
400		<i>Combretocarpus</i> <i>rotundifolius</i>	---	FM	Maripat, Engkersit	Cii
401		<i>Pellacalyx</i> sp.	---	---	Tulang ular	C
402	Rosaceae	<i>Prunus arborea</i> (Bl.) <i>Kalkman</i>	542	Bogor	Suluh rimba	E
403	Rubiaceae	<i>Dichilanthe borneensis</i> <i>Baill.</i>	093, 483	Leiden	Berus	C
404		<i>Gaertnera vaginans</i> (DC) <i>Merr.</i>	507	Bogor	Mula asu, Mula anjing	C
405		<i>Gaertnera vaginata</i> var. <i>junghuhniana</i> (DC) Merr.	500, 505	Bogor	Sabar bubu rimba	Ci
406		<i>Gaertnera</i> sp.	095	Leiden	?	C
407		<i>Gardenia tentaculata</i>	086	Leiden	Landak kecil	D
408		<i>Gardenia tubifera</i>	001, 462	Leiden	Landak angkis	D
409		<i>Gardenia</i> sp.	429	---	Landak	A
410		<i>Gardenia</i> sp.	399, 457	---	Landak besar	D
411		<i>Hydnophytum</i> <i>formicarium</i>	---	---	Empukung	B,C
412		<i>Ixora ithyoides</i> Brem.	501	Bogor	?	Ci
413		<i>Ixora paludosa</i> (Bl.) Kurz.	311	Bogor	Mentangis	A,(B)
414		<i>Ixora mentangis</i>	021, 121, 385	Leiden	Mentangis	A,(B)
415		<i>Ixora salicifolia</i>	049	Leiden	?	D
416		<i>Ixora</i> sp.	511	Bogor	?	C

417		<i>Mitragyna speciosa</i>	---	---	Purik rawa	C
418		<i>Morinda</i> sp.	521	Bogor	Keretih bukit	E
419		<i>Myrmecodia tuberosum</i>	---	---	Empekung	B,C
420		<i>Nauclea purpurea</i> Roxb.	379	Bogor	Bengkai	Bi,D
421		<i>Nauclea subdita</i>	---	---	Bengkai	D
422		<i>Psychotria montensis</i> Moore	098, 106, 323	Bogor	Akar engke- rabang	A,B,D
423		<i>Psychotria</i> sp.	524	---	?	Ci
424		<i>Timonius flavescens</i> (Jack) Baker	316	Bogor	Temirit, Kermirit	A
425		<i>Timonius salicifolius</i>	010a, 380	Lciden	Temirit, Kermirit	A
426		<i>Timonius stipulosus</i> (Scheff) Boerl.	507b	Bogor	Mula asu, Mula anjing	C
427		<i>Timonius timon</i> (Spreng) Merr.	561	Bogor	?	E
428		<i>Timonius</i> sp.	112	Lciden	Tembesu sungai	C
429		<i>Timonius</i> sp.	561	---	?	E
430		<i>Uncaria sclerophylla</i> (Hunter) Roxb.	114, 454	Bogor	Akar kelait	B,C,H
431		<i>Uncaria</i> sp.	---	---	Akar kelait bukit	E,H
432		<i>Urophyllum arboreum</i> (Reimv. Ex Bl.) Korth.	516	Bogor	?	C
433		<i>Urophyllum hirsutum</i> Hook.f.	107, 456	Bogor	Kebesi rimba	Ci
434		<i>Urophyllum</i> <i>macrophyllum</i>	089	Leiden	Lilin	D
435		<i>Uvaria</i> sp.	---	Teysmann	?	D
436		?	461	---	Serang	Bi
437		?	---	---	Merambang	C
438	Sapindaceae	<i>Guttoa</i> sp.	508	Bogor	?	C
439		<i>Lepisanthes amoena</i> (Hassk.) Leenh.	057, 370, 398	Bogor	Kelensuak, (K)ensuak	D
440		<i>Lepisanthes alata</i> (Bl.) Leenh.	355	Bogor	Kelili	E,H
441		<i>Nephelium ?cuspidatum</i>	---	WTM	Sibau	Ci,E
442		<i>Nephelium</i> sp.	---	---	Nipis kulit	Ci,E
443		<i>Nephelium</i> sp.	---	---	Paregi	Cii
444		<i>Xerospermum</i> <i>noronhianum</i> (Bl.) Bl.	518	Bogor	Keranjik tikus	C
445	Sapotaceae	<i>Palaquium</i> sp.	---	---	Nyatuh, (Sebalpau)	Ci
446		<i>Palaquium</i> sp.	---	---	Nyatuh durian	E
447		<i>Palaquium</i> sp.	---	---	Nyatuh nangka	E
448		<i>Palaquium</i> sp.	---	---	Pudu	Cii
449		<i>Planchonella obovata</i> (R.Br.) Pierre	348, 486	Bogor	Libang	Bi
450	Scrophulari- aceae	<i>Limnophila erecta</i>	---	WoR	?	lake
451		<i>Lindnera</i> sp.	---	WoR	?	lake
452		?	388	---	Bunga rup	(E)H



453	Sterculiaceae	<i>Leptonichya heteroclita</i> Kurz.	575	Bogor	?	C
454		<i>Melochia corchorifolia</i> L.	---	WoR	Rumput jelumpang	D
455		<i>Pterospermum</i> sp.	---	---	Banyur hutan	Ci
456		<i>Sterculia</i> sp.	134	Leiden	?	F
457	Symplocaceae	<i>Symplocos</i> <i>cochinchinensis</i> (Lour.) Moore ssp. <i>Laurina</i> (Retz.) Noot. var. <i>laurina</i>	147, 467	Bogor	Tekuluk	Bi
458		<i>Symplocos</i> sp.	470, 497, 498	---	?	Bii
459	Theaceae	<i>Eurya</i> sp.	---	---	Jirak	F
460		<i>Ptoiarium alternifolium</i>	---	WTM	Jengil	E,F
461		<i>Ternstroemia</i> cf. <i>toguan</i>	519, 530	Bogor	(Nyatoh)	C
462		<i>Ternstroemia</i> sp.	---	De Mol	Arang- arang	B
463		<i>Ternstroemia</i> sp.	023	---	?	D
464	Thymelaeaceae	<i>Gonystylus bancanus</i>	007	Leiden	Ramin	Cii
465		<i>Gonystylus velutinus</i>	---	FM	Medang semat	E
466	Tiliaceae	<i>Microcos</i> ? <i>stylocarpa</i>	016, 307	Leiden	Tengku- rung (- asam)	B
467	Urticaceae	<i>Poikilospermum</i> <i>microstachys</i>	062	Leiden	?	D
468		<i>Poikilospermum</i> sp.	046	Leiden	?	D
469		<i>Poikilospermum</i> sp.	101	Leiden	?	Ci
470		<i>Villebrunea rubescens</i>	318	Bogor	Karniong	(E),H
471	Verbenaceae	<i>Clerodendrum</i> sp.	133	Leiden	Rumput semut	F
472		<i>Premna foetida</i> Reimw.	321	Bogor	Buas-buas	D,H
473		<i>Teysmanniodendron</i> <i>sarawakanum</i>	117, 123	Leiden	Mutun	(B),D
474		<i>Vitex pinnata</i> L.	302	Bogor	Leban(g)	(E),H
475	Vitaceae	<i>Cayratia</i> sp.	128	Bogor	Akar lelembai	D
476		<i>Cissus</i> sp.	047	Bogor	Akar gundi	D
477		<i>Cissus</i> sp.	068	Bogor	Akar sempiruk	E
478		<i>Cissus</i> sp.	060	Bogor	?	D
479	Zingiberaceae	?	522	---	Lemas rimba	Ci
480		?	532	---	Liak hantu	Ci
<b>FERNS AND FERN ALLIES</b>						
481	Aspidiaceae	<i>Tectaria</i> sp.	---	Polak	Paku	B,C,D, E
482	Aspleniaceae	<i>Asplenium nidus</i>	---	---	Paku rajang	B,C,D, E
483	Athyriaceae	<i>Diplazium</i> sp.	082	Leiden	Paku	E
484	Blechnaceae	<i>Blechnum finlaysonianum</i>	033	Leiden	Paku kijang	(E),H
485		<i>Stenochlaena palustris</i>	037	Leiden	Paku lemedin	(E),H
486	Gleicheniaceae	<i>Dicranopteris linearis</i>	034	Leiden	Resam	(E),H
487	Hypolepidaceae	<i>Pteridium aquilinum</i>	---	---	Paku bedegak	(E),H

488	Lindsaeaceae	<i>Lindsaea walkerae</i> Hook.	---	Polak	?	E
489	Lycopodiaceae	<i>Lycopodium cernuum</i>	---	---	Enkabut	E,F
490	Oleandraceae	<i>Oleandra</i> sp.	---	Polak	?	B,C,D
491	Ophioglossaceae	<i>Helminthostachys zeylanica</i> Hook.	---	Polak	?	E
492	Polypodiaceae	<i>Dipteris conjugata</i>	---	Piggott	Paku	E
493		<i>Drynaria quercifolia</i>	---	---	Paku	B,C,D, E
494		<i>Microsorium sarawakensis</i>	---	---	Paku	B,C,E
495		<i>Platynerium coronarium</i>	---	---	Paku	B,C,D, E
496		<i>Polypodium verrucosum</i>	032	Leiden	Paku kubuk	B,C,D
497	Schizaceae	<i>Lygodium flexuosum</i>	036	Leiden	Paku belit	D,E,G, H
498		<i>Lygodium microphyllum</i>	035	Leiden	Paku belit	D,E,G, H
499		<i>Schizaea dichotoma</i>	---	Piggott	Rumput empangil	B,C,D
500	Selaginellaceae	<i>Selaginella</i> sp.	---	---	Paku	E
501	Taenitidaceae	<i>Taenitis</i> sp. A	---	WG, Polak	Paku	B,C,D, E
502		<i>Taenitis</i> sp. B	---	WG, Polak	Paku	B,C,D, E
503	Vittariaceae	<i>Antrophyum reticulatum</i>	052	Leiden	?	D
504		<i>Vittaria</i> sp.	---	Polak	Paku	D,E

**NOTES:**

\*Collection number, as by Giesen (1-200), and Zulkarnain and Giesen (201-600)

**\*\*Identification:**

Airy Shaw: Airy Shaw, H.K. (1975)  
 Argent: pers. comm. G. Argent, Edinburgh Herbarium (1993)  
 Beccari: Beccari (1904)  
 Bogor: Bogor Herbarium  
 Danser: Danser (1927, 1931)  
 de Mol: de Mol (1933-34)  
 Dransfield: pers. comm. J. Dransfield, Kew Herbarium (1986, 1993)  
 FM: Flora Malesiana  
 FMal: Flora of Malaya  
 Leiden: Leiden Herbarium  
 Piggott: Piggott (1988)  
 Polak: Polak (1949)  
 Ross: Ross *et al.* (1996)  
 Vink: pers. comm. Vink, Leiden Herbarium (1994)  
 Teysmann: Teysmann (1875)  
 WoR: Soerjani, M., A.J.G.H.Kostermans and G.Tjitrosopomo (1987)  
 WTM: Corner (1952)

**\*\*\*Habitat types:**

A: Dwarf swamp forest  
 Bi: Stunted swamp forest, dominated by *Kenarin-Menungau-Kamsia*  
 Bii: Stunted swamp forest, dominated by *Kawi-Kamsia*  
 Ci: Tall swamp forest, dominated by *Kelansau-Emang-Melaban*  
 Cii: Tall swamp forest, dominated by *Ramin-mentangur kunyit*

- D: Riparian forest  
E: Hill forest  
F: Heath forest (*kerangas*)  
G: Disturbed vegetation in former swamp forest habitat  
H: Disturbed vegetation in former dryland forest habitat

FIRE IN THE DANAU SENTARUM LANDSCAPE:  
HISTORICAL, PRESENT PERSPECTIVES

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This paper presents a quantitative analysis of the extent of forest and scrub burning in the Danau Sentarum area, West Kalimantan, Indonesia. Burn scar areas were detected using remotely sensed data from four dates (1973, 1990, 1994, and 1997) obtained for a 24-year period. The results show a significant increase in the total burnt area in the 197,000 ha study site, from 5,483 ha in 1973 to 17,941 ha by mid-1997. Of the area burned by 1997, 8,021 ha, or 45% of the total burnt area, was tall forest (fresh-water swamp, peat swamp, or riverine) in 1990. This indicates a considerable role of forest destruction in the burning process. Another trend that was found was an increase in the maximum size of burn scars between 1973 and 1997, from 581 ha to 1,339 ha. It is still too early to fully explain these trends in terms of underlying causes, but field data suggest three main factors lie behind the burning and interact in a way that is not yet fully understood. These are environmental factors, resource extraction activities, and increasing human population pressure. An another potential factor, with a yet unclear role in fires, is conflicts within and between villages. Further in-depth research is required to investigate the underlying causes of fire in Danau Sentarum.

## Introduction

Fire is and has been part of the Danau Sentarum landscape for a long time. The oldest evidence of fires at Danau Sentarum comes from the analysis of pollen and charcoal records carried out recently by Anshari *et al.* (in press). The record provides a picture of changing vegetation over the past 30,000 years and charcoal is present throughout the record. The analysis identified increased burning levels and indicators of forest disturbance during the past 1,400 years (Anshari *et al.*, in press).

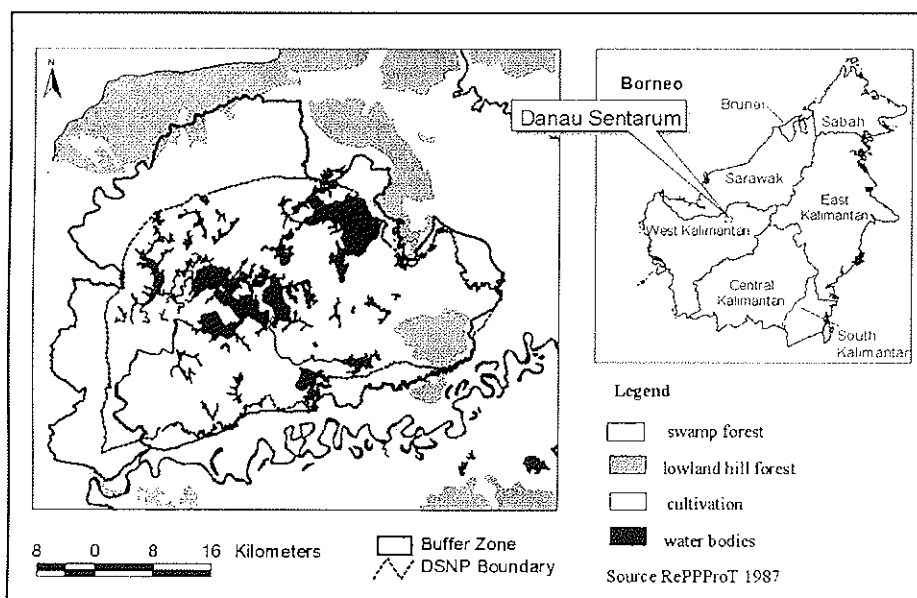


Figure 1. Location of study area.

Providing a more recent description of fire, from the mid-19th century up until present time, there are many written accounts of visits to the Danau Sentarum area that provide a wealth of fire descriptions. One of the first explorers to mention the evidence of swamp forest fires at Danau Sentarum was Pfeiffer (1856) who visited the area in January 1852. She described extensive areas of burnt standing trees in the swamps to the northwest of the lakes. Gerlach (1881) visited the area in March 1881 and commented on both drought and fires. He mentions the pronounced drought of 1877; a year that is now known to have exhibited a strong El Niño Southern Oscillation (Trenberth and Hoar, 1997; Brookfield *et al.* 1995; Harger, 1995a; 1995b). In 1877, the lakes were almost completely dry with only small trickles of water in the channels, and one could walk for miles on the dry lake bed (Gerlach, 1881). As to the cause of the fires, Gerlach blamed the Dayaks for setting fire to the forests during the dry season for sheer enjoyment. Further visits by Bock (1882), Molengraaff (1900), Enthoven (1903) provide interesting, albeit somewhat anecdotal descriptions of fires in Danau Sentarum around the turn of the 19<sup>th</sup> century, suggesting that the use of fire was common, although the underlying reasons

for burning remained unclear. Helbig (1937) who described much burned land in the northern hills of the Danau Sentarum area confirmed this picture.

Some visitors to the lakes did not encounter evidence of fires. Polak (1949) did not report any traces of burnt forests, even though she looked for them. Vaas (1952) who accompanied Polak suggested that the lack of fires was due to the absence of fishing activities during the Second World War.

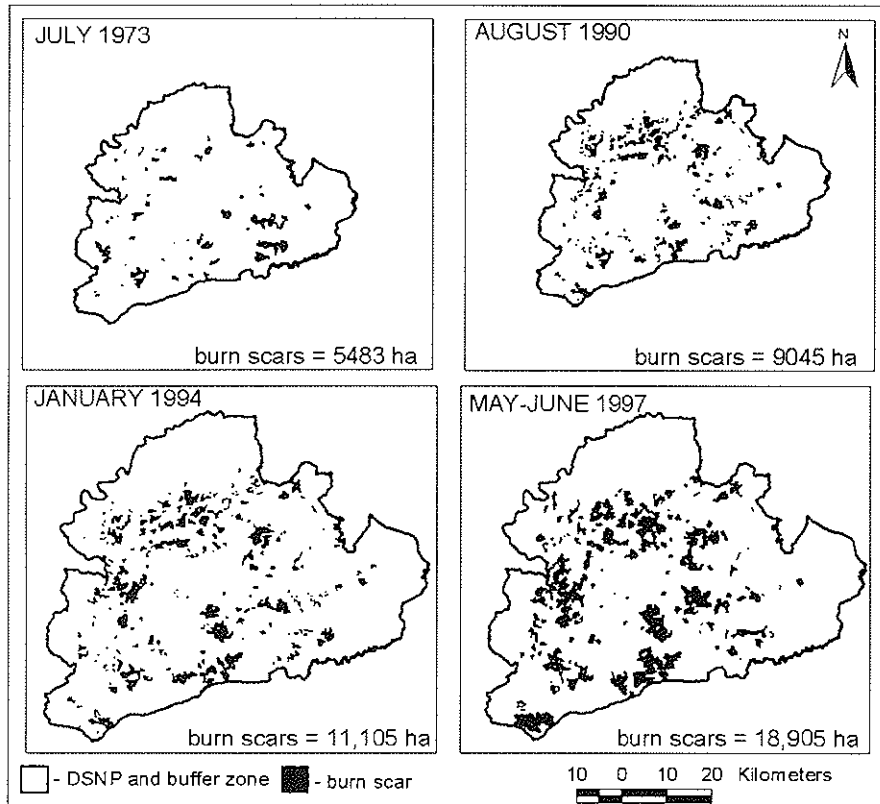


Figure 2. Distribution of burn scars (1973-1990-1994-1997).

Much of the more recent analysis of fires in Danau Sentarum was carried out during the DFID-funded Conservation Project (1992-1997) (also see Wadley *et al.*, 2000). During his initial study of Danau Sentarum in 1986, Giesen described extensive tracts of burnt swamp forest in the north, along the Sumpa River, and also an active fire near the village of Nanga Leboyan (Giesen, 1987). He found that fires were fairly common in the dwarf and stunted swamp forest types where high litter amount and open canopy increase fire risk during dry conditions (Giesen, 1996). Giesen (1987) postulated that an increase in commercial logging and the activities of fishermen were the main underlying causes of fires at Danau Sentarum. It was found in some areas that fishermen clear swamp forest with fire to increase the area of open water for placing fixed gill-nets (Giesen, 1987).

Giesen also hypothesised that much of the dwarf and stunted forest at Danau Sentarum is fire-induced.

In 1994, Luttrell (1994) carried out the first study specifically on fires in Danau Sentarum. The outcome of this research was that the underlying causes of burning were complex and results of the fieldwork were inconclusive. In general, it was found that local people attributed fires to neglect (of cigarettes, campfires, and fish-drying fires) or jealousy over resources. Blaming another ethnic group (Malay or Iban) or outsiders (loggers) was also common. One new cause, not mentioned by previous observers, was that fires were ignited to facilitate the capture of the red-phase Arowana fish (*Scleropages formosus*), a valuable, and now rare, ornamental fish. Burning created shallow, open waters at the forest edge, where the Arowana could be lured at night by lamps and scooped up by nets (Luttrell, 1994).

Giesen (1996) carried out vegetation studies in 27 recently burnt areas in June 1994. These showed that the species that most often survive a fire are: *Shorea balangeran* (*kawi*) (in 80% of fires), *Crudia teysmannia* (*timba tawang*) (65%), *Mesua hexapetalum* (*kamsia*) (51%) and *Syzygium* sp. (*tengelam*) (51%). This does not mean that many trees survive a fire: for a given fire this may vary between 0–25 percent of all trees. On average, however, about 1–3 percent of all trees appear to survive a typical fire. Survival is important for recruitment, and relatively fire-tolerant species such as the aforementioned four are most likely to form an important element in the recovering vegetation. Of these four species, *kawi* survives in the greatest numbers. A second important element in areas recovering from fires are the pioneer species; i.e. those species that newly establish themselves from propagules (seeds, fruit). The most important pioneer species observed at burnt sites at DSNP are shrubs *Croton* cf. *ensifolius* (*melayak*), *Ixora mentangis* (*mentangis*), *Timonius salicifolius* (*kerminit*), and the herbs *Polygonum* spp. *lembung* and *kumpai* (various grasses). For more detail on the vegetation characteristics of burned areas in Danau Sentarum refer to Giesen (2000).

Since 1992, fires in the Danau Sentarum have also been studied using remote sensing and Geographic Information System (GIS) techniques. Dennis *et al.* (1998; in press) conducted a forest cover change study in three village territories for the period 1973–1990–1994. The study showed that fire had affected all three areas to varying extent with the impact being most severe in swamp forest. However, the results showed that within this small sample there was great variability in the pattern of fires. Two of the sites were fishing villages located within swamp forest with fairly similar characteristics. However, one of the areas, located in the middle of the Park had experienced little fire damage between 1973 and 1994, whereas the other had experienced a 5-fold increase in fires over the same period. Interviews in 1996 with this community about the causes of these fires focused on motivations of jealousy or revenge and on inadvertent wildfire caused by insufficiently extinguished cooking fires. Another possible source, reported to Dennis in 1997, was the burning of waterhyacinth *Eichhornia crassipes*, which cause problems for navigation by small boats. Apparently, people thought that by burning this plant in dry season they would prevent its re-growth when the area became inundated again. Overall, the researchers remained dissatisfied with these explanations, despite considerable efforts on several occasions to understand the picture more fully. What the study did show was the potential of combining remote sensing/GIS with socio-economic and ethnographic data for understanding the causes and impacts of burning.

Based on the above sources of information, two general fire regimes appear to be present in the area. One is seen in the upland areas and along the larger rivers, where fire has been used for centuries as part of the swidden agriculture system. The other is seen in the low-lying swamp forests in and around the lakes where fire has been present for centuries but not for any apparent use like cultivation. The causes and impacts of these swamp forest fires are still poorly understood and this paper describes how remote sensing and GIS techniques were used to contribute to an understanding of the trends and patterns of swamp forest fires within the Danau Sentarum National Park between 1973 and 1997.

### Methods

The aim of this particular study was to quantitatively assess the changing pattern of burning between 1973 and 1997 using remote sensing and GIS techniques. Dennis and Kurniawan (2000) analyzed forest cover change using remote sensing and GIS for an area of 425,000 ha centering on the Park. This study was carried out as part of the Joint Research Centre of the European Commission's TREES Project on tropical forest cover monitoring. The change analysis was carried out for the period 1990–1997. Building on the results of the TREES Project, the Center for International Forestry Research (CIFOR) and the International Centre for Research in Agroforestry (ICRAF) included Danau Sentarum as one of its eight sites for the study of underlying causes and impacts of fires in Indonesia.

Remote sensing provides a valuable source for quantitative measurement and monitoring of burned areas (Trigg and Flasse, 2000; Antikidis *et al.*, 1999; Hoffmann *et al.*, 1999; EUFREG, 1998; Liew *et al.*, 1998; Siegert and Hoffmann, 1998; Pereira *et al.*, 1997). Recent burns have a high composition of charred material and a spectral reflectance that is very distinct from vegetation. Over time the spectral reflectance of the burn scar changes, as pioneer and eventually secondary vegetation grows back. Interpretation of satellite imagery, with a good knowledge of field conditions, allows burn scar maps to be created. Unless collateral information on the exact date of burning is known it is not possible to date burn scars precisely from satellite imagery alone.

For this study, the term burn scar does not exclusively refer to fresh burns. It includes areas that were recently burnt (within a few months of the image date), areas of charred woody-vegetation with some young, vigorous growth of pioneer species, such as grasses, and areas that may have patches of scrub, grass and burnt woody vegetation (see Figure 3). The important factor is that all the areas identified as burn scars still had the characteristics of having burned at some time in the recent past, it should also be added that most areas were checked on the ground. These areas had not regenerated to the extent that they would be classified as swamp scrub or forest. Using time series of remote sensing data also enabled backwards and forwards checking of burn scars and facilitated the creation of a fire history. In addition to information on the location and size of burn scars, information on the land cover types that are being affected by fire can also be obtained.

This particular study is confined to the Danau Sentarum National Park including the buffer zone (see Figure 1). The area comprises open lakes, seasonally flooded peat and freshwater swamp forest, and lowland hills. In this study satellite imagery or aerial photography for 1973, 1990, 1994 and 1997 was used to gain an insight into the size of



the area affected by fire, and trends in land cover change associated with fire. Table 1 provides details of the data used.

Type	Date	Source
Landsat MSS	14 July 1973	DFID Conservation Project
Landsat TM	28 August 1990	DFID Conservation Project
B/W air photo	2 January 1994	DFID Conservation Project
SPOT XS	31 May, 11 June, 12 July	TREES/CIFOR Project

**Table 1. Remotely sensed data used for the study.**

Ideally, change detection procedures should involve data acquired by the same (or similar) sensor and be recorded using the same spatial resolution, viewing geometry, spectral bands, time of day and period/season of acquisition (Richards, 1986). During the period in which we intended to assess change, 1973 to 1997, the choice of sensors for the early period (1970s) was limited to Landsat MSS. By the 1990s, a wider choice of sensors was theoretically available. However, we were ultimately limited by the availability of cloud-free imagery and photography. In this case, we were forced to compare Landsat MSS with a spatial resolution of 80m x 80m, with Landsat TM with a spatial resolution of 30m x 30m, SPOT with a spatial resolution of 20m, and 1:35,000 black and white aerial photography.

In addition to the differences in sensors and spatial resolution, the seasonal variability within the dataset added to the difficulties of maintaining a consistent level of interpretation. Danau Sentarum is a seasonally flooded forest area with a complex and fluctuating hydrological cycle (Klepper, 1994; Giesen, 1996). From week to week, the water levels fluctuate, submerging or exposing vegetation in the process. The Landsat MSS imagery is dated July 1973 and showed high flood levels, thus much of the dwarf swamp forest and burnt swamp areas were submerged. This contrasted sharply with the Landsat TM imagery dated August 1990, which was at the height of the dry season, clearly showing areas of dwarf swamp forest and recent (within a few months) and older swamp forest burning. On the Landsat MSS imagery, burn scars were not easily identified because the area was flooded. Areas that showed a sparse covering of shrub vegetation or appeared to show remnants of woody vegetation were considered burn scars. Experience of comparing recent imagery with field observations supports this assumption. The aerial photography, dated January 1994, represents a typical picture of medium-to-high water levels. On the air photos charred trees and the lack of woody vegetation easily identify this burn scar class. In flooded areas, burnt areas are identified by areas of water dotted with patchy vegetation and single standing trees, as distinct from clear open water.

The SPOT imagery covers 3 dates (May, June and July) in 1997 just as water levels are beginning to fall. The SPOT imagery pre-dates the extremely dry conditions of the 1997 El Niño. On the TM and SPOT there is quite a broad range of spectral values for this class, ranging from highly reflective (no woody vegetation) to less reflective with a mixture of burnt/woody and non-woody vegetation. Information from field checks improved interpretation of this class.

All image processing was carried out using the PC ERDAS software (ERDAS, 1991) and PC ER Mapper. Classifications and subsequent spatial analyses were achieved with PC ArcView. Ensuring that the four different data sets overlay exactly (co-register) is critical for valid change analysis. Without this, spurious results will occur. The Landsat TM was geometrically corrected using ground control points obtained from 1:50,000 scale topographic base maps and GPS surveys. The Landsat MSS and the SPOT images were then co-registered to the Landsat TM image. The registration between images was then checked visually. The correspondence was deemed sufficient for the change analysis. On-screen digitizing, using the digitizing methodology developed by TREES (Dennis and Kurniawan, 2000; Feldkoetter, 1999), was chosen as the method of forest cover classification for the Landsat MSS, Landsat TM, and SPOT.



**Figure 3.** Burn scar area at Danau Seriang, 1997 (this area burned in 1990-91, and again in 1997).

Despite the great amount of user interaction in the classification process problems were still encountered. The Landsat MSS image is one of the early products of the Landsat mission and the quality of the image, even after image restoration, was not good. This plus the limited number of spectral bands (four: green, red and two near infrared) meant that the results of the classification were variable. The inclusion of a mid-infrared band is generally favored for discrimination of natural vegetation types. Inaccurate classification was particularly apparent in areas of heterogeneous vegetation and areas of steep topography. By comparison the classification of the Landsat TM and SPOT were easier because of the excellent quality of the image and higher spatial and spectral resolution of the image than the MSS.

Finally, conventional accuracy assessment of the classification was not carried out. However, the interpreter of the imagery already had 8-years field experience of the site and with a wealth of material such as GPS located site photos it was felt that the accuracy was very high. Also, the results of the change analysis did not detect any spurious changes, such as burn scars becoming dense swamp forest on the subsequent date. Further research will involve quantitative accuracy assessment.

## Results

### Cumulative change in burn scars

The results of the burn scar analysis show that there was a significant increase in the area of burnt swamp forest in Danau Sentarum between 1973 and 1997 (see Figure 2). Within the 197,000 ha study area, the area classified from satellite imagery as burn scars in swamp areas increased from 5,483 ha in 1973 to 18,905 ha by mid-1997, this equates to a 245% increase (see Table 2).

	July 1973	Aug. 1990	Burnt area increase 1973-1990	Jan. 1994	Burnt area increase 1990-1994	May-July 1997	Burnt area increase 1994-1997
Burn scars in swamp forest (ha)	5,483	9,045	+ 3,562 (+ 64.9%)	11,105	+2,060 (+22.7%)	18,905	+7,800 (+ 70.2%)
Burn scars as % of total land area	3.3	5.6	-	6.8	-	11.7	-
Area of swidden agriculture (ha)	5,910	7,751	-	5,890	-	7,658	-

**Table 2. Burn scar area 1973–1997 (size of study area: 197,000 ha; size of total land area: 162,000 ha).**

The area classified by field work as swidden agriculture, a system which uses fires, did not change greatly over the period 1973–1997 with an increase of only 1,748 hectares or about 30% (see Table 2). The following results only deal with burnt swamp areas not associated with swidden agriculture.

The increase in burning can be analyzed for 3 time periods 1973–1990, 1990–1993, and 1993-1997. Between 1973 and 1990, the area of burn scars increased by 3,562 hectares (+64.9%) from 5,483 hectares to 9,045 hectares, see Table 2. An annual increase was not calculated because burning did not occur every year. During this 17-year period there were three El Niño events (Trenberth and Hoar, 1997; Brookfield *et al.* 1995)—1976/77, 1982/3, and 1987—one every 5.6 years, which produced prolonged dry periods. In addition there were approximately 5 dry years—1975, 1976, 1979, 1986, and 1989—in which fires could also occur. Assuming there were only 8 years in which the swamps were dry enough for fires to take place, the annual increase in burnt area, allowing a correction for years in which no burning occurred, was 8.1%.

Between 1990 and early 1994, the area of burning increased by 2,060 hectares or 22.7%. During this three-year period there was one El Niño event in 1991 (Trenberth and Hoar, 1997; Brookfield *et al.*, 1995), and two dry years (1990 and 1992). Based on this data the annual corrected increase in burning is 7.5%, which is just lower than during the 1973-1990 study period.

The final period in the study is mid-1994 until mid-1997. During this period the burnt area increases from 11, 105 ha to 18, 905 ha, equating to an increase of 70.2%. One El Niño (in 1994) and no other dry years were observed during this period, the 1997 El Niño occurred after the 1997 image date and was not included in this analysis. Therefore, assuming one fire year the annual corrected increase in burnt area is 70.2%.

#### Forest change and burn scars

Using the GIS, it was possible to look at the forest types being burned. Giesen (1996, 2000) devised the forest classification scheme used here. Between 1973 and 1990, stunted swamp forest and dwarf swamp forest are affected most, with respectively 2,240 ha and 3,075 ha being completely destroyed by fire (see Table 3). It is also important to note that 27.5% of the burn scars remained unchanged or burned again during the 17-year period. Regenerating dwarf swamp forest was also badly burned, accounting for 11.9% of the pre-fire composition.

	Composition of 1990 burn scars in 1973 (ha)	Composition of 1997 burn scars in 1990 (ha)
<b>Burn Scar</b>	2,489	6,389
<b>Dwarf swamp forest</b>	3,075	2,206
<b>Dwarf swamp forest (regeneration)</b>	1,082	2,005
<b>Tall (peat) swamp forest</b>	139	1,332
<b>Riparian forest</b>	20	74
<b>Stunted swamp forest</b>	2,240	6,761
<b>Cultivation</b>	-	138
<b>Total</b>	<b>9,045</b>	<b>18,905</b>

Table 3. Burn scar forest cover composition pre-fire.

Between 1990 and 1997, the areas most affected by fires were again swamp forest, dwarf swamp forest, and regenerating dwarf swamp forest, but there was also an increase in the area of tall (peat) stunted swamp forest burned. In this period the area of swamp forest burned was 6,761 ha or 37% of the total area burned. 7% of the burn scars was previously tall (peat) swamp forest, which is a significant increase over the earlier period. 32% of burn scars remained unchanged in their appearance or burned again between 1990 and 1997. The amount of dwarf swamp forest as a percentage of the total burn scar area dropped from 46% in the earlier period to 22% in the second period.

#### Burn scar dimensions

Analysis of the size of burn scars between 1973 and 1997 shows an interesting pattern. In 1973, only 60 distinct burn scars were identified in the study area, the mean size of the burn scars was 91 ha, with the largest being 581 ha and the smallest being < 1 ha. By 1990, the number of burn scars had increased to 248 with the mean size dropping to 36 ha, however the range in size was much greater with the largest burn scar being 453

ha and the smallest being 1 ha. The burn scar statistics for 1994 did not differ much from 1990, but 1997 saw a large change. Although the number of burn scars did not change greatly, 174 compared to 248 in 1990, the mean size of burn scars increased from 36 ha to 108 ha and the maximum size increased dramatically from 453 ha to 1,339 ha.

### Discussion

The results of the analysis show a clear increasing trend in the total area and size of burn scars between 1973 and 1997. There is a substantial increase in the total burnt area from 5,483 ha in 1973 to 18,905 ha in 1997, with a steady increase in the intervening years. In parallel with a total increase in burnt area is an increase in the overall size of individual burnt areas. Delving deeper into these changes shows that the impact of fires is worsening in recent years. Analysis of pre-fire composition of the burn scars gives an insight into the changing impact of fires on the swamp forests. In the first time period studied, 1973-1990 (see Table 3), the main types of vegetation affected are dwarf swamp forest and stunted swamp forest. This finding conforms well with Giesen's observation that dwarf and stunted swamp forest at Danau Sentarum are particularly vulnerable to fires (Giesen, 1996). There is also a strong likelihood that much of the dwarf swamp forest in the area has previously burned. This is evidenced by the fact that areas that at one point in the analysis were regenerating swamp forest became dwarf swamp forest in the next time period and then in the subsequent period burned again, repeating the cycle. Further analysis of the time series would be valuable in testing Giesen's hypothesis that much of the dwarf and stunted forest at Danau Sentarum is fire-induced (Giesen 1996). Giesen (pers. comm.) remarks that species composition of dwarf swamp forest, which is dominated by *kerminit*, *melayak* and *mentangis*, also supports this hypothesis: A few fires would lead to dominance by fire tolerant species such as *kawi*, while repeated fires would lead to a dominance of pioneer species, such as *mentangis*, *melayak* and *kerminit*. In the second time period, 1990-1997 (see Table 3), there is a shift away from dwarf swamp forest being the main victim of fire to stunted swamp forest, and more worryingly, tall peat swamp forest. This indicates that new types of forest are being burned in addition to areas that have historically burned such as the fire-prone scrub-like dwarf swamp forest. In addition to forest areas burning, on average, 30% of the burn scars in 1973-1990 and 1990-1997 period remain unchanged or are burned again. This is an important finding because it indicates the vulnerability of these areas to repeat burning.

The results of the burn scar analysis show a shift in recent years to an increase in the size of burnt area. For example, the largest single burn scar in 1990 was 435 ha but by 1997 the largest single burn was 1,339 ha. Analysis of some of the large burn scars shows that in previous years the area was composed of smaller unlinked burns but over time these burns have merged. The reason for this could be that areas that have previously burned are more prone to burning in future years. Each time an area burns the likelihood that it burns beyond the boundaries of the earlier burn is high, especially as most of these fires are uncontrolled.

Having analyzed the trends and processes of fire in Danau Sentarum, some insight can be gained in the possible underlying causes. However, as the research is still ongoing it is yet impossible to find a clear explanation of these causes. Evidence from interviews and field observation show that fires in the swamps of Danau Sentarum can be either deliberate or accidental and during El Niño years the number of fires increases considerably due to prolonged dry conditions. Identifying the underlying causes has

proved difficult as evidenced by the earlier work of Giesen (1996) and Luttrell (1994). Their hypotheses on the main causes of fire, i.e. forest resource exploitation and fishing, however, still apply today. This doesn't, however, answer why there is an increasing trend in fires. Here we speculate on some of the more detailed underlying processes, which are currently being researched by the authors as part of the USFS-funded fire research by CIFOR and ICRAF. Field analysis, including detailed interviews in five villages, show that for each village area there is a specific set of reasons why certain areas were burned.

In broad terms, the results of the village interviews showed that there are three main reasons for fires: resource extraction; increased population and greater access; and climatic conditions conducive to fire. Firstly, fires connected with resource extraction from both forest and water areas have been cited as a cause since the first reports of fires in the 1800s. Many interviewees did not admit to deliberately using fire as a tool in improving fishing areas as cited by both Giesen (1996) and Luttrell (1994). However, interviewees would blame others for such practices which leads one to believe that there is some truth in this cause. Carelessness with cooking fires in the swamps during the dry season was also often cited. Direct observations by the authors in 1994, 1997 and 1999, proved that fires can start from cooking fires which have not been properly extinguished. Over time, certain resources have played a more important role than others. One interesting example was the valuable *Arowana* fish, which was extensively sought during the 1980s, actually until it almost disappeared. As described by Luttrell (1994) fire was used in the search for the fish, many of the fires in the 1980s may have been due to a demand for *Arowana*. People also remember times when fire was used to encourage a flush of grass that would lure deer (*rusa*) out of the surrounding forests. However, deer are now very rare in the forests surrounding the lakes and hunting of the deer in this way is no longer practiced. It has further been reported that Iban use fire when hunting for soft-shelled turtles during the dry season, while honey collecting is also a possible cause of fires: harvesting involves smoking the bees out of a hive with smoldering torches, and under dry circumstances fires could easily spread.

Secondly, there is an increasing population and increasing accessibility in the Danau Sentarum area, both because of improved transportation and increased resource extraction. This is linked to a population increase. Jeanes (1997) reports that the human population in the Danau Sentarum area has been on the increase, and in 1997, the total population of the Park had reached 8,480 permanent residents, with an additional 2,400 that migrate to the area during the dry season for seasonal fishing (Erman, 1998). A positive correlation between human population and burning is expected.

Thirdly, there may be natural reasons for an increase in burning. There is a possible trend of an increased frequency of the El Niño phenomenon, which is generally accompanied by very dry conditions in the Danau Sentarum area. Local people noticed a big increase in fires from 1991 onwards, especially in 1991, 1994, and 1997, all of which are known El Niño years. Furthermore, the ongoing deforestation in the upper Kapuas area is possibly leading to greater fluctuations in river level. In 1986, floods were already more pronounced than in the decades before, and this trend will continue if changes in land cover continue (W. Giesen, pers. comm; pers. obs.). Whether this increased flooding frequency is counter-balanced by more frequent drying out of the lakes' area is yet unknown, but as the lakes area connected with the river, such trends are possible. A final

natural reason for increased fires may be the increasing amount of combustible material that is left behind after logging and also the increased fire proneness of areas that were already burned.

These three main factors interact in ways that we do not yet understand, also because they may be very site-specific. For instance, two villages may have conflicting ideas about ownership or use rights of a certain resource use area (see e.g. Dennis *et al.*, 1998). Increasing resource extraction by, for instance, improved market access, may go hand in hand with increased conflict risks, because of higher population pressure, which, in very dry times, may lead to many fires. However, on the other hand, the potential threat of a conflict may be counteracted by an agreement between villages and the expected fires might not occur.

An assessment of the impact of the devastating fires of the 1997/98 El Niño is still on going for DSNP. Anecdotal evidence from the area suggests that 1997 fires and smoke was the worst in living memory, although the smoke may not all have emanated from the proximate area. Post-1997 imagery has not yet been analyzed, but Erman (1998) identified 46 fires from 1997 ground surveys in the area. The chances are high that the burnt area has increased, and that due to the prolonged drought associated with the 1997/98 El Niño that many areas of swamp forest burned.

Before it will be possible to really understand the underlying processes in more detail, village-level fieldwork is needed. We believe that within this research the past can be a key to understanding the present and future. Suggested research therefore includes further analysis of vegetation change patterns in relation to climatological data, and village interviews investigating the underlying causes of why a certain area burned. The ultimate goal would be to gain a level of understanding that would allow one to address the true underlying causes of the fire, something that is badly needed for proper management of the fire problem.

### Acknowledgements

The research described in this paper was carried out partly during the CIFOR/ICRAF study, which is funded by the United States Forest Service. We thank the Ministry of Forestry (MOFEC) in Jakarta, and the Agency for the Conservation of Natural Resources (BKSDA) in Pontianak, for allowing us to do field research in the Danau Sentarum area. We also like to thank our countless informants from Danau Sentarum who are helping us to improve our knowledge of the fire issues in their area.

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BALANCING SUPPLY AND DEMAND: A CASE STUDY OF RATTAN IN  
THE DANAU SENTARUM NATIONAL PARK, WEST KALIMANTAN,  
INDONESIA

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The Danau Sentarum National Park (DSNP) contains 30,000 ha of lake and 81,000 ha of lowland, seasonally flooded forest. It is the largest network of inland lakes on the island of Borneo. The park is inhabited by over 5,500 Malay fishermen who live in permanent or mobile settlements along the major watercourses. Most of the fishing implements used by the local population are made from rattan, and large quantities of rattan are also harvested and sold to timber companies for lashing together rafts of logs. The three most commonly used species at DSNP are *duri antu* (*Calamus schistoacanthus* Bl.), *duri tapah* (*Calamus tapa* Becc.), and *duri pelanduk* (*Ceratolobus hallierianus* Dransfield). Inventory results indicate that the three rattans differ greatly in terms of the number of harvestable clumps/ha (>4.0 m tall). The most abundant species, *duri antu*, forms populations with over 900 clumps/ha., *duri pelanduk* grows at densities of 400-500 clumps/ha, and *duri tapah* averages only 50 clumps/ha. Based on the observed relationship between clump height and number of canes/clump, it is estimated that there are over 34,000 *duri antu* canes/ha growing in the flooded forest of DSNP. Although these densities seem impressive, an analysis of local demand, productivity, and current harvest intensities reveals that local rattan resources are being gradually over-exploited. In response to this situation, several fishing communities have started to manage their rattan resources by controlling harvests and rehabilitating and enriching natural stands.

### Introduction

Ethnobotanical studies have traditionally been concerned with documenting the relationships between people and plants at one moment in time. It is clear, however, that these relationships are extremely dynamic and that both the people and the plants are in a constant state of flux. The plants, through their local abundance, growth habits, and physical or chemical properties, influence the pattern of use by human populations. The people, through activities such as planting, resource management, destructive harvesting, and over-exploitation, continually impact the structure and dynamics of local plant populations. Simple species lists alone are insufficient to document the complex feedback

loops that occur between a plant resource and its user group. To really examine the use, mis-use, and/or conservation of plant resources by indigenous populations, ethnobotanists need to broaden the focus of the questions they are asking (e.g. Peters, 1996).

The three basic parameters that determine the long-term impact of plant use are resource stock, growth, and offtake. Stock refers to the number of individuals of a particular species that are available in the forest at a given point in time. Growth represents the total amount of harvestable resource that is produced by these individuals in a year. Offtake refers to the quantity of material that is actually harvested each year. The relationship between stock, growth, and offtake is relatively straightforward. Abundant species of large stock produce the largest amount of resource in a year, while sparse, low-density resources exhibit a production rate that is much smaller. To exploit these resources on a sustained-yield basis year after year, it is important that the annual offtake be no larger than the annual growth. If harvest levels exceed the growth, the current stock of the resource is reduced, subsequent growth is also reduced, and, over time, the resource is gradually depleted. In excessive cases of over-exploitation, the species may be complete eliminated from the forest.

The collection of data on resource stock, growth, and offtake can provide a new dimension to ethnobotanical studies. To illustrate the utility of such an approach, the results from a long-term study of rattan in western Borneo are presented. The research documents the interplay between supply (stock) and demand (offtake) that characterizes the exploitation of a valuable forest resource, and demonstrates the key role that resource yield (growth) plays in determining the ultimate sustainability, or unsustainability, of this activity. The results presented herein also show that some indigenous communities are very aware of the dynamic nature of the interactions between people and plants--and that they frequently take concrete steps to maintain the balance between the supply and the demand of the resources upon which they depend.

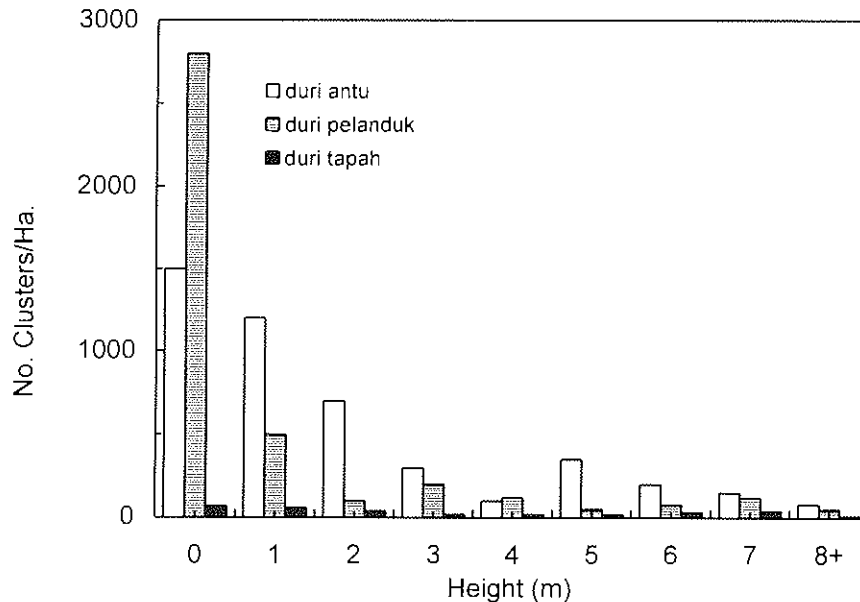
### Study Site

The research was conducted at the Danau Sentarum National Park (DSNP) in the Kapuas Hulu district of West Kalimantan, Indonesia. The park covers an area of 132,000 ha in the floodplain of the upper Kapuas River about 700 km upstream from the estuary at Pontianak. About 30,000 ha of DSNP is occupied by seasonal lakes and watercourses, the remainder of the area is covered by seasonally flooded swamp forest, riparian forest, scattered patches of peat forest, and dipterocarp hill forest (Giesen, 2000). The park contains a rich fauna including over 250 species of fish, more than 250 species of birds, crocodiles, pythons, gibbons, proboscis monkeys, and the occasional sun bear and orangutan (Jeanes and Meijaard, 2000). The annual rainfall in the region averages 3500 mm/yr with water levels in the lakes and rivers fluctuating 8 to 12 m during the flood cycle.

The DSNP is inhabited by over 5,500 Malay fishermen who live in permanent or mobile settlements along the major lakes and watercourses. The houses, sidewalks, and docks of the permanent villages are built on stilts 3 to 4 m in the air; mobile settlements are made of houseboats and floating docks that have been lashed together. Given the lack of unflooded terrain suitable for cultivation, fishing, rather than agriculture, is the primary subsistence activity and it has been estimated that from 80 to 90% of the local population is involved in this pursuit (Giesen, 1987; Colfer *et al.*, 2000).

### Rattan Species

The flooded forests of Danau Sentarum contain three species of rattan that are used by local communities. *Duri antu* (*Calamus schistoacanthus* Bl.) and *duri pelanduk* (*Ceratolobus hallerianus* Dransfield) are slender, clustering rattans with stem diameters ranging from 3.0 to 6.0 mm. *Duri antu* cane is strong, flexible and extremely resistant to flooding, while *duri pelanduk* produces a cane that breaks rather easily and will rot after a year in the water. *Duri tapah* (*Calamus tapa* Becc.), in contrast, is a large diameter (10.0 to 12.0mm), solitary rattan. Although stiff and somewhat hard to work with, *duri tapah* canes are relatively resistant to flooding. The fruits of all three species are edible.

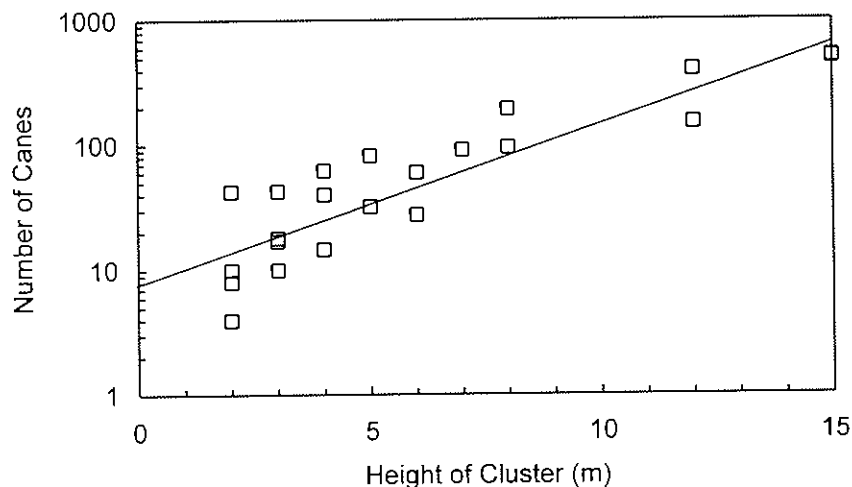


**Figure 1.** Density and size-class distribution of *duri antu*, *duri pelanduk*, and *duri tapah* populations within the DSWR. Histograms are divided into eight 1.0 m height classes with a zero class for seedlings and small saplings (0-100 cm tall). Data collected using replicate 10 m wide transects of variable length; see text for exact sample area at each site.

### Distribution and Abundance of Local Rattans

To quantify the available supply of rattan cane at Danau Sentarum, replicate strip transects were sampled at four different localities within the park: Sungai Berbaju, Sungai Leboyan, Sungai Insiluk, and Nanga Sauk. Exact sample sizes varied from site to site. A 10 X 200 m transect (2,000 m<sup>2</sup>) was sampled at Sungai Berbaju and Sungai Leboyan, Sungai Insiluk was sampled using a 10 X 1,000 m transect (10,000 m<sup>2</sup>), and a 10 X 100 m transect was sampled at Nanga Sauk. All of the rattan clumps encountered in each transect were counted, identified to species, and the height of the tallest cane in each

clump estimated visually. All transects were oriented at right angles to the topography and slope corrections were applied as necessary to maintain a constant horizontal sample.

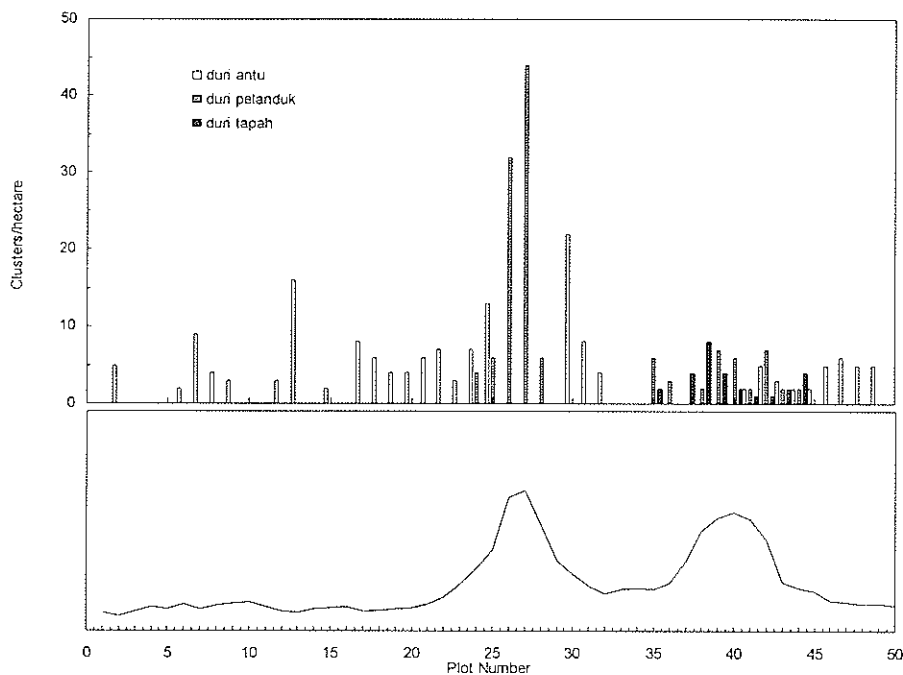


**Figure 2.** Number of *duri antu* canes as related to the height of a cluster. Cane density data are shown on a  $\log_{10}$  scale; regression lines based on general linear model, i.e.  $\log_{10}$  Number of Canes =  $a + b$  (Cluster Height). Parameter values and coefficient of determination are as follows:  $a = 0.927$ ,  $b = 0.121$ ,  $r^2 = 0.82$ .

The results from the inventory are presented in Figure 1. Separate histograms have been constructed for each rattan species using the average values from all transects. As is shown in the figure, the three rattan species differ greatly in terms of the total number of harvestable clumps/ha ( $\geq 4.0$  m tall). The most abundant species, *duri antu*, can form populations containing over 900 clumps/ha, *duri pelanduk* was recorded at densities of 400-500 clumps/ha, and *duri tapah* was never observed in densities greater than 50 clumps/ha. An additional point of interest concerns the size-class distribution of the rattan populations recorded in the transects. Although the shape of the histogram is different for each species, all of them reflect a greater number of small individuals than large individuals. This result suggests that the rattan populations at DSNP are regenerating themselves, and that the harvest of large canes is being replaced to some degree by the recruitment of new individuals into the population.

It is important to note that the data shown in Figure 1 are for the number of clusters of each rattan species encountered in the transects. One cluster of a multi-stemmed rattan (e.g. *duri antu* or *duri pelanduk*), however, can be composed of numerous single canes. The more relevant question is "how many individual rattan canes of merchantable length occur in the forests of DSNP?" Data collected from a subsample of *duri antu* clumps provides a useful estimate of the magnitude of this number. As is shown in Figure 2, there is a strong exponential relationship ( $r^2 = 0.82$ ) between the height of a *duri antu* clump and the total number of canes that it contains. Small, 2.0 m tall clusters may contain only five to ten canes; a single 15 m tall cluster may contain over 500 canes.

Multiplying the number of clusters in each class by the estimated number of canes per cluster for that size class, it is calculated that there are over 34,000 *duri antu* canes/ha ( $\geq 4.0$  m tall) in the lowland forests of DSNP.



**Figure 3.** Density of *duri antu*, *duri pelanduk*, and *duri tapah* clusters recorded in 50 contiguous 10 X 20 m plots along a 1.0 km transect at Sungai Insiluk. Bottom of graph shows general topography traversed by the transect; the two peaks shown are 2–3 m above the rest of the floodplain.

A final aspect of the distribution and abundance of rattans at DSNP that can be examined using the inventory data concerns the habitat requirement of each species. This is illustrated in Figure 3, which divides the results from the kilometer-long Sungai Insiluk transect into fifty contiguous 10 X 20m plots and shows the density of *duri antu*, *duri pelanduk*, and *duri tapah* clusters recorded in each plot. The transect topography shown in the lower half of the figure was estimated visually based on the height of the flood line on the trees in each plot.

As can be appreciated in the histogram, all three rattan species were recorded in the Sungai Insiluk transect, but there is a definite pattern in the way that the species are associated. The first 22 plots (440 m) in the transect were in very low-lying terrain and *duri antu* was the only rattan species recorded. After this the transect climbed up a small levee and *duri pelanduk* started to appear in the plots with *duri antu*. The elevation of the transect continued to gradually increase and by plot 26 the forest was completely dominated by *duri pelanduk*. Further along the transect, *duri tapah* plants started to

appear in association with *duri pelanduk*. The plots sampled toward the end of the transect (e.g. plots 46-50) were in progressively lower terrain and these sites were dominated exclusively by *duri antu*. Based on these results, it appears that *duri antu* does best on the low sites, *duri tapah* occupies the high sites, and *duri pelanduk* can share the middle ground with either of the other two rattan species.

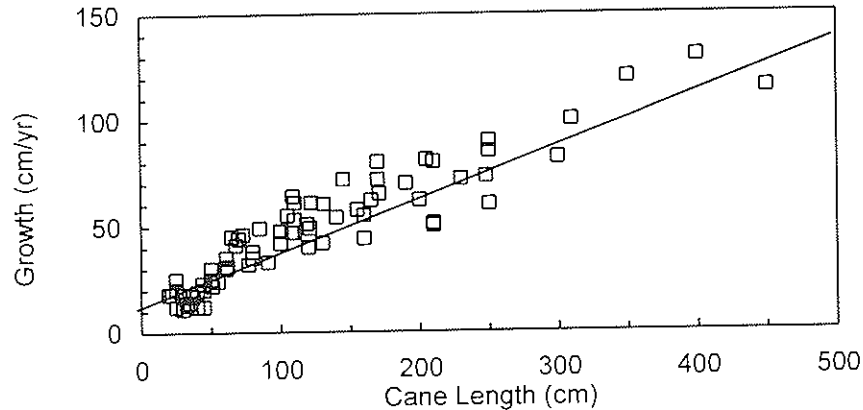


Figure 4. Annual extension growth as related to cane length for *duri antu* (*Calamus schistoacanthus*) in the flooded forests of DSWR. Regression line based on general linear model, i.e.  $\text{growth} = a + b(\text{cane length})$ ; parameter values and coefficient of determination are:  $a = 13.458$ ,  $b = 0.191$ ,  $r^2 = 0.75$ .

### Rattan Growth

Collecting growth and yield data for rattan is usually an extremely tedious and time-consuming task involving tree climbing and the periodic re-measurement of marked shoots. The annual rise and fall of the lakes at DSNP, however, provides a useful short cut for making preliminary estimates of productivity. As a result of the flood cycle, much of the vegetation in the park is under water for several months of the year. The sites examined in this study flood to a depth of 2.0 to 5.0 m and may be completely out of the water for a period of only three to four months each year. All but the tallest rattan canes are submerged during the flood cycle. When the water level subsides, these canes exhibit a rapid growth response and growth continues until the site begins to flood again. The new leaves and stem tissue produced during the low water period are glossy and green, while older leaves produced the previous year are covered with sediment from the long period of submersion. A reasonable estimate of annual growth can be obtained by measuring the length of the new stem tissue produced by a rattan immediately prior to flooding. Although these measurements are clearly under-estimates, as the plants do not cease to grow immediately at the onset of flooding, they provide a useful, albeit conservative, approximation of rattan productivity.

Growth data collected for *duri antu* using this procedure are presented in Figure 4. A total of 78 individuals representing a range of different height classes were measured. For this species, there is a linear relationship between plant size and extension growth for



canes up to 5 m long, and the relationship is strong enough from a statistical standpoint that stem growth can be meaningfully predicted from cane length. The fact that tall plants grow faster than short plants is not surprising given that the leaves of the larger canes stay out of the water longer than those of shorter plants, i.e. they have a longer "growing season." Of further interest in Figure 4 is that *duri antu* canes, especially the larger ones, exhibit a very fast rate of growth. Most of the canes produced about 50 cm of stem tissue/year and a few sample plants grew more than 1.0 m. These growth rates are comparable to those reported for other *Calamus* species in upland habitats (e.g. Dransfield and Manokaran, 1994, Bogh, 1995). Multiplying the size-specific growth estimates shown in Figure 4 by the number of canes/hectare in different size classes (from data in Figure 1 and Figure 2) provides a rough estimate of the total annual yield/hectare of *duri antu* cane. Based on these calculations, the forests at DSNP are producing about 4,500 m of *duri antu* cane per hectare each year. Given the existence of approximately 40,000 ha of forest containing *duri antu* at DSNP (Giesen, 2000), these yield estimates scale up to a total annual cane production of 180,000 km.

The high density and productivity of *duri antu* and other rattans at DSNP would suggest that there is more than enough rattan cane to supply the needs of the local fishing communities. From the supply side, the available stock of forest resources would seem inexhaustible. Before accepting this conclusion, however, it is important to examine the demand side of the equation in greater detail. Under high levels of exploitation and little management, history has shown that abundant forest resources frequently do not stay abundant for very long.

#### **Local Use and Demand for Rattan**

Rattan stems are extremely strong and flexible, and the canes from many species can tolerate long periods of submersion in water without rotting. Not surprisingly, rattans are a highly valued source of cordage and weaving material at DSNP and large quantities are harvested every year for both subsistence use and sale. No other non-timber forest resource in the park is exploited with this intensity.

Rattan is usually collected as an alternative activity during periods when fishing opportunities are limited in the lakes region (Aglionby, 1997). The exact timing of cane collection depends on the particular species being exploited. *Duri antu*, for example, is extremely tolerant of flooding and, as was shown earlier, natural populations of this species occur in habitats that are much lower than those occupied by *duri pelanduk* or *duri tapah*. The exploitation of *duri antu*, therefore, is limited to the early part of the flood cycle before its habitat becomes completely inundated, while *duri pelanduk* and *duri tapah* can be exploited for a much longer period.

Harvesting rattan is a relatively straightforward, yet strenuous task. After first locating a suitable specimen in the forest, the collector repeatedly tugs on the stem until the entire cane is dislodged and falls from the canopy. Care must be taken not to break the stem. Once on the ground, the spiny leaves and sheath around the stem are removed with a knife (*parang*) and the cane is bundled for transport out of the forest. Collectors preferentially harvest canes that are 4 m or longer; shorter or broken canes are used for making fishing implements. Local collectors report that one person can harvest up to one hundred and fifty 4 m canes on a good day. The rattan is usually sold in bundles of 50 canes. Women and children are frequently the most important rattan collectors in the community.

The great majority of the rattan harvested at DSNP is used on a subsistence basis for making fish traps, or sold to timber companies for lashing log rafts together. Both of these uses consume a very large quantity of rattan. Fish traps are an essential component of the livelihood of Malay fishermen at DSNP, and almost every household is equipped with an assortment of different fishing tools, e.g. *bubu*, *pengilar*, *bubu keli*, and *seruak* (Giesen, 1987; Dudley, 2000). The *bubu*, or cylindrical fish trap, is an especially ubiquitous implement. The rattan used to make these traps (almost always *duri antu*) is first cured with smoke to make it more durable and water resistant. Depending on the frequency with which it is used, a cured and well-made *bubu* can last from 5 to 10 years. The construction of one *bubu* requires about 500 *duri antu* canes; *pengilar*, *seruak*, and *bubu keli* require 40 to 50 canes.

As an example of how much rattan this subsistence use requires, Dudley (2000) reports a total of 2,550 *bubu*, 7,550 *pengilar*, 3,950 *bubu keli*, and 16,500 *seruak* in use at DSNP. The construction of these fishing implements represent a total harvest of more than 2.5 million *duri antu* canes, i.e. 15,300 km of rattan. Assuming that these traps must be replaced every five years on average, this represents an annual harvest of 510,000 six-meter long *duri antu* canes, or 3,060 km of rattan. As noted earlier, the forest is producing about 4,500 m of rattan or 750 merchantable canes/ha each year.

The sale of rattan for lashing logs together also consumes a significant quantity of cane. Timber companies need some way to tie logs together so that they can be floated downriver to sawmills, and rattan cane is apparently the strongest and most cost-effective material for this purpose. The buyers are reportedly not very demanding about the quality of the material they receive as long as the canes are 5.0 to 6.0 m long. Given the difficulty of distinguishing *duri antu* from *duri pelanduk* once the stem sheath has been stripped away, commercial collectors supply the latter species whenever they can.

To float the timber downriver, the logs are grouped together in lots of 20 logs, the "sinker" logs being mixed strategically together with the "floaters." Three bundles of rattan (approximately 150 canes) are needed to lash together one lot of logs. These lots are then lashed together into large rafts that may contain from 20 to 30 lots. During the course of this study, four large rafts of logs were sampled to determine the quantity of rattan required. The average size of a log raft was found to be 400 logs (i.e. 20 lots), with each raft containing approximately 18 km of rattan (i.e. 20 lots X 150 canes/lot X 6 m/cane). During periods of peak logging in the concessions around the park, as many as 12 to 15 log rafts a month can be observed floating through the park. Lashing these rafts together adds another 30,000 to 40,000 rattan canes to the monthly demand for rattan at DSNP.

Taken together, rattan harvesting for making fish traps and for selling to timber companies consumes about 550,000 six-meter long canes/year. More than 730 ha of lowland forest, or 22 ha for each of the 32 fishing villages in DSNP, are required to produce this quantity of material each year. Given that it takes about 12 years to produce a merchantable *duri antu* cane (average growth=50 cm/yr), each village needs a minimum of 260 ha of forest to supply its subsistence and commercial rattan needs. It should be noted that this calculation assumes that both demand and supply remain constant over time.

The current collection of rattan at DSNP exhibits two characteristics that suggest that the local demand for the resource is exceeding the productive capacity of the forest. First,

villagers complain that they must go further and further into the forest each year to find sufficient quantities of long cane to harvest. This is especially the case with *duri antu*. Second, rattan theft is becoming an increasingly common problem in the park. In most cases, it is the larger villages, many of which have already overexploited their rattan stocks, which are accused of stealing rattan from the forests surrounding the smaller villages. The great majority of the stolen rattan is sold to timber companies. In spite of the apparent abundance of rattan at DSNP, these patterns describe a classic scenario of resource over-exploitation (Peluso, 1983; Siebert and Belsky, 1985).

### **Balancing Supply and Demand**

Perhaps the most interesting aspect of the relationship between the fisherman and the rattan at DSNP is that the people, in this case, are aware that the plants they depend on are running out and they have started to do something about it. The response of local fishing communities to an impending rattan shortage has taken two different forms: (1) stricter control of access to the resource, and (2) rehabilitation and enrichment of natural stands.

Rattan is such an important component of human subsistence that it has always been one of the most openly accessible forest resources at DSNP. Traditionally, communities have allowed the residents of other villages to enter their forest area and to harvest as much rattan as they need as long as verbal permission from the village head (*ketua nelayan*) was secured. This open policy, however, appears to be gradually changing. The results from informal surveys conducted at DSNP revealed that five villages have recently implemented sanctions against the commercial harvest of rattan. Each of these villages also complained of dwindling rattan stocks or illegal harvesting. Although there are still a large number of villages that reported rattan scarcity (N=11) or theft (N=5) and have yet to do anything about it, and although it is clearly too early to assess the effectiveness of these community resource controls, the behavior of these five villages provides an interesting case of where access to a valuable forest resource is being restricted in response to resource scarcity. This is quite a bit different from the “tragedy of the commons” scenario (*sensu* Hardin, 1968) that one might expect in such a situation.

Shortly after drafting a new set of regulations controlling the harvest of rattan by outsiders, the residents of the village of Sumpak approached the scientific staff at the field station in DSNP and requested technical assistance to grow rattan. It should be remembered that these people are fisherman, not farmers, and that they have little experience with plant propagation and tending. It was clear to them that they needed more rattan, but they didn't know exactly how to go about it. They had, however, put a lot of thought into the idea and were very clear on which species they wanted to plant and where they wanted to plant them. On the higher terrain across the river in front of the village they wanted to plant *duri tapah*, while on a lower site located to the north they wanted to plant *duri antu*. Clearly, the fisherman at Sumpak know the habitat requirements of their local rattan species.

A total of 48 *duri tapah* seedlings were planted on the higher site and 82 *duri antu* seedlings were planted on the lower site. Almost everyone in the village—men, women, and children—turned out to assist with the planting. All of the seedlings used in the operation were transplants that had been dug up in the forest. Two weeks after planting, the two sites were re-visited to assess seedling mortality. Approximately 25% of the *duri tapah* seedlings were showing signs of yellowing and necrosis, and a slightly higher

percentage of dying seedlings were encountered among the *duri antu* transplants. Much of this mortality was the result of careless and hasty transplanting. Although a common response to finding a dead seedling was "that must have been one of those planted by the children," the importance of careful transplanting was embarrassingly clear to everyone involved. Additional enrichment plantings were planned for the following year.

It is important to realize that the rattan plantings at Sumpak are about more than simply increasing the supply of a scarce resource. To put things in perspective, each of the 60 *duri antu* seedlings that survived may grow, branch, and produce a harvestable rattan cluster with about 10 to 15 canes. This is enough rattan to produce about one *bubu*. The real significance of the rattan planting at Sumpak has to do with village initiative. It has to do with not ignoring the resource depletion that is going on all around you. It has to do with taking a first concrete step, albeit a small one, towards forest management and sustainable resource use.

The enrichment planting by the Sumpak community did not go unnoticed by other villages in the park. Soon after the Sumpak experience, representatives from several villages expressed an interest in rehabilitating their own rattan stocks, and plans were developed to establish a rattan nursery at the UK-Indonesia Tropical Forest Management Project (UK-ITFMP) field station at Bukit Tekenang. The nursery was created with the help of four villages, and more than 10,000 *duri tapah* seeds were germinated, planted in trays in trays, and transplanted to polybags. By the end of the year, 700-800 seedlings were ready for outplanting, and plans were made for establishing three additional nurseries to supply the growing local demand for rattan seedlings. Although these activities have experienced some problems, e.g. low germination rates due to excessive shade in the nursery and disruption of transplanting work by the lack of a dry season in 1996 and 1997, local interest in the rehabilitation of rattan stocks persists.

As further indication of village initiative, a small, rattan handicraft industry was also established at DSNP (Giesen and Aglionby, 2000). The rattan cane was locally processed into baskets and sold to selected, up-scale markets in Pontianak, Jakarta, and Singapore with the assistance of the UK-ITFMP. Almost 5,000 baskets were sold during the first 1.5 years of the project and the total annual income derived from rattan was increased by 15%. Interestingly, the total volume of rattan harvested from the forests of DSNP during this period did not increase (Wickham, 1997).

### Conclusion

A static analysis of the rattan situation at Danau Sentarum could provide a variety of different impressions. It could show that the fisherman in the park depend solely on three species of rattan, and that one species in particular, *duri antu*, is favored for making their fish traps. Or it could describe the abundance with which these three species occur in the forest. Or it could document that almost 4,000 km of rattan are harvested each year from the park. However, it is only through the integration of time-specific parameters like growth and yield that we glimpse the real dynamic between people and plants that is occurring at DSNP, i.e. the local populations are harvesting more than the forest can produce. The outcome of a chronic imbalance between supply and demand is relatively easy to extrapolate. If the demand functions do not change, or if nothing is done to increase the available supply of the resource, natural populations of the species will become severely degraded over time.

The salient feature of the research reported here is that local populations appear to be manipulating the supply side of the equation to ensure that this type of resource depletion does not happen. In the “doom-and-gloom” world of tropical forest destruction and biodiversity loss, the management initiative demonstrated by the fishermen at DSNP is a small success story. Similar responses to resource shortages are undoubtedly occurring in other tropical forest communities. By detecting and carefully documenting the dynamics of this process, ethnobotanists can make a major contribution to the conservation and sustainable use of tropical forest resources.

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## DANAU SENTARUM'S WILDLIFE

PART 1. BIODIVERSITY VALUE AND GLOBAL IMPORTANCE OF  
DANAU SENTARUM'S WILDLIFE

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Recent survey efforts in and around the Danau Sentarum National Park (DSNP), West Kalimantan, Indonesia suggest that the site comprises faunal biodiversity of both bioregional and global importance. Site faunal inventory has yielded a globally significant listing of 240 confirmed fish spp., or 71% of Borneo's freshwater fish fauna; not including 19 potentially new and endemic species awaiting confirmation. This data suggesting the site to be the most biodiverse in Indonesia with respect to fish fauna, and one of the world's most biodiverse lake systems. With regionally significant listings of 237 confirmed bird species, and a tentative listing of 143 mammal species (representing 48% and 65% of Borneo's bird and non-marine mammal fauna, and 14% and 65% of Borneo's endemic bird and mammal species), such biodiversity data form an adequate basis, and ample justification, for initiation of immediate habitat and faunal community conservation effort at the site. Yet ecological detail lacks to initiate firmer "species-focused" conservation programs. This data gap, and the need for further ecological and taxonomic research, becoming increasingly crucial as the risk of site and regional species extinction mounts in face of accelerating habitat destruction and uncontrolled harvest and trade impacts.

**Introduction and methods**

Numerous authors (e.g. Dennis, *et al*, 1997; Giesen, 1987; Kottelat, 1993) have mentioned the Danau Sentarum National Park (DSNP) and near catchment surrounds as a site of global importance in terms of ecological uniqueness, regional hydrological importance, and local and regional economic importance. However, the importance of the site as a refuge and habitat for an expanding list of animal species, has only been realized as a result of surveys over the last 10 years. With the varied terrestrial and aquatic habitats of the Danau Sentarum lake basin and swamp forest surrounds having been shown to constitute one of the more important and richer sites for wildlife biodiversity within Borneo.

In view of the DSNP site's importance, and against a background of increasing human population and development pressure, there is currently a pressing need to initiate

concerted conservation action to head-off the mounting risks of local and regional species extinction. As such, the need for clear definition of the full faunal biodiversity of the DSNP site is becoming more crucial as time passes. The following account thus goes some way to define the importance of DSNP and its swamp and hill forest surrounds in terms of faunal biodiversity. This output hopefully provides a framework of baseline data adequate to support the wildlife preservation and site conservation programs urgently needed within DSNP and near catchment surrounds.

Basic methodology in this report follows the following sequence for each main groups of species, i.e. invertebrates, reptiles and amphibians, birds and mammals: 1. All the DSNP survey literature on these groups is evaluated; 2. Complete species lists are shown in the Annexes; and 3. To highlight the “key” conservation species of the site, an assessment is made of the endemic, globally threatened (IUCN), CITES listed, legally protected, rare and locally vulnerable species that occur in the area. Special attention however needs to be directed to the tentative mammal species listing in this paper. Where the majority of species records (62%) were identified based on color plates and interview of local community hunters (Iban predominantly). Producing results, which regardless of the expert level of local knowledge, must be held in some doubt with respect to the rarer, restricted-range and in some cases highly unlikely recorded species.

## Results

### Invertebrates

Information on the invertebrate fauna of DSNP is scant due to a lack of comprehensive survey effort. Giesen (1987) provides a brief description concerning site invertebrates in the main DSNP lake basin. He notes that gastropods are relatively common in association with the higher nutrient level waters close to the Kapuas River (five species collected; *Pila ampullacea*, *Ctenodesma sp.*, *Schepmania sp.* and two *Bellamyia species*). Yet, they were uncommon in acid black water areas of the lake basin further from the main river. Local bees were noted to be predominantly *Apis dorsata* by Giesen (1987); with details of local *Apis dorsata* migratory and nesting behaviour expanded on by Pierce-Colfer (1993a) and Firmansyah (1996). Ant species were noted as common by Giesen (1987), but remained unidentified. An unidentified wasp species (locally called *gamang*) was also noted, whose papery combs are collected and larvae cooked for human consumption. Of the Crustaceans, two unidentified crab species were found to exist in small streams flowing into and within the swamp forests. Crustaceans, however, were reported as rare in the Kapuas river and lake habitats. Several species of freshwater shrimp also occur in the area, although their distribution is mainly restricted to the Kapuas River and main tributaries feeding the lake basin.

### Fish

Considerable work on the inventory of fish species of the Kapuas basin and DSNP has been carried out, with fisheries and fish species surveys already starting in the mid-19<sup>th</sup> century. Vaas (1952: 1-10) is noted, however, as being the first to have surveyed within the Danau Sentarum lakes area and adjacent rivers, identifying a total 72 fish species. Giesen (1987) expanded the species list and identified a total of 113 species. Noveriawan (1992) presented a short inventory of 24 fish species from the central lakes basin. Suryaningsih (1993) mentioned a list of over 87 species recorded in fish catch surveys. Dudley and Widjanarti (1993a) expanded Giesen's earlier list, while referring to



the work of Roberts (1989), and produced a list of 122 fish species for the lake basin and catchment surrounds.

Kottelat (1993) followed-up with a systematic review and expanded on earlier work and collections to produce a list of 175 fish species for DSNP and surrounding catchment (125 species from within the central lakes basin). He estimated that 50 species might be added if surrounding swamp forests and forest streams were better surveyed. No less than two new fish genera, 11 new fish species and a possible seven more species “likely also to be new” (needing more identification work) were discovered during this review and field survey. These included the undescribed genera of Cyprinidae gen. spec. nov. and “*Pelteobagrus*” ornatus, the new species *Osteochilus* aff., *Pentalineatus*, *Parachela* spec. nov., *Rasbora* spec. nov., Cyprinidae gen. spec. nov., *Barbucca* spec. nov.; *Mystus* spec. nov.; *Silurichthys* spec. nov.; *Gymnochanda* spec. nov.; *Pseudogobiopsis* spec. nov.; *Betta* aff. *pugnax* 1; *Betta* aff. *pugnax*, and the possible new species *Kalimantania* cf. *lawak*, *Puntius* aff. *binotatus* 1, *Puntius* cf. *lineatus*, *Rasbora* aff. *sumatrana*, *Pelteobagrus* cf. *ornatus*, *Silurichthys* cf. *hasseltii* and *Gymnochanda* cf. *filamentosa*) Three of the new species were later confirmed by Kottelat (1995: 51-64), plus a further new species (*Akysis fuscus*) by Ng and Kottelat (1996: 19-26) (listed in Table 1).

The review by Kottelat (1995: 51-64) and further survey work by Widjanarti (1995a; 1995b; 1996) brought the site list to 218 species. With the Martin-Smith (1996) survey of buffer zone peat forests and adjacent headwater streams, a further 14 species were added (including two possibly new species; *Rasbora* spec. nov. and *Nemacheilus* spec. nov.—shown in Annex 1). A compilation of the site’s fish species is presented in Annex 1. The list, covering DSNP, buffer zone and near-catchment surrounds, contains 240 “confirmed” fish species, or, if including 26 species marked as “?”, 266 fish species from 39 families. With local and English names, specific notes on levels of site abundance and population threat, endemism, global threat status (CITES listing and IUCN rating), national (and Sarawak) protection status and notes on observers, listed for each species.

**Table 1. Key Fish Species of DSNP.**

Species	English Name	Local Name	Status / Notes
<b>Globally Threatened (IUCN):</b>			
<i>Balantiocheilus melanopterus</i>	Bala Shark	<i>Ketutung</i>	I (considered threatened)
<i>Scleropages formosus</i>	Asian Arowana	<i>Siluk</i>	K (suspected threatened)
<b>CITES Listed:</b>			
<i>Scleropages formosus</i>	Asian Arowana	<i>Siluk</i>	List I
<b>New Species (Endemics?):</b>			
<i>Kalimantania</i> cf. <i>lawak</i>			possibly new—under review
<i>Osteochilus pentalineatus</i>			new—confirmed
<i>Parachela cyanea</i>			new—confirmed
<i>Puntius</i> aff. <i>binotatus</i> 2			possibly new—under review
<i>Puntius</i> cf. <i>lineatus</i>			possibly new—under review
<i>Rasbora</i> aff. <i>sumatrana</i>			possibly new—under review

<i>Rasbora spec. nov. 1</i>	new species?— unconfirmed
<i>Rasbora spec. nov. 2</i>	new species?— unconfirmed
Cyprinidae gen. <i>spec. nov.</i>	new species?— unconfirmed
<i>Mystus spec. nov.</i>	new species?— unconfirmed
<i>Pelteobagrus cf. ornatus</i>	possibly new—under review
<i>Silurichthys cf. hasseltii</i>	possibly new—under review
<i>Silurichthys spec. nov.</i>	new species?— unconfirmed
<i>Akysis fuscus</i>	new species—confirmed
<i>Gymnochanda cf. filamentosa</i>	possibly new—under review
<i>Gymnochanda spec. nov.</i>	new species?— unconfirmed
<i>Pseudogobiopsis spec. nov.</i>	new species?— unconfirmed
<i>Betta enisae</i>	new species—confirmed
<i>Betta aff. pugnax 1</i>	new species—?? B. enisae??
<i>Betta aff. pugnax 2.</i>	new species?— unconfirmed

Table 1 providing summary the “key” conservation species in listing the 20 confirmed and potentially new species (highly likely to be endemic to Borneo); the two IUCN-listed species; and the one CITES listed species found at the site. Analysis and comments of Giesen (1987), Kottelat (1993) and Dudley (1996), noting a further 34 fish species (as marked in Annex 1) which are now locally extinct (Ext.), vulnerable to fishing pressure (V) or showing signs of stunting in fish length (X) within DSNP. These being additional “key” species in need of population monitoring and conservation action. Only one species in the Annex 1 list (i.e. the Asian Arowana), however, is protected by Indonesian (or Sarawak) law.

### Reptiles and Amphibians

Data on the amphibians of DSNP are limited, with only Giesen (1987) commenting that frogs are common along the Kapuas River but rare in the lakes. Acid waters, the annual dry season and predatory fish were quoted as possible reasons for their absence from lake basin habitats. More work has been carried out on reptiles. Giesen (1987) made some notes on reptile observations, as did various researchers working in the area (e.g. A. Russon and J. Aglionby). Frazier (1994) and Ross *et al.* (1996) carried out some work on crocodile species distribution and abundance. Walter (1996) and Sumarni and Soraya (1996) carried out the most detailed site studies on the species, habitats and local trade of fresh water turtle and tortoise species. A species list compiled from all studies is presented in Annex 2, listing 24 “confirmed” reptile species; or, if including two species (*Crocodylus raninus* and *Trionyx gangeticus*) needing further confirmation, a total of 26

species. *Crocodylus raninus*—was possibly seen at DSNP by J. Aglionby in 1995; for more recent updates see S. Frazier elsewhere in this volume. For *Trionyx gangeticus*, there are unconfirmed observations by Sumarni and Soraya (1996), which would mean a possible first record in Indonesia. It needs to be noted that the snake and lizard inventory is far from complete; with no systematic survey conducted.

**Table 2. Key Reptile Species of DSNP (so far identified).**

Species	English Name	Local Name	Status / Notes
<b>Globally Threatened (IUCN):</b>			
<i>Crocodylus raninus</i>	Raninus Crocodile	<i>Buaya kodok</i>	Ex. (considered extinct)— yet to be confirmed
<i>Tomistoma schlegeli</i>	Asian Arowana	<i>Buaya sinyulong</i>	E (endangered)
<i>Crocodylus porosus</i>	Estuarine Crocodile	<i>Buaya rabin</i>	V (vulnerable)
<i>Manouria emys</i>	Asian Brown Tortoise	<i>Baning</i>	V (vulnerable)
<i>Orlitia borneensis</i>	Malaysian Giant Turtle	<i>Biuku</i>	I (considered threatened)
<i>Geomyda spinosa</i>	Spiny Turtle		I (considered threatened)
<i>Cyclemys dentate</i>	Asian Leaf Terrapin	<i>Kura-Kura Air</i>	K (suspected threatened)
<i>Malayemys subtrijuga</i>	Ricefield Terrapin	-	K (suspected threatened)
<i>Pyxidae mouhoutti</i>	Keeled Box Turtle	-	K (suspected threatened)
<i>Amyda cartilagenea</i>	Labi-labi Sungai	Asian Softshell Turtle	K (suspected threatened)
<i>Dogonia bibroni</i>	Labi-labi Kuning	Asian Giant Softshell Turtle	K (suspected threatened)
<b>CITES Listed:</b>			
<i>Tomistoma schlegeli</i>	False Ghavial	<i>Buaya sinyulong</i>	List II
<i>Crocodylus porosus</i>	Estuarine Crocodile	<i>Buaya rabin</i>	List II
<i>Manouria emys</i>	Asian Brown Tortoise	<i>Baning</i>	List II
<i>Varanus salvator</i>	Water Monitor	<i>Biawak</i>	List II
<i>Varanus bornensis</i>	Bornean Monitor	<i>Biawak Kalimantan</i>	List II
<i>Python reticulatus</i>	Reticulated Python	<i>Ular sawa</i>	
<b>New Species (Endemic):</b>			
<i>Crocodylus raninus</i>	Raninus crocodile	<i>Buaya kodok</i>	endemic thought extinct— to be confirmed “?”

The key reptile species of conservation importance and requiring monitoring are again those species which are endemic to Borneo, globally threatened (IUCN), CITES listed, legally protected or noted as rare or under local pressure. Table 2 provides a

summary listing of these “key” species, with one possibly endemic to Borneo (i.e. *Crocodylus raninus*), 11 globally threatened, and six CITES listed species shown. All these species are judged to be under varying levels of pressure and threat, particularly the crocodile species, fresh water turtle species, monitor lizard and python species, whose skins and meat are traded out of DSNP. Annex 2 shows that only seven species are protected under Indonesia or Sarawak law.

### Birds

The survey and inventory of bird species at DSNP is the most complete of all animal taxa. Detailed bird lists are provided by Giesen (1987) (66 species), Sebastian (1993) (73 species), Suriansyah (unpublished check-list, 215 species), Noveriawan (1993) (58 species), Hood (1993) (86 species), Dennis (1993), Dennis *et al.* (1997; 1996), and van Balen (1993) and van Balen and Jensen (1994) (228 species). These authors conducted surveys throughout the Park with some limited surveys of the Semujan and Menyukung hill forests. To these works the observations of Pierce-Colfer *et al.* (1993b), and Wadley *et al.* (1994; 1995; 1996) can be added. They recorded 74 bird species from the Lanjak hills. Other hill surveys were conducted by Jensen (1994), who recorded 100 and 85 species respectively for the Semujan and Menyukung hills alone. Van Balen *et al.* (this volume) still consider the inventory to be incomplete for some habitats.

The resulting species list compiled from all above studies is presented in Appendix 1 in van Balen *et al.* (this volume). It lists 237 “confirmed” bird species; or, if including 45 species still uncertain and needing confirmation (i.e. species marked with “?”), a total of 282 species from 52 families. An analysis of the bird list shows that DSNP contains about 36 CITES-listed species (minus an additional three CITES listed species still requiring confirmation); 72 nationally protected bird species; 5 confirmed Bornean endemics; and 31 confirmed globally threatened species. Table 3 provides a summary of the more important endemic and globally threatened “key” conservation species.

**Table 3. Key Bird Species of DSNP.**

Species	English Name	Local Name	Status / Notes
<b>Globally Threatened (IUCN):</b>			
<i>Polyplectron schleiermacheri</i>	Bornean Peacock Pheasant	<i>ruwai</i>	Cr (critical; local extinct?)?
<i>Ciconia stormi</i>	Storm's Stork	<i>karau</i>	E (endangered)
<i>Ardeola bacchus</i>	Chinese Pond Heron	<i>pelanduk</i>	E (endangered)
<i>Leptoptilus javanicus</i>	Lesser Adjutant Stork	<i>bangau tongtong</i>	V (vulnerable)
<i>Spizaetus nanus</i>	Wallace's Hawk-eagle	-	V (vulnerable)
<i>Lophura erythrophthalma</i>	Crestless Fireback	<i>sempidan</i>	V (vulnerable)
<i>Lophura ignita</i>	Crested Fireback Pheasant	<i>sempidan</i>	V (vulnerable)
<i>Columba argentina</i>	Grey Wood Pidgeon	<i>pergam</i>	V (vulnerable)
<i>Lophura bulweri</i>	Bulwer's Pheasant	<i>sengayan</i>	V (vulnerable)
<i>Carpococcyx radiceus</i>	Sunda Ground-	<i>bubut</i>	V (vulnerable)

<i>Ducula pickeringi</i>	Cuckoo Grey Imperial Pigeon		V (vulnerable)
<i>Aceros corrugatus</i>	Wrinkled Hornbill	<i>kukuk</i>	V (vulnerable)
<i>Pycononotus zeylanicus</i>	Straw-headed Bulbul		V (vulnerable)
<i>Anhinger melanogaster</i>	Oriental Darter	<i>dendang air</i>	NT (near threatened)
<i>Ardea sumatrana</i>	Great-billed Heron	<i>kukak</i>	NT (near threatened)
<i>Aviceda jerdoni</i>	Jerdon's Baza	<i>elang bulit</i>	NT (near threatened)
<i>Haliastur leucogaster</i>	White-bellied Sea-eagle	<i>elang kangkam</i>	NT (near threatened)
<i>Ichthyophaga humilis</i>	Lesser Fish-eagle	<i>elang ikan kecil</i>	NT (near threatened)
<i>Melanoperdix nigra</i>	Black Partridge	<i>empitu</i>	NT (near threatened)
<i>Treron fulvicollis</i>	Cinnamon-headed Green Pigeon	<i>pune herak</i>	NT (near threatened)
<i>Treron capellei</i>	Large Green Pigeon	<i>punai</i>	NT (near threatened) “?”
<i>Psittinus cyanurus</i>	Blue-rumped Parrot Greater Coucal	<i>bayan keladan</i> <i>bubut</i>	NT (near threatened)
<i>Centropus sinensis</i>			NT (near threatened)
<i>Batrachostomus javanensis</i>	Javan Frogmouth		NT (near threatened)
<i>Caprimulgus concretus</i>	Bonapartes Nightjar		NT (near threatened)
<i>Anthracoceros malayanus</i>	Black Hornbill	<i>buluk</i>	NT (near threatened)
<i>Buceros vigil</i>	Helmeted Hornbill	<i>tajak</i>	NT (near threatened)
<i>Megalaima rafflesii</i>	Red-crowned Barbet	<i>toгу</i>	NT (near threatened)
<i>Trichastoma rostratum</i>	White-chested Babbler		NT (near threatened)
<i>Trichastoma bicolor</i>	Ferruginous Babbler		NT (near threatened)
<i>Cyornis turcosus</i>	Malaysian Blue Flycatcher		NT (near threatened)
<i>Centropus rectunguis</i>	Short-toed Coucal		R (rare)
<i>Dryocopus javensis</i>	White-bellied Woodpecker		I (considered threatened)
<b>Endemic Species:</b>			
<i>Polyplectron schleiermachaeri</i>	Bornean Peacock Pheasant	<i>ruwau</i>	Old interviews— extinct “?”
<i>Haematortyx sanguiniceps</i>	Crimson-headed Partridge	<i>merah mata</i>	Outside of area “?”
<i>Arborophila hypertyra</i>	Red-breasted Partridge	<i>empitu</i>	Old records “?”
<i>Lophura bulweri</i>	Bulwer's Pheasant	<i>sengayan</i>	
<i>Batrachostomus harterti</i>	Dulit Frogmouth		Needs confirming??
<i>Harpactes whiteheadi</i>	Whitehead's Trogon		

<i>Megalaima pulcherrina</i>	Golden-naped Barbet	<i>tegok</i>
<i>Napothera atrigularis</i>	Black-throated Wren Babbler	
<i>Cyornis superbus</i>	Bornean Blue Flycatcher	
<i>Prionochilus xanthopygius</i>	Yellow-rumped Flowerpecker	<i>kuncit selatan</i>
<i>Arachnothera juliae</i>	Whitehead's Spiderhunter	
<i>Lochura fuscans</i>	Dusky Munia	
<i>Pityriasis gymnocephala</i>	Bornean Bristlehead	

### Mammals

Although not as intensively and systematically surveyed as the birds or fish, inventory of mammal species at DSNP has been extensive. Such studies within the Park and covering nearby hill ranges include the early observations of Giesen (1987) (14 species) and the more detailed inventory of Hood (1993) (45 species). The observations and interview data from hunting studies by Pierce-Colfer *et al.* (1993b), and Wadley *et al.* (1994; 1995; 1996) added data from the surrounding Lanjak uplands (41 species), while Harmaya's (1996) work, based on observations and interviews, focused on the tall peat swamp forests (28 species). Lastly, the systematic interview work of Erman and Sudrajat (1997) and Erman (1997), amongst buffer zone and catchment Dayak communities, produced a list of 134 mammal species, as observed by the local community. It needs to be noted that the methodology used in these latter surveys, i.e. interviews based on mammal field guide pictures (Payne *et al.*, 1985), may not always be reliable in identifying certain groups of mammal species, such as squirrels or tree-shrews (pers. obs.).

The resulting species list compiled from all above studies (recording actual observations and community interview data) is presented in Annex 3, listing 143 mammal species from 21 families. The list contains 55 species recorded as observed and 88 noted from secondary sources (interviews with local communities). Table 4 providing summary of the 16 IUCN threat-rated and 26 Bornean endemic, "key" conservation species, reportedly found at the site. With Annex 3 detailing an additional 26 CITES-listed and 31 nationally protected species. Additional species as the Eurasian Otter (*Lutra lutra*) and the mystery Bovine "*sapi nyalang*" (reported from Hutan Nung by a local community) have also been recorded as occurring at DSNP. Yet, these remain unlisted in Annex 3 and uncouned in the biodiversity figures in being highly unlikely to exist. Special note also to be made of the 88 species identified via local community report which also require field sighting or collection to formally confirm their presence.

Table 4. Key Mammal Species of DSNP.

Species	English Name	Status / Notes
<b>Globally Threatened (IUCN):</b>		
<i>Pongo pygmaeus</i>	Orang utan	E (endangered)
<i>Nasalis larvatus</i>	Proboscis monkey	V (vulnerable)
<i>Helarctos malayanus</i>	Sun Bear	V (vulnerable)
<i>Neofelis nebulosa</i>	Clouded Leopard	V (vulnerable)
<i>Arctogalidia trivirgata</i>	Small-toothed Palm Civet	I (considered threatened)
<i>Martes flavigula</i>	Yellow-throated Martin	I (considered threatened)
<i>Prionailurus planiceps</i>	Flat-Headed Cat	I (considered threatened)
<i>Pardofelis marmorata</i>	Marbled Cat	I (considered threatened)
<i>Prionailurus bengalensis</i>	Leopard Cat	I (considered threatened)
<i>Martes personata</i>	Ferret-badger	K (suspected threatened)
<i>Dyakopterus spadiceus</i>	Dayak Fruit Bat	K (suspected threatened)
<i>Lutra perspicillata</i>	Smooth Otter	K (suspected threatened)
<i>Lutra sumatrana</i>	Hairy-nosed Otter	K (suspected threatened)
<i>Aonyx cinerea</i>	Oriental Small-clawed Otter	K (suspected threatened)
<i>Cyanogale bennettii</i>	Otter-civet	K (suspected threatened)
<i>Catopuma badia</i>	Bay Cat	R (rare)
<b>Endemic Species:</b>		
<i>Suncus ater</i>	Black Shrew	
<i>Tupaia montana</i>	Mountain Treeshrew	
<i>Tupaia gracilis</i>	Slender Treeshrew	
<i>Tupaia picta</i>	Painted Treeshrew	
<i>Tupaia splendida</i>	Ruddy Treeshrew	
<i>Tupaia dorsalis</i>	Striped Treeshrew	
<i>Dendrogale melanura</i>	Small-Tailed Treeshrew	
<i>Nasalis larvatus</i>	Proboscis Monkey	
<i>Presbytis frontata</i>	White-Fronted Langur	
<i>Presbytis rubicunda</i>	Maroon Langur	
<i>Callosciurus baluensis</i>	Kinabalu Squirrel	
<i>Callosciurus orestes</i>	Banded Squirrel	
<i>Callosciurus adamsi</i>	Ear-Spot Squirrel	
<i>Sundasciurus jentinki</i>	Jentink's Squirrel	
<i>Sundasciurus brookei</i>	Brooke's Squirrel	
<i>Lariscus hosei</i>	Four-Striped Ground Squirrel	
<i>Drenomys everetti</i>	Bornean Mountain Ground Squirrel	
<i>Excilisciurus exilis</i>	Plain Pygmy Squirrel	
<i>Excilisciurus whiteheadi</i>	Whitehead's Pygmy Squirrel	
<i>Rheithrosciurus macrotis</i>	Tufted Ground Squirrel	
<i>Petaurillus hosei</i>	Hose's Pygmy Flying Squirrel	
<i>Aeromys thomasi</i>	Thomas's Flying Squirrel	
<i>Chiropodomys major</i>	Large Pencil-Tailed Tree-Mouse	
<i>Hystrix crassispinis</i>	Thick-Spined Porcupine	
<i>Hemigalus hosei</i>	Hose's Civet	
<i>Herpestes hosei</i>	Hose's Mongoose	
<i>Catopuma badia</i>	Bay Cat	
<i>Muntiacus atherodes</i>	Bornean Yellow Muntjac	

## Discussion

To evaluate the bioregional importance of DSNP in terms of wildlife conservation the site biodiversity parameters provided in Table 5 are used.

**Table 5. Biodiversity parameters of DSNP (confirmed species and potential new species).**

Taxa	Total species Borneo	Total species DSNP	% Borneo	New species ?	Endemic species	IUCN listed species	CITES listed species	National Protected species
Fish (fresh-water)	340	240	71	19?	??	2	1	2
Reptiles	?	24 (So Far)	?	1?	1?	10	6	6
Birds	502	293	58	-	9	31	36	72
Mammals	220	143	65	-	29	16	26	31
Plants	>15,000	>670	±5	10	33?	?	?	?

### Fish

The relative value of DSNP with respect to fish fauna is markedly high. Comparatively a selected global list of 71 tropical and temperate lakes (Groombridge, 1992), shows only three lakes with greater lacustrine fish species diversity than the 226 species of DSNP lakes and surrounds (Lake Tanganyika with >250 fish species, Lake Victoria (plus Lake Kyoga) with >250 species and Lake Malawi with 338 fish species). Thus the DSNP lakes, swamp forest and catchment surrounds are the richest site in terms of fish species diversity so far surveyed in Indonesia. Similarly, the Kapuas river basin as a whole, with 315 species of fish (35 endemic to Borneo) (Kottelat, 1993) is Indonesia's richest river system so far surveyed. Groombridge (1992) lists only the Mekong river basin (with approximately 500 species) as having more freshwater fish species in the Eurasia region than the Kapuas. As can be seen in Table 5, DSNP not only supports 70% of Borneo's 340 species of freshwater fish (and 76% of the Kapuas fish fauna), it also supports a high proportion of West Borneo's endemic species, with the 19 potentially new species recently surveyed (Table 1) all highly likely to be endemic to Borneo (Kottelat, 1993). Finally, something specifically worth mentioning is that DSNP represents the only protected site, within the known range of the valuable and rare "red-phase" Arowana (*Scleropages formosus*), a species which is CITES I listed, IUCN threat listed, and nationally protected.

### Reptiles

The true biodiversity value of the DSNP site for reptile species is unknown due to low number of species (24 species) so far confirmed. Yet the possibility of re-finding populations of the "extinct" Bornean endemic, *Crocodilus raninus*, would place DSNP amongst the most important crocodile conservation sites in the world in terms of species diversity (for more details on this refer to S. Frazier's paper elsewhere in this volume). With the site already supporting two globally endangered and CITES listed crocodile



species (*C. porosus* and *T. schlegeli*) (although with low population numbers). The site also supports high tortoise and soft-shelled turtle diversity (12 to 13 species); with eight of these species globally threatened and one CITES listed. Considering that many of these species are caught in the DSNP, traded abroad (e.g. Walter, 1996), and their populations seemingly declining, an assessment of populations and poaching levels is urgently required.

### **Birds**

The DSNP site with at least 237 bird species, of which 5 are endemic to Borneo, appears to be one of Indonesia's and Borneo's high bird biodiversity sites, supporting 48% of Borneo's bird fauna, and 14% of Borneo's endemic species. MacKinnon and Phillips (1993) list data on bird species numbers in other Borneo reserves as: Mt. Kinabalu National Park, 289 species; Mt. Mulu National Park, over 260 species; Danum Valley Conservation area, 240 species; Kutai National Park, 236 species; Tanjung Puting National Park, 218 species; and Barito Ulu research area 230 species. In comparison with MacKinnon and Phillips' data on other protected areas in Borneo, it would appear that DSNP may also be one of the highest bird diversity protected area sites in Borneo. Add to this the long list of key conservation species found within and surrounding DSNP (i.e. nine endemics, 31 globally threatened (IUCN) species, 36 CITES listed species and 72 nationally protected species), and the site may also be rated of high global and national importance in terms of bird species conservation. It is worth noting that despite DSNP being a large wetland, waterfowl and other birds associated with wetlands only occur in low numbers, as was already noted by Beccari (1904). Most likely this is related to continuous egg and young bird poaching by fishermen (Enthoven, 1903; pers. obs.; A. Erman, pers. comm.; R. H. Dennis, pers. comm.), and to a lack of suitable habitat or food (W. Giesen, pers. comm; Giesen, 1987). If poaching levels could be brought down to a lower level, the lakes area could increase significantly in importance for wetland birds, adding to the area's global importance and also attractiveness for eco-tourism.

### **Mammals**

DSNP surveys (Annex 3) indicate a possible 143 mammal species, of which 29 listed species are endemic to Borneo. Of these, 55 species have actually been observed by I-UKTFMP staff (nearly all confirmed with cross-referencing), while the remainder was recorded via secondary data collection (i.e. interviews with local community) (see Annex 3). The total number represents 65% of the non-marine mammal fauna of Borneo, and 65% of the Borneo's 44 endemic species. Again, this indicates that a high proportion of Borneo's biodiversity occurs at this one site. Furthermore, considering the number of key conservation species (i.e. 29 endemic species; 16 globally threatened species (IUCN); 26 CITES listed species and 31 nationally protected species), the DSNP site and surrounds may also be rated of global and national importance for mammal species conservation. With the globally significant DSNP populations of orangutan (*Pongo pygmaeus*) (Meijaard *et al.*, 1996; Rijksen and Meijaard, 1999) and proboscis monkey (*Nasalis larvatus*) (Meijaard and Nijman, 1999: 15-24) being worthy of special mention (as noted elsewhere in this volume).

### **Conclusions**

Aside from consideration of the poorly inventoried reptile, amphibian and invertebrate taxa, the bio-regional (and hence also global) conservation importance of the

DSNP and near catchment sites appears clear. Analysis of fish, mammal and bird lists suggest the DSNP site and near-catchment to be the most important freshwater fish biodiversity site in Indonesia, and amongst the most important bird and mammal biodiversity sites in Borneo on strength of total, globally threatened and endemic species numbers. It is therefore clear that any plan to safeguard a considerable part of Indonesia's biodiversity for the long-term future should incorporate an utmost attempt to successfully preserve Danau Sentarum's natural riches.

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ORDER/ FAMILY/ Species <sup>i</sup>	Local Name (Lan- guage) <sup>ii</sup>	English Name <sup>iii</sup>	Abund <sup>iv</sup>	Ende- mic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habitat <sup>ix</sup>	Observation Notes <sup>x</sup>
<i>janthochir</i>									
<i>Cyclocheilichthys repasson</i>	Buin, Buing								K1
<i>Eirmotus octozona</i>	Berbaju, Bangah, Tebalang								K1
<i>Epalzeorhynchus kalopterus</i>	Seluang Hantu, Seluang Batu, S. Merah	Flying Fox Barb	V						DW, K1
<i>Hampala bimaculata</i>									MS
<i>Hampala macrolepidota</i>	Lang- kung, Adung, Dungan	Sebarau							DW, K1
<i>Hypophthalmichthys molitrix</i>	Patjur	Carp							???
<i>Kalimantania cf. lawak</i>				*					Wetland Data- base WI K1
<i>Labeo chryso- phekadion</i>	Temunit, Ikan arang, Kak'	Black "shark"	r, X						DW, K1
<i>Labio barb- us fasciatus</i>	Masik, Ma, Senkirik								
<i>Labio barb- us festivus</i>	Kujam, Kujan Merah								DW, K1
<i>Labio barb- us kuhlii</i>	Kujam putih	Kawan							K1
<i>Labio barb- us ocellatus</i>	Bauk tadung								DW, K1
<i>Labio barb- us cf.</i>	Kujam putih								X W
<i>sumatranus</i>									
<i>Leptobarbus hoevenii</i>	Jelawat	Sultan Fish	V						DW, K1
<i>Leptobarbus melanopterus</i>	Piyam, Piam		V						DW, K1
<i>Leptobarbus melantaenia</i>	Behau, Piam, Bundung								???
<i>Luciosoma setigerum</i>	Wader, Johar, Kelekui								Wetland Databas e WI ???
									Wetland Databas e WI

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<i>Luciosoma spilopleura</i>	Dalang, Penyuar								K1
<i>Luciosoma trinema</i>	Kenyuar, Juajo, Nyenyu- ar								DW, K1
<i>Macrochi- richthys macrochirus</i>	Belantau, Timah- timah	Fresh- water Dorab	V, X						DW, K1
<i>Neobary- notus microlepis</i>	Bubuk								K1
<i>Osteochilus borneensis</i>		Carp							DW, K1
<i>Osteochilus haseltii</i>	Palua merah, Nilem	Carp							W
<i>Osteochilus intermedius</i>	Menyadin	Carp							DW, W
<i>Osteochilus kahaja-nensis</i>	Palau	Carp							K1
<i>Osteochilus kappenii</i>	Palau	Carp							DW, K1
<i>Osteochilus melano- pleura</i>	Kelabau, Kelabau padi	Carp	V, X						DW, K1
<i>Osteochilus microce- phalus</i>	Bantak	Carp							DW, K1
<i>Osteochilus pentalineatus</i>	Engkarit, Karit	Carp		*					K1, W, K2
<i>Osteochilus cf. pleurotaenia</i>	Palau batu,								K1
<i>Osteochilus schlegelii</i>	Kulung Kelabau putih= kebali, Kebali batu, Kebali	Carp	V, X						DW, K1
<i>Osteochilus spilurus</i>	Bantak batu	Carp							K1
<i>Osteochilus triporos</i>	Menya- din, Riu'	Carp							DW, K1
<i>Osteochilus waandersii</i>	Bantak batu, Bantak surik, Umpan- umpan	Carp							DW, K1
<i>Oxygaster anomalura</i>	-	-							K1
<i>Parachela cyanea</i>	Lipi			*					W, K2

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<i>Parachela hypophthalmus</i>	Lipi, Entebuloh, Ikan kaca								DW, K1
<i>Parachela oxygastroides</i>	Kelampak, Entebuloh,		X						DW, K1
<i>Paracrossochilus vittatus</i>	Seluang batu, Enseluai batu, Tulum								W
<i>Pectenocypris balaena</i>	Seluang maram								K1
<i>Puntioplites bulu</i>	Tengalan	Barb	V, X						DW, K1
<i>Puntioplites sp.</i>									W
<i>Puntioplites waandersii</i>	Umpan	Barb							DW, K1
<i>Puntius anchisporus</i>	Berbaju	Barb							K1
<i>Puntius aff. binotatus 2</i>	Bangas, Bunter	Common Barb, Two-spot Barb		*					K1
<i>Puntius endecanalis</i>	Berbaju	Barb							K1
<i>Puntius eugrammus</i>	Engkarit, Karit	Barb							DW, W
<i>Puntius everetti</i>	Berbaju, Telotong	Barb							W
<i>Puntius hexazona</i>									MS
<i>Puntius johorensis</i>									K1
<i>Puntius lateristriga</i>	Bangas, Dokun	Spanner Barb							K1
<i>Puntius cf. lineatus</i>	Engkarit	Lesser-striped Barb		*					K1
<i>Puntius rhomboocellatus</i>	Berbaju	Barb							K1
<i>Puntius tetrazona</i>	Badju, Ikan Badja, Berbaju	Four-banded Tiger Barb							DW
<i>Rasbora agryrotaenia</i>	Seluang, Enseluai bujur, Selaung bujur	Rasbora							W



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<i>Thynnichthys polylepis</i>	Bauk ketup, Baul pipih		X						DW, K1
<i>Thynnichthys thymnoides</i>	Entukan, Lumo								DW, K1
<i>Thynnichthys vaillanti</i>	Kenedia, Mengangin							???	Wetland Databas e WI
<i>Tor douronensis</i>	Garing, Semah, Kencera, Sengkareng							???	Wetland Databas e WI
<i>Cyprinidae gen. spec. nov.</i>	-	-		*					K1
BALITO- RIDAE									
<i>Barbucca diabolica</i>	-								DW
<i>Ellopostoma megalomycter</i>	Eng-krunyuk, Seluang eng-krunyuk	Hill-stream Loach							DW, K1
<i>Gastromyzon punctulatus</i>	Dekat								DW, W
<i>Homaloptera nebulosa</i>	Susuh batang, Selusur	Clouded Torrent Loach							K1
<i>Homaloptera ophirolepis</i>	Susuh batang, Lelekat	Torrent Loach							W
<i>Homaloptera orthogoniata</i>	Susuh batang, Ketapang	Clown Torrent Loach							K1
<i>Homaloptera stephensoni</i>	Susuh batang, Selusur	Torrent Loach							K1
<i>Homaloptera weberi</i>	Susuh batang, Selusur								W
<i>Nemacheilus kapuasensis</i>	Ikan batu, Mema-nyur	Hill-stream Loach							K1
<i>Nemacheilus lactogeneus</i>	Ikan batu, Mema-nyur	Hill-stream Loach							K1
<i>Nemacheilus pfeifferae</i>	-	-							W
<i>Nemacheilus saravacensis</i>	Ikan batu, Mema-	Hill-stream							K1

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	nyur	Loach							W
<i>Nemacheilus selangoricus</i>	Ikan batu, Mcma- nyur	Grey- banded Loach							K1
<i>Nemacheilus spiniferus</i>	Ikan batu, Mema- nyur								MS
<i>Nemacheilus spec. nov.</i>	-	-							W
<i>Neogastro- myzon nieuwen-huisi</i>	Dekat	Hill- stream Loach							
COBITIDAE									
<i>Acanthopso- ides molobrion</i>		Lesser Horse- faced Loach							K1
<i>Acantho- psoides robertsi</i>									K1
<i>Acantopsis cf. dialuzona</i>									DW, K1
<i>Botia hymenophysa</i>	Engkadik, Langli, Pansck	Beau- fort's Loach	V, X						DW, K1
<i>Botia macra- canthus</i>	Ulang uli, Entebi- ring, Ikan macan	Clown Loach	V, X						
<i>Lepido- cephalich- thys pristis</i>	Emplu- nyu	Saw- spined Loach							K1
<i>Pangio agma</i>	Ikan cacing								W
<i>Pangio anguillaris</i>	-	-							W
<i>Pangio kuhlii</i>	Ikan cacing								K1
<i>Pangio malayana</i>									
<i>Pangio oblonga</i>	Ikan cacing	Grey Eel Loach							W
<i>Pangio semicincta</i>									W
<i>Pangio shelfordii</i>	Ikan cacing	Reticu- lated Loach							K1
<i>Pangio superba</i>	Ikan cacing	Loach							
<b>SILURIFORMES</b>									
<b>BAGRIDAE</b>									



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<i>Hemistilurus heterorhynchus</i>	Lais tirnah Lais timah								DW, W
<i>Kryptopterus apogon</i>	Lais jungang		X						DW, KI
<i>Kryptopterus bicirrhis</i>	Lais tipis. Lais	Glass Catfish							DW, KI
<i>Kryptopterus cryptopterus</i>	Lais juara, Lais tunggul								DW, KI
<i>Kryptopterus lais</i>	Lais tipis. Lais								DW, W
<i>Kryptopterus limpok</i>	Lais janggot. Lais kerak								KI
<i>Kryptopterus macrocephalus</i>	-								DW, KI
<i>Kryptopterus micronema</i>	Lais bangah, Lais jugang								DW, KI
<i>Kryptopterus minor</i>	Lais kaca, Lais tipis								DW, KI
<i>Kryptopterus schilbeides</i>	Lais buluh, Lais kuning								DW, KI
<i>Ompok bimaculatus</i>	Tapak, Wagal, Tapah, Tapah rawang	Butter Catfish. Two- spotted Ompok							KI
<i>Ompok cf. eugeneiatus</i>	Lais nipah								DW, KI
<i>Ompok eugeneiatus</i>	Lais nipah								DW, KI
<i>Ompok hypophthalmus</i>	Lais butu, Lais pendek mulut, Limpok								DW, W
<i>Ompok sabanus</i>	Anak lais, Lelipai								DW, KI
<i>Silurichthys cf. hasseltii</i>	Anak lais. Indai lelipai, Lelipai	Hasselt's Leaf Catfish		*					KI
<i>Silurichthys schneideri</i>	Anak lais, Indai	Schnei- der's Leaf							KI



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	lelipai, Lelipai	Catfish							
<i>Silurichthys phaiosoma</i>	Anak lais, Indai lelipai, Lelipai								DW, W
<i>Silurichthys spec. nov.</i>				*					
<i>Wallago leeri</i>	Tapah	Gaint Malayan Catfish							DW, KI
PANGASI- IDAE									
<i>Laides hexanema</i>	Lais juara, Seladang	Panga- sius							W
<i>Pangasius humeralis</i>		Panga- sius							DW, KI
<i>Pangasius micronema</i>	Langu, Riu	Panga- sius							DW, KI
<i>Pangasius nasutus</i>	Sela- dang, Patin	Panga- sius							DW, W
<i>Pangasius niuwenhuisii</i>									MS
<i>Pangasius poly- uranodon</i>	Duara, Juara, Sadarin	Panga- sius							DW, KI
SCHIL- BIDAE									
<i>Pseudeu- tropius brachypo- pterus</i>	Nuayang tebal, Nuajang, Rui' pate'	Schilid Catfish							DW, KI
<i>Pseudeu- tropius moolen- burghae</i>	Nuayang tipis, Nuajang, Rui' pate'	Schilid Catfish							DW, KI
AKYSIDAE									
<i>Acrochordo- nichthys cf.</i>	Lakut	Stream Catfish							KI
<i>Melano- gaster</i>									
<i>Acrochordo- nichthys chameleon</i>	Lakut								W
<i>Acrochordo- nichthys rugosus</i>	Kekel, Jompul	Stream Catfish							??? Wetland Data- base WI
<i>Akysis fuscus</i>		Stream Catfish		*					K3
<i>Akysis poly- staphylodon</i>		Stream Catfish							??? Wetland

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<i>Breiten- steimia insignis</i>	Dekat								Data- base WI W
PARAKY- SIDAE									W
<i>Parakysis anomalo- pteryx</i>	Dekat								W
SISORIDAE									W
<i>Glyptothorax major</i>	Kalakotai	Wrinkle- bellied Catfish							W
<i>Glyptothorax platypogon</i>	Kalakotai	Sucking Catfish							W
<i>Glyptothorax platypo- gonoides</i>	Kalakotai	Wrinkle- bellied Catfish							???
									Wetland Data- base WI
CLARIIDAE									W
<i>Clarias batrachus</i>	Kelik, Lele	Common Walking Catfish							DW
<i>Clarias leiacanthus</i>	Kelik, Kelih	Walking Catfish							KI
<i>Clarias meladerma</i>	Kelik, Duri	Saw Spined Walking Catfish							
<i>Clarias teysmanni</i>	Kelik kuning	Forest Walking Catfish							
CHACIDAE									DW, KI
<i>Chaca bankanensis</i>	Tuka, Beliung, Entuka	Angler Catfish							
ARIIDAE									???
<i>Arius polystaphy- lodon</i>	Songot, Ikan perut, Djabal, Djahan	Sea Catfish							Wetland Data- base WI
<i>Arius thalassinus</i>	Manyong utik, Gugup, Baung gugup	Sea Catfish							???
									Wetland Data- base WI
<i>Cephalo- cassis melanochir</i>	Gugup, Songot	Sea Catfish							DW, W
<i>Hemiarus</i>	Dukang,	Sea							DW



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<i>Gymno- chanda cf. filamentosa</i>	Anak senara.	Glass Perchlet		*					KI
<i>Gymno- chanda sp. nov.</i>	Anak senara			*					KI
<i>Paradoxo- dacna piratica</i>	Senara	Glass Perchlet	X						KI
<i>Parambassis apogonoides</i>	Senara, Gaba- gaba	Glass Perchlet	X						DW, KI
<i>Parambassis macrolepis</i>	Senara,	Glass Perchlet	X						DW, KI
<i>Parambassis wolffii</i>	Senara, Sempe- kah		X						DW, KI
DATNIO- IDIDAE									
<i>Coius microlepis</i>	Ringau, Ringan	Banded Triple-tail	X						DW
TOXO- TIDAE									
<i>Toxotes microlepis</i>	Sumpit	Archer Fish							W
<i>Toxotes chatareus</i>	Sumpit	Seven- spot Archer Fish	r						Giesen (1987) ????
NANDIDAE									
<i>Nandus nebulosus</i>	Patung rimba, Empu- kung, Patung dundu	Leaf Fish							DW
PRISTO- LEPIDIDAE									
<i>Pristolepis fasciata</i>	Patung, Empa- tung, Ikan tempeh	Banded Leaf Fish							DW, KI
<i>Pristolepis cf. grooti</i>									DW, MS
POLY- NEMOIDEI									
POLY- NEMIDAE									
<i>Polystonemus multifilis</i>	Tenggulu, Kurau, Kurau janggut	Thread- fin							DW, KI
<i>Polystone- mus longi-</i>		Thread- fin							??? Wetland

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<i>pectoralis</i>									Data- base WI
<b>GOBIOIDEI</b>									
ELEO- TRIDIDAE									
<i>Oxyeleotris marmorata</i>	Ketutuk, Bakutut, Bodo- bodo	Marbled Goby	V						DW, KI
GOBIDAE									
<i>Pseudo- gobiopsis spec. nov.</i>				*					KI
<b>ANABAN- TOIDEI</b>									
LUCIO- CEPHA- LIDAE									
<i>Lucio- cephalus pulcher</i>	Emplu- nyu, Plunyu	Pikehead							KI
HELOSTO- MATIDAE									
<i>Helostoma temminckii</i>	Biawan, Bawan, Tam- bakan	Kissing Gouramy							DW, KI
OSPHRO- NEMIDAE									
<i>Osphro- nemus goramy</i>	Kaloi, Gurami, Kali	Giant Gouramy							DW, KI
<i>Osphronemus cf. Septem- fasciatus</i>									KI
BELON- TIDAE									
<i>Belontia hasseltii</i>	Sepat	Javan Combtail							DW, KI
<i>Betta akarensis</i>	Empala, Em- plasek								KI
<i>Betta anabatoides</i>	Melantau	Fighting Fish							MS
<i>Betta cf. bellica</i>									MS
<i>Betta dimidiata</i>	Empala, Emplasek	Fighting Fish							KI
<i>Betta enisae</i>	Empala, Emplasek			*					W, K2
<i>Betta fusca</i>		Fighting Fish							Giesen (1987) ???

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<i>Betta aff. pugnax 1</i>		Forest Fighting Fish		*					KI
<i>Betta aff. pugnax 2</i>		Forest Fighting Fish		*					KI
<i>Parosphromenus ornaticauda</i>	Empala, Emplasek								W
<i>Trichogaster leerii</i>	Sepat, Engkribang, Ensepat	Pearl Gouramy							DW, KI
<i>Trichogaster pectoralis</i>	Sepat siam	Snake-skin Gouramy							DW, W
<i>Sphaerichthys vaillanti</i>	Sepat, Ensepat								KI
<b>CHANO-IDEI</b>									
<b>CHAN-NIDAE</b>									
<i>Channa bankanensis</i>	Runtuk	Black-water Snake-head							DW, KI
<i>Channa lucius</i>	Runtuk, Gabus cina	Forest Snake-head							DW, KI
<i>Channa maruloides</i>	Piyang	Flower Snake-head							DW, KI
<i>Channa melanopterus</i>	Bujuk, Kchung, Ruwan	Snake-head							DW
<i>Channa melasoma</i>	Gabus tobang, Buhung, Toman	Black Snake-head							DW
<i>Channa micropeltes</i>	Toman, Anak toman, Gabus tobang	Giant Snake-head							DW, KI
<i>Channa orientalis</i>									W
<i>Channa pleurophthalmus</i>	Kerandang	Snake-head							DW, KI
<i>Channa striata</i>	Delak, Gabus, Telak	Striped Snake-head	X						DW, KI
<b>MASTACEMBE-</b>									

ORDER/ FAMILY/ Species'	Local Name (Lang- guage) <sup>ii</sup>	English Name <sup>iii</sup>	Abund <sup>iv</sup>	Ende- mic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habitat <sup>ix</sup>	Observ- ation Notes <sup>x</sup>
<b>LOIDEI</b>									
MASTA- CEMBE- LIDAE									
<i>Macro- gnathus aculeatus</i>	Tilan kelokoi, Luda	Long- nosed Spiny Eel	X						DW, K1
<i>Macro- gnathus armatus</i>	Tilan, Kekar, Kelekui, Entunuk								??? Wet- land Data- base WI
<i>Macro- gnathus keithi</i>	Anak Tilan								??? Wet- land Data- base WI
<i>Macro- gnathus maculatus</i>	Tilan kapar, Tilan	Buff- backed Spiny Eel	X						K1
<i>Mastacem- belus erythrota-enia</i>	Tilan sabang Tilan	Fire Eel	X						DW, K1
<i>Mastacem- belus unicolor</i>	Tilan kelokoi		X						K1
<b>PLEURO- NECTI- FORMES</b>									
CYNOGLOS- SIDAE									
<i>Cynoglossus kapuasensis</i>	Kenilah, Ikan Lidah	Tounguc- sole							K1
<i>Cynoglossus waandersii</i>	Kenilah, Ikan Lidah	Toungue- sole	r						K1
SOLEIDAE									
<i>Achiroides leucho- rhynchus</i>	Kenilah, Ikan Lidah								W
<i>Achiroides melanor- rhynchus</i>	Kenilah, Ikan Lidah	Fresh- water Sole							K1
<i>Synaptura cf. panoides</i>	Kenilah, Ikan lidah								??? Wetland Data- base WI
<b>TETRA- ODONTI- FORMES</b>									
TETRA- ODONTI-									

ORDER/ FAMILY/ Species <sup>d</sup>	Local Name (Lan- guage) <sup>ii</sup>	English Name <sup>iii</sup>	Abund <sup>iv</sup>	Ende- mic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habitat <sup>ix</sup>	Observation Notes <sup>x</sup>
DAE									K I
<i>Chonerhinus amabilis</i>	Buntal lemas	Pufferfish							DW, K I
<i>Chonerhinus nefastus</i>	Buntal lemas	Golden Pufferfish							W
<i>Chonerhinus silus</i>	Buntal lemas								W
<i>Tetraodon leirus</i>	Buntal	Red-spot Pufferfish							???
<i>Tetraodon nigroviridis</i>	Buntal	Spotted Pufferfish							Wetland Data-base WI K I
<i>Tetraodon palembagensis</i>	Buntal	Reticulate Pufferfish							

<sup>i</sup>**Taxonomic reference:** Both species names and order of listing of species Families and Orders have been adapted according to Kottelat, M., Whitten, A. J., Kartikasari, S. N. and Wirjoatmodjo (1993) *Freshwater Fishes of Western Indonesia and Sulawesi*. Periplus Editions Ltd.

<sup>ii</sup>**Local names:** As collected by the field observers listed on-site (all in local Malay); names adapted from Widjanarti, H. E. A. (1996) *Checklist of the Freshwater Fishes of Danau Sentarum Wildlife Reserve and Adjacent Areas, Kapuas Hulu, West Kalimantan, Project 5, I-UKTFMP, Wetlands International-PHPA-ODA*.

<sup>iii</sup>**English names:** Adapted from Kottelat et.al. (1993).

<sup>iv</sup>**Abundance:** Abundance on-site (DSWR) or degree of vulnerability to fishing or trading pressure as remarked by Giesen (1987) or Kottelat (1993): **r**—rare; **ext**—previously present yet now locally extinct; **V**—vulnerable to fishing and trading pressure (as per Giesen (1987), Kottelat (1993) or Dudley (1996). **X**—Indications from catch survey data, Dudley (1996), that species caught are small in size compared to expected average sizes (lengths)—i.e. a possible indicator of over-fishing. Reference: Dudley, R.G. (1996) *The Fishery of Danau Sentarum Wildlife Reserve, West Kalimantan, Indonesia: Management Considerations*. Project 5, I-UKTFMP, Consultancy Report. WI-PHPA-ODA (project report 219).

<sup>v</sup>**Endemicity:** No listing of endemic fish species of Western Borneo has been located, the only species marked are those which may be endemic, in being new species, possibly new species, and species under taxonomic review (as noted by Kottelat (1993), (1995) and (1996).

<sup>vi</sup>**CITES:** CITES listings derived from Anon. (1995) *Checklist of Fish and Invertebrates Listed in the CITES Appendices*. Joint Nature Conservation Committee Report (UK CITS Scientific Authority). **I**—Listed in Appendix I CITES, endangered spp., trade in which is normally prohibited.

<sup>vii</sup>**IUCN rating:** IUCN rating of global threat to spp. as adopted from Groombridge, B. (1993) *1994 IUCN Red List of Threatened Animals*. Compiled by the World Conservation Monitoring Centre, Cambridge, U.K. IUCN—The World Conservation Union. **E**—endangered; **V**—vulnerable; **R**—rare; **I**—indeterminate (considered E, V or R); **K**—insufficiently known (suspected E, V or R).

<sup>viii</sup>**National Law:** Both Indonesian Law and Sarawak Law (Malaysia).

**Indonesian Law:** Ref. Anon (1973) *Jenis Satwa Dilindungi di Kalimantan Barat, Sub-Balai KSDA, Kalimantan Barat, 1973*. Daftar Satwa yang Dilindungi di Indonesia, 10 Juni 1991—List 301/Kpts-II/1991 contained in Anon (?) *Kumpulan Peraturan tentang Flora/Fauna dan Bagian*



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Bagainya, Sub-Balai Konservasi Sumber Daya Alam Kalimantan Barat. Species marked by **1**—are protected as per Keputusan Menteri Pertanian No. 716/Kpts/Um/10/1980. Further clarification of protection status of *Notopterus* sp. as provided by Suwelo, I. S., Supangkat, S. dan Junia, C. (1996) Limnologi dan Konservasi Lingkungan Hidup Rawa, Danau dan Sungai: Habitat Biota Langka. Prosiding Ekspose Limnologi dan Pembangunan, Bogor, LIPI/Puslitbang Limnologi.

**Sarawak Law:** Ref. *Forestry Department of Sarawak, Protected Animals of Sarawak. Poster Series—Poster 2 S*—Protected Animal, illegal to hunt, kill, capture, sell, offer for sale, import, export, or be in possession of without a license, any protected animal, or any trophy, flesh, egg or nest there. Native rural residents engaged in traditional hunting for own consumption excluded.

<sup>ix</sup>**Habitats:** No notes have been taken in the majority of cases of the habitats from which fish species were collected. Thus this column has been left blank to be filled in as observations are made in future in the field. Some notes on habitat, however, are available in Widjanarti (1996) for more detailed reference.

<sup>x</sup>**Notes on Observers:** To detail who has first observed the listed species in the DSWR lakes area and surrounds, the following codes have been employed: **DW**—Species inventoried by Dudley and Widjanarti (1993a)—project report 25; **K1**—Species inventoried and confirmed by Kottelat (1993)—project report 50 **W**—Species added to previous inventory by survey work of 1994, reported in Widjanarti (1995b) and (1996), project reports 151 and 211 (note all Kottelat (1993) spp. are also listed by these reports); **K2**—new species confirmed by Kottelat (1995)—report 157; **K3**—new species confirmed by Ng and Kottelat (1996)—report 203; **MF**—additional species added by surveys of Martin-Smith (1996)—report 207; **M**—Review of *Notopterus* spp. of Danau Sentarum, Dr. A. Mangalik (1997c)—project report 268.

ANNEX 2: SYSTEMATIC LIST OF REPTILE SPECIES: DANAU  
SENTARUM NATIONAL PARK AND NEAR-CATCHMENT SURROUNDS

ORDER/ FAMILY/ Species <sup>i</sup>	Local Name (Language) <sup>ii</sup>	English Name <sup>iii</sup>	Status <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habitat <sup>ix</sup>	Observation Notes <sup>x</sup>
<b>TESTUDINES</b>									
<b>TESTUDINIDAE</b>									
<i>Manouria emys</i>	Baning (I)	Asian Brown Tortoise Burmese Brown Tortoise	few		II	V, 3	S	Aq./terrestrial; HF, hill streams	Int.-WG, OW ( <i>Testudo emys</i> ; <i>Geochelone emys</i> )
<b>EMYDIDAE</b>									
<i>Orlitia borneensis</i>	Biuku (I)	Malaysian Giant Turtle	abund			1	1	Aq.; TF, RF, SS, DS, lakes, rivers streams	Obs.-OW ( <i>Bellia borneensis</i> ; <i>Hardella baileyi</i> )
<i>Siebenrockiella crassiscollis</i>	Kura-kura Jaung (I)	Black Marsh Turtle	abund					Aq./terrestrial; TF, SS, DS, streams & paddy	Obs.-OW ( <i>Emys c.</i> ; <i>Orlitia c.</i> ; <i>Siebenrockiellata c.</i> )
<i>Cuora amboinensis</i>	Kura-kura Tambit (I)	Asian Box Turtle Malayan Brown Turtle	abund					Aq./terrestrial; TF, SS, DS, paddy	Obs.-OW ( <i>Cuora amboinensis</i> )
<i>Cyclemys dentata</i>	Kura-Kura Air (I)	Asian Leaf Terrapin, Asian Stream Terrapin	few			3		Aq.; TF, HF, hill streams, paddy	Obs.-OW
<i>Heosemys spinosa</i>	Kura-kura Umung (I)	Spiny Turtle	rare			K, 1		Aq./terrestrial; TF, SS, DS	Obs.-OW ( <i>Heosemys spinosa</i> )
<i>Malayemys subtrijuga</i>	-	Ricefield Terrapin, Snail Eating	rare			3		Aq.; TF, SS, rivers, lakes,	Obs.-OW ( <i>Damonia</i> )

ORDER/ FAMILY/ Species <sup>d</sup>	Local Name (Lan- guage) <sup>ii</sup>	English Name <sup>iii</sup>	Status <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habitat <sup>ix</sup>	Obser- vation Notes <sup>x</sup>
		Terrapin						paddy	<i>subtri- juga</i> )
<i>Pyxidae mouhottii</i>	-	Keeled Box Turtle	rare			3		Aq.; TF, SS, HF, streams	Obs.- OW ( <i>Cy- clemmys mou- hotti</i> )
TRIONYCHIDAE									
<i>Anyda cartilaginea</i>	Labi-labi Sungai	Asian Softshell Turtle	abund			3		Aq.; rivers, lakes, ponds, TF, SS	Obs.- OW ( <i>Trionyx cartilagi neus</i> , <i>Testudo cartilagi nea</i> )
<i>Dogania subplana</i>	Labi-labi Hitam	Malayan Softshell Turtle	few					Aq.; rivers, lakes, Hill bases, TF, a) SS	Int.-OW ( <i>Trionyx subplan</i> <i>a</i> )
<i>Pelochelys bibroni</i>	Labi-labi Kuning	Asian Giant Softshell Turtle	rare			3		Aq., streams, TF	Obs.-SS Int.-OW ( <i>Trionyx bibroni</i> )
<i>Chitra indica</i>	Labi-labi Besar	Narrow- headed Softshell Turtle, Giant Fresh- water Turtle					1	Aq., streams, rivers, Hill bases, TF	Obs.-SS Int.-WG
<i>Trionyx gangeticus</i>		Indian Softshell Turtle						Aq., streams, rivers, TF	Obs.- SS???? (identi- fication uncer- tain???)
CROCODYLIA									
CROCODILIDEA									
<i>Crocodylus raninus</i>	Buaya Kodok	Raninus Crocodile					Ex.		Obs.-JA (photogr aph). Identi- fication Dr. C. A. Ross, Smith- sonian Insti- tution.,

ORDER/ FAMILY/ Species <sup>i</sup>	Local Name (Language) <sup>ii</sup>	English Name <sup>iii</sup>	Status <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habitat <sup>ix</sup>	Observation Notes <sup>x</sup>
<i>Crocodylus porosus</i>	Buaya Rabin	Estuarine Crocodile			II	V	1, 2 / S		USA ???? Obs.- SF, AR, project staff numerous
<i>Tomistoma schlegeli</i>	Buaya Sinyulong	False Gharial			II	E	1 / S		Obs.- SF, AR " " " "
<b>SAURIA</b>									
AGAMIDAE									
<i>Draco sp.</i>									Obs.- ???? Wetland Database
VARANIDAE									
<i>Varanus salvator</i>	Biawak	Common Water Monitor			II		1		Obs.- KSDA report 1995, HN
<i>Varanus hornensis</i>	Biawak Kalimantan	Borneo Monitor			II		2		Obs.- KSDA report 1995, WG, HN
<b>SERPENTES</b>									
BOIDAE									
<i>Python reticulatus</i>	Ular Sawa, Ular Petola	Reticulated Python			II			Aq., SS	Obs.- WG
ACROCHORDIDAE									
<i>Acrochordus javanicus</i>		Elephants Trunk Snake						Aq., TF	Obs.- AR (photo- graph)
COLUBRIDAE									
<i>Calamaria leucogaster</i>		Reed Snake species						HF	Obs.- WG
<i>Dendrelaphis pictus</i>	Telampar	Painted Bronze-back						-	Obs.- ??? Wetland Database

ORDER/ FAMILY/ Species'	Local Name (Language) <sup>ii</sup>	English Name <sup>iii</sup>	Status <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habitat <sup>ix</sup>	Observation Notes <sup>x</sup>
<i>Ahaetulla sp.</i>		Whip- snake species						HF	Obs.- RW
<i>Boiga dendrophila</i>	Ular Air, Ular Bakau	Mangrove Snake Yellow- ringed Cat Snake						RF, TF	Obs.- HN, KJ, WG (Ident. Zool. Museum Bogor)
<i>Boiga sp.</i>		Cat Snake species						HF	Obs.- RW
<i>Homalopsis buccata</i>		Puff- faced Water Snake						RF	Obs.- WG (Ident. Zool Museum Bogor)

## ANNEX 3

ORDER / FAMILY / Species <sup>xi</sup>	Local Name (Indo- nesian) <sup>xii</sup>	English Name <sup>xiii</sup>	Status <sup>xiv</sup>	En- demic <sup>xv</sup>	CITES <sup>xvi</sup>	IUCN <sup>xvii</sup>	Nat. Law <sup>xviii</sup>	Habitat <sup>xix</sup>	Observation Notes <sup>xx</sup>
<b>PELECANIFORMES</b>									
PHALACROCO- RACIDAE									
<i>Anhinga melanogaster</i>	dendang air (M) (pecuk ular)	Oriental Darter	M			NT	3 / S	Aq., SS, RF	BB, WG, RD1, BS, RD2
<b>CICONIIFORMES</b>									
ARDEIDAE									
<i>Ardeola bacchus</i>	pelanduk (M)	Chinese Pond Heron	M				1 / S	Aq.	LJ, AJ, RD2 ???- Smy- thies 1981
<i>Ardea sumatrana</i>	kukak (M) (cangkak laut)	Great- billed Heron				NT	S	Aq., SS	RD1, IH, RJ, TS, RD1, BS, RD2
<i>Ardea purpurea</i>	kujak (M) (cangkak merah)	Purple Heron	M				S	Aq., SS/ RF	BB, WG, IH, TS, RD1, BS, RD2
<i>Casmerodius albus</i>		Great Egret	M				1 / S	Aq., DF/RF	BB, RD1, BS, RD2
<i>Egretta garzetta</i>	(kuntul putih)	Little Egret	M				1 / S	Aq., SS/RF	BB, RD1, BS, RD2
<i>Mesophoyx intermedia</i>		Inter- mediate Egret	M				1 / S	Aq.	RD2
<i>Egretta eulophytes</i>		Chinese Egret	M			E	1 / S	Aq.	RD2
<i>Bubuculus ibis</i>		Cattle Egret	M				1 / SS	Aq.	RD2
<i>Butorides striatus</i>	(kakakan laut)	Striated Heron	M/R				S	Aq., SS/ RF	BB, IH, TS, BS, RD2
<i>Ixobrychus sinensis</i>		Yellow Bittern	M/R				S	Aq.	RD2
<i>Ixobrychus cinnamomeus</i>		Cinna- mon	M/R				S	Aq., SS	TS, LJ, RD2

ORDER / FAMILY / Species <sup>xx</sup>	Local Name (Indo- nesian) <sup>xiii</sup>	English Name <sup>xiii</sup>	Status <sup>xiv</sup>	En- demic <sup>xv</sup>	CITES <sup>xi</sup>	IUCN <sup>xiii</sup>	Nat. Law <sup>xviii</sup>	Habitat <sup>xix</sup>	Obser- vation Notes <sup>xx</sup>
		Bittern							
<i>Dupetor flavicollis</i>		Black Bittern	M				S	Aq., TF	BB, TS, BS, RD2
<i>Nycticorax nycticorax</i>	(kowak malam)	Black- crowned Night- heron					S	Aq., RF	IH, TS, BS, RD2
<i>Nycticorax calendonicus</i>	(kowak merah)	Rufous Night- heron	M				1	Aq.	BS
CICONIIDEA									
<i>Ciconia stormi</i>	karau (M)	Storm's Stork			+	E	6 / SS	Aq., RF, TF	BB, BS, AE, IH, TS, RD2
<i>Leptoptilus javanicus</i>	bangau tongtong (M)	Lesser Adjutant Stork				V	1 / SS	Aq.	KJ, RD2
FALCONIFORMES									
PANDIONIDAE									
<i>Pandion haliaetus</i>		Osprey			II		+ / S	Aq., RF, TF	BB, RD1, BS, RD2
ACCIPITRIDAE									
<i>Machae- ramphus alcinus</i>	(elang kelela- war)	Bat Hawk			II		2 / S	HF	BS, RD2
<i>Aviceda jerdoni</i>	elang bulit (M)	Jerdon's Baza			II	NT	2 / S	Aq., TF	BB, WG, RD1, BS, RD2
<i>Pernis ptilorhynchus</i>	elang bulit (M) (sikep madu)	Oriental Honey- buzzard			II		2 / S	HF, TF	IH, RD1, BS, RD2
<i>Haliastur indus</i>	elang samak (M)	Brah- miny Kite			II		2, 7 / S	Aq., B, DS, SS, RF	BB, WG, HN, IH, RD1, RD2
<i>Haliaeetus leucogaster</i>	elang kangkam (M)	White- bellied Sea-eagle			II		2, 7 / SS	Aq., SS	HN, TS, BS, RD2
<i>Ichthyophaga humilis</i>	(elang ikan kecil)	Lesser Fish-eagle			II	NT	2 / S	Aq., TF	BB, BS, RD2
<i>Ichthyophaga ichthyaetus</i>	(elang ikan)	Grey- headed Fish-eagle			II	NT	2 / SS	Aq., HF	BB, IH, TS, BS, RD2

ORDER / FAMILY / Species <sup>vi</sup>	Local Name (Indo- nesian) <sup>vii</sup>	English Name <sup>viii</sup>	Status <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>xi</sup>	IUCN <sup>xvii</sup>	Nat. Law <sup>xviii</sup>	Habitat <sup>xix</sup>	Observation Notes <sup>xx</sup>
<i>Spilornis cheela</i>	elang nantu (M)	Crested Serpent- eagle			II		2 / S	Aq., RF, TF	BB, IH, TS, RD1, BS, RD2
<i>Ictinaetus malayensis</i>	elang malon (M) (ilang hitam)	Black Eagle			II		2 / S	TF, HF	IH, WG, BS, RW, RD2
<i>Buteo spp.</i>		Buzzard			II		2 / S		RD2
<i>Butastur indicus</i>	elang buiit (M)	Grey- faced Buzzard	M/R		II		2, 7 / S	DS, SS	HN, RD1, RD2
<i>Accipiter trivirgatus</i>	(elang jambol garis dagu)	Crested Goshawk			II		2 / S	DS, SS, HF	BB, TS, BS, RD2
<i>Accipiter gularis</i>		Japanese Sparrow- hawk	M		II		2 / S		TS, RD2
<i>Spizaetus cirrhatus</i>		Change- able Hawk- eagle			II		2 / S	RF, HF	BB, IH, TS, RD1, BS, RD2
<i>Spizaetus nanus</i>		Wallace's Hawk- eagle			II	V	2 / S	HF, SS	BB, TS, RD1, RD2
<i>Spizaetus alboniger</i>	elang kelabuk (M)	Blyth's Hawk- eagle			II		2	Aq., RF	WG, IH, RD1, BS, RD2
FALCONIDAE									
<i>Microhierax fringillarius</i>	alap-alap capung	Black- thighed Falconet					2 / S	TF, HF	BB, TS, BS, RD2
<i>Falco peregrinus</i>	alap-alap kawang	Peregrine	M		I		2 / S		BS
ANSERIFORMES									
ANATIDAE									
<i>Dendrocygna javanica</i>	(belibis kecil)	Lesser Tree Duck						Aq, TF	BB, BS
<i>Dendrocygna arcuata</i>		Wander- ing Whis- tling Duck						Aq.	RD2
GALLIFORMES									
PHASIANIDAE									
<i>Coturnix</i>	(puyuh)	Blue-							BS,



ORDER / FAMILY / Species <sup>v</sup>	Local Name (Indo- nesian) <sup>iii</sup>	English Name <sup>iii</sup>	Status <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>viii</sup>	Nat. Law <sup>viii</sup>	Habitat <sup>ix</sup>	Observation Notes <sup>x</sup>
<i>chinensis</i>		breasted Quail							RD2
<i>Melanoperdix nigra</i>	empitu (M)	Black Partridge				NT	S	HF	LJ, RD2 (int.)
<i>Rollulus rouloul</i>	Sengayan (I), siau (M)	Crested Partridge					S	HF	BS, RW, RD2 (int.)
<i>Arborophila hyperythra</i>	empitu (M)	Red- breasted Partridge		E			S	HF	IH (int.) RD2 ??? (old record)
<i>Haematortyx sanguiniceps</i>	merah mata (M)	Crimson- headed Partridge		E			S	HF	LJ, IH (int.), EM, RD2 ??? (outside area)
<i>Polyplectron schleier- macheri</i>	ruwai (M)	Bornean Peacock Pheasant		E	II	Cr	5 / SS	HF	WG (int.), IH (int.), RD2 ??? (old record)
<i>Lophura erythroph- thalma</i>	Sempi- dan (I)	Crestless Fireback				V	S	HF	RW
<i>Lophura ignita</i>	Sempi- dan (M)	Crested Fireback Pheasant				V	S	TF, HF	BB, IH, RJ, BS, RD2 (int.)
<i>Lophura bulweri</i>	Senga- yan, burung buah (M) (belia)	Bulwer's Pheasant		E		V	4 / S	TF, HF	WG, IH (int.), RD2, BS, RD2
<i>Argusianus argus</i>	ruwai (M)	Great Argus			II		2 / SS	TF, HF	BB, IH (int.), RJ, BS, RD2
<b>GRUIFORMES</b>									
RALLIDAE									
<i>Amaurornis phoenicurus</i>	keruak (M)	White- breasted Waterhen						Aq, SS, DS, TF	BB, TS, WG, TS, BS, RD2
<i>Gallirallus striatus</i>		Slaty- breasted Rail						Aq.	RD2
<i>Rallina fuscata</i>	(kroak)	Red- Legged Crake						Aq.	BS
<i>Gallicrex</i>	(kroak)	Water-	M					Aq.	BS

ORDER / FAMILY / Species <sup>v</sup>	Local Name (Indo- nesian) <sup>xii</sup>	English Name <sup>xiii</sup>	Status <sup>xiv</sup>	En- demic <sup>xv</sup>	CITES <sup>xvi</sup>	IUCN <sup>xvii</sup>	Nat. Law <sup>xviii</sup>	Habitat <sup>xix</sup>	Observation Notes <sup>xx</sup>
<i>cinerea</i>		cock							
<b>CHARADRIIFORMES</b>									
<b>CHARADRIIDAE</b>									
<i>Charadrius dubius</i>	kedidi (M)	Little Ringed Plover	M				S	Aq., lakes	TS, BS, RD2
<b>SCOLOPACIDAE</b>									
<i>Tringa brevipes</i>	sulit pantai (M)	Grey-tailed Tattler	M				S	Aq.	LJ, RD2 ???- record Smy- thies 1981
<i>Tringa glareola</i>		Wood Sand-piper	M				S	Aq., SS, TF	BB, BS, RD2
<i>Tringa hypoleucos</i>	burung apung (M)	Common Sandpiper	M				S	Aq., HF	BB, TS, RD1, BS, RD2
<b>LARIDAE</b>									
<i>Sterna albifrons</i>	kelapai, tintin apai (M)	Little Tern	R				1	Aq., lakes	BB, WG, HN, IH, TS, BS, RD2
<i>Sterna nilotica</i>		Gull-billed Tern	M				1	Aq.	RD2, AE
<b>COLUMBIFORMES</b>									
<b>COLUMBIDAE</b>									
<i>Columba argentina</i>	pergam (M)	Grey Wood Pidgeon				V	SS	?	WG
<i>Treron curvirostra</i>		Thick-billed Green Pigeon						SS, TF	BB, TS, RW, RD2
<i>Treron fulvicollis</i>	(punc herak)	Cinnamon-headed Green Pigeon				NT		RF, SS, TF	BB, IH, TS, BS, RD2
<i>Treron olax</i>	punai (M)	Little Green Pigeon						SS, TF	BB, WG, TS, BS, RD2
<i>Treron vernans</i>	(punc)	Pink-headed Green Pigeon						SS	BB, BS, RW, RD2

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<i>Treron capellei</i>	punai (M)	Large Green Pigeon				NT			IH, BS, RD2 ??? Smythies 1981
<i>Ducula pickeringi</i>		Grey Imperial Pigeon				V		?	WG
<i>Ducula badia</i>	(empergon)	Mountain Imperial Pigeon						HF	BS
<i>Ducula aenea</i>		Green Imperial Pigeon					S	RF, SS, HF	BB, WG, TS, BS, RD2
<i>Macropygia emiliana</i>		Ruddy Cuckoo-dove						SS, TF, HF	BB, RJ, BS, RD2
<i>Streptopelia chinensis</i>	terkukur (M)	Spotted Dove						SS, TF	BB, WG, HN, TS, RD1, BS, RD2
<i>Chalco-phaps indica</i>		Emerald Dove						SS, HF	BB, TS, BS, RW, RD2
<i>Geopelia striata</i>	(ketitir)	Zebra Dove							BS, RD2
<i>Ptilonopus jambu</i>		Jambu Fruit Dove							BS
<b>PSITTACIFORMES</b>									
PSITTACIDAE									
<i>Psittacula longicauda</i>	bayan (M)	Long-tailed Parakeet			II			B, SS, RF, TF	BB, WG, HN, IH, TS, BS, RD2
<i>Psittinus cyanurus</i>	(bayan keladan)	Blue-rumped Parrot			II	NT	S	TF	BB, BS, RD2
<i>Loriculus galgulus</i>	entelit (M)	Blue-crowned Hanging-parrot			II		S	B, RF, DS, SS, TF	BB, WG, HN, IH, TS, BS, RD2
<b>CUCULIFORMES</b>									
CUCULIDAE									
<i>Clamator</i>		Chestnut-	M						RD2

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<i>coromandus</i>		winged Cuckoo						HF	BS, RJ, RD2
<i>Cuculus vagans</i>		Mou- stached Hawk- cuckoo						HF	BB, RD2
<i>Cuculus fugax</i>		Hodgson's Hawk- cuckoo	M/R					SS, TF, HF	BB, HN, TS, RD2
<i>Cuculus micropterus</i>	Kang- kang kuk (M)	Indian Cuckoo	M/R						RD2
<i>Cuculus saturatus</i>		Oriental Cuckoo							TS
<i>Cacomantis variolus</i>		Brush Cuckoo						SS, HF	BB, BS, RD2
<i>Cacomantis sonnerati</i>	(bibit)	Banded Bay Cuckoo						SS, TF, HF	BB, TS, RD1, BS, RW, RD2
<i>Cacomantis merulinus</i>	(bibit)	Plaintive Cuckoo						?	TS, BS, RD2
<i>Cacomantis sepulcralis</i>		Rusty- breasted Cuckoo						SS, TF, HF	BB, BS, RD2
<i>Chrysococ- cyx xantho- rhynchus</i>		Violet Cuckoo						DS, TF	BB, BS, RD2
<i>Chrysococ- cyx minutillus</i>		Little Bronze Cuckoo						SS, DS, TF, HF	BB, TS, RD1, RD2
<i>Surniculus lugubris</i>		Drongo Cuckoo							RD2
<i>Eudynamis scolopacea</i>		Asian Koel	M						
<i>Phaenico- phaeus diardi</i>	bubut (M) mendo' jugam (I)	Black- bellied Malkoha						RF, SS, HF	BB, IH, TS, BS, RW, RD2
<i>Phaenico- phaeus sumatranus</i>	manuk ilai, menuk pergon	Chest- nut- bellied Malkoha						B, SS, DS, TF	BB, WG, HN, TS, RD2
<i>Phaenico- phaeus chlorophaeus</i>	manuk ilai coklat (M) mendo' iliali (I)	Raffles's Malkoha						SS, DS, RF, TF, HF	BB, HN, IH, TS, BS, RW, RD2
<i>Phaenico- phaeus curvirostris</i>		Chest- nut- breasted						SS, RF, HF	BB, IH, TS, AJ, BS,

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		Malkoha							RW, RD2 BS
<i>Carpococcyx radiceus</i>	bubut	Sunda Ground- Cuckoo				V			
<i>Centropus sinensis</i>	bubut (M)	Greater Coucal				NT		DS, SS, RF, TF, HF	BB, WG, HN, IH, TS, RD1, BS, RW, RD2 BS
<i>Centropus rectunguis</i>		Short- toed Coucal				R			
<i>Centropus bengalensis</i>	terkop (M)	Lesser Coucal						?	IH, WG, BS, RD2
<b>STRIGIFORMES</b>									
TYTONIDAE:									
<i>Phodilus badius</i>		Oriental Bay Owl						SS, TF	BB, WG, BS, RD2
STRIGIDAE:									
<i>Otus rufescens</i>	elang pipit (M)	Reddish Scops- owl			II		S	B	HN, BS, RD2
<i>Otus lempiji</i>		Collared Scops- owl			II			SS, TF	BB, BS, RD2
<i>Otus spilo- cephalus</i>		Mountain Scops- owl			II		S	HF	BS ???
<i>Bubo sumatranus</i>		Barred Eagle-owl			II		S	SS, TF	BB, BS, RD2, EM, RoD
<i>Ketupa ketupu</i>	elang hantu, tertampi (M)	Buffly Fish-owl			II		S	Aq., DS, RF, TF, SS	BB, TS, LJ, HN, IH, TS, RD2
<i>Ninox scutulata</i>		Brown Boobook	M/R		II		S	TF	BB, BS, RW, RD2
<i>Strix lepto- grammica</i>	tertampi (M)	Brown Wood- owl			II		S	HF	BB, IH (int.), RJ, BS, RD2
<b>CAPRIMULGI- FORMES</b>									

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PODARGIDAE									
<i>Batrachostomus cornutus</i>		Sunda Frog-mouth							LJ, RD2 ???
<i>Batrachostomus harterti</i>		Dulit Frog-mouth		E	I				IH (int.), RD2 ???
<i>Batrachostomus javensis</i>		Javan Frog-mouth				NT			BS
CAPRIMULGIDAE									
<i>Eurostopus temminckii</i>		Malaysian Eared Nightjar						SS	BB, BS, RD2
<i>Caprimulgus concretus</i>		Bona- parte's Nightjar				NT		?	BB
<i>Caprimulgus indicus</i>		Grey Nightjar	M					RF	RD1, RD2
APODIFORMES									
APODIDAE									
<i>Hydrochous gigas</i>		Giant Swiflet	V				S		BS ???
<i>Collocalia cf fuciphaga</i>	layang- layang hitam (M)	Edible- nest Swiflet					S	DS, SS	BB, HN, RJ, RD2
<i>Collocalia maxima</i>		Black- nest Swiflet					S	SS, RF, TF, HF	BB, IH, RJ, RD1, BS, RD2
<i>Collocalia esculenta</i>		Glossy Swiflet					S	HF	BB, TS, RJ, BS, RD2
<i>Collocalia linchi</i>		Cave Swiflet						SS, HF	RD1, RD2
<i>Hirundapus caudacutus</i>		White- throated Needle- tail	M					SS	RJ, BS, RD2
<i>Hirundapus cochinchinensis</i>		Silver- backed Needle- tail	M					SS	RD1, BS, RD2
<i>Hirundapus giganteus</i>		Brown- backed Needle- tail	M / R					SS	BB, TS, RD1, BS, RD2
<i>Raphidura leucopygialis</i>	layang- layang biasa (M)	Silver- rumped Swift						B, SS, DS, RF, TF	BB, HN, IH, TS, RD1, BS,

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<i>Apus affinis</i>		Little Swift						SS	RD2 BB, TS, RD1, BS, RD2
<b>HEMIPROCINIDAE</b>									
<i>Hemiprocne longipennis</i>		Grey- rumped Tree-swift						?	BB, TS, RD1, BS
<i>Hemiprocne comata</i>		Whis- kered Tree-swift						RF	BB, TS, RD1, BS
<b>TROGONIFORMES</b>									
<b>TROGONIDAE</b>									
<i>Harpactes whiteheadi</i>		White- head's Trogon		E			1	HF	RW
<i>Harpactes kasumba</i>		Red- naped Trogon					1	RF, HF	BB, RJ, RD2
<i>Harpactes diardii</i>		Diard's Trogon					1	HF	BB, RJ, RD2
<i>Harpactes duvaucelii</i>		Scarlet- rumped Trogon					1	HF	BB, RJ, RD2
<b>CORACIFORMES</b>									
<b>ALCEDINIDAE</b>									
<i>Alcedo atthis</i>		Common King- fisher	M				1 / S	Aq. ?	RJ, BS, RD2
<i>Alcedo meninting</i>	burung shin (M)	Blue- eared King- fisher					1, 7 / S	Aq, B,SS,TF, RF, HF	BB, HN, IH, TS, RD1, BS, RD2
<i>Ceyx rufidorsus</i>	sin (M), ketupung (M)	Rufous- backed King- fisher					1 / S	HF	WG, BS, RW, RD2
<i>Ceyx erithacus</i>	shin (M)	Oriental Dwarf King- fisher	M/R				1 / S	SS, RF, HF	BB, WG, IH, RD2
<i>Pelargopsis capensis</i>	bekakak (M)	Stork- billed King- fisher					1, 7 / S	Aq.,B,DS ,SS,TF, HF	BB,WG, HN,IH, TS, RD1, BS, RD2
<i>Lacedo pulchella</i>		Banded King-					1 / S	HF	BB, RJ, BS,

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<i>Halcyon pileata</i>		fisher Black- capped King- fisher	M				I / S	Aq., RF	RD2 IH, BS, RD2
MEROPIDAE									
<i>Nyctornis amictus</i>	Kang- kang kuso' (I)	Red- bearded Beccater						HF	BB, RJ, BS, RW, RD2
<i>Merops viridis</i>		Blue- throated Beccater	M					HF	RW, RD2
CORACIIDAE									
<i>Eurystomus orientalis</i>		Common Dollar- bird	M/R					HF	BB, BS, RD2
BUCEROTIDAE									
<i>Aceros comatus</i>		White- crowned Hornbill			II		I / SS	HF	BB, RJ, BS, RW, RD2
<i>Anorrhinus galeritus</i>	berui (M) sentuku (I)	Bushy- crested Hornbill			II		I / SS	HF	BB, IH (int.), RJ, BS, RD2
<i>Aceros undulatus</i>	undan (I)	Wrea- thed Hornbill			II		I / SS	SS, HF	BB, IH (int.), TS, BS, RW, RD2
<i>Aceros corrugatus</i>	kukuk (M) kejako' (I)	Wrinkled Hornbill			II	V	I / SS	HF	LJ, IH (int.), TS, RW, RD2
<i>Anthracoceros malayanus</i>	buluk (M) berue' (I)	Black Hornbill			II	NT	I / SS	HF, RF, SS	BB, WG, IH, TS, BS, RW, RD2
<i>Anthracoceros albirostris</i>	enteliang (M) berue' (I)	Asian Pied Hornbill			II		I / SS	DS, SS, RF, TF, HF	BB, WG, HN, IH, RD1, BS, RW, RD2
<i>Buceros rhinoceros</i>	Kenya- lang (M/I)	Rhino- ceros Hornbill			II		I / SS	HF	BB, WG, IH, TS, RJ, BS, RD2
<i>Buceros vigil</i>	tajak (M)	Helmeted Hornbill			I	NT	I / SS	HF	BB, WG, IH



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<b>PICIFORMES</b>									
<b>CAPITONIDAE</b>									
<i>Megalaima chrysopogon</i>		Gold Whis- kered Barbet							(inL), RJ, AJ, RW, RD2
<i>Megalaima rafflesii</i>	togu' (I)	Red- crowned Barbet				NT	SS, TF, HF	BB, IH, TS, RJ, BS, RW, RD2	BS
<i>Megalaima henricii</i>	togu' (I)	Yellow- crowned Barbet							
<i>Megalaima mystaco- phanos</i>		Red- throated Barbet					SS, HF	BB, RJ, RW, RD2	
<i>Megalaima australis</i>		Bluc- eared Barbet					SS, TF, RF, HF	BB, IH, TS, BS, RW, RD2	
<i>Megalaima pulcherrina</i>	tegok (I)	Golden- naped Barbet		E			HF	RW	
<i>Calorham- phus fuliginosus</i>		Brown Barbet					HF	BB, BS, RD2	
<b>INDICATORIDAE</b>									
<i>Indicator archipela- gicus</i>		Malay- sian Honey Guide							BS, RD2
<b>PICIDAE</b>									
<i>Sasia abnormis</i>	kulat (M) (keta- pang)	Rufous Piculet					S	B, DS, TF, HF	BB, HN, BS, RW, RD2
<i>Celeus brachyurus</i>	belatok (M)	Rufous Wood- pecker					S	HF, RF	BB, IH, TS, BS, RW, RD2
<i>Picus puniceus</i>	belatak hijau (M)	Crimson- winged Wood- pecker					S	B, SS, DS, TF, RF	BB, HN, BS, RW, RD2
<i>Picus miniaceus</i>	belatak belang (M)	Banded Wood- pecker					S	SS, DS, TF, RF	BB, WG, HN, IH,

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<i>Dinopium javanense</i>		Common Golden-back					S	?	TS, BS, RD2 TS, BS, WG, BS, RD2
<i>Chrysocolaptes lucidus</i>		Greater Golden-back					S		RD2 ??? (video BS, Feb 1994)
<i>Meiglyptes tristis</i>	belatuk batu (M)	Buff-rumped Woodpecker					S	SS, TF, HF	BB, RD1, BS, RD2
<i>Meiglyptes tukki</i>	belatuk hutan (M)	Buff-necked Woodpecker					S	B, SS, DS, TF	BB, HN, TS, RD1, BS, RD2
<i>Picoides moluccensis</i>	belatuk tawang (M)	Sunda Woodpecker					S		BS, RD2
<i>Mulleripicus pulverulentus</i>		Great Slaty Woodpecker					S	SS, RF, TF, HF	BB, IH, BS, RD2
<i>Dryocopus javensis</i>	belatuk tawang (M)	White-bellied Woodpecker				I	S	B, DS, SS, TF, HF	BB, HN, TS, BS, RD
<i>Dendrocopos canicapillus</i>		Grey-capped Woodpecker					S	?	RD2
<i>Hemicircus concretus</i>		Grey-and-buff Woodpecker					S	SS, TF	BB, RD2
<i>Blythipicus rubiginosus</i>	belatau (M)	Maroon Woodpecker					S	B, DS, SS, RF, TF, HF	BB, HN, IH, BS, R, W, RD2, EM, RoD
<i>Reinwardtipicus validus</i>		Orange-backed Woodpecker					S	DS, TF, HF	BB, RJ, BS, RD2
<b>PASSERIFORMES</b>									
<b>EURYLAIMIDAE</b>									
<i>Corydon sumatranus</i>		Dusky Broad-bill							BS
<i>Cymbirhynchus macro-</i>	Gang-gang (M)	Black-and-red						SS, TF, HF	BB, WG,

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<i>rhynchos</i>		Broadbill							HN, RD1, BS, RD2
<i>Eurylaimus javanicus</i>		Banded Broadbill						TF, HF	BB, BS, RD2
<i>Eurylaimus ochromalus</i>	pat, emaroï (M)	Black- and- yellow Broadbill						DS, SS, RF, TF, HF	BB, WG, HN, TS, RJ, BS, RW, RD2
<i>Calyptomena viridis</i>		Green Broadbill						TF, HF	BB, RJ, BS, RD2
PITTIDAE									
<i>Pitta sordida</i>		Hooded Pitta					1	TF, HF	BB, RJ, BS, RD2
<i>Pitta moluccensis</i>		Blue- winged Pitta					1		RJ, BB, RD2 ???
HIRUNDINIDAE									
<i>Delichon dasypus</i>	layang- layang besar (M)	Asian House- martin	V					DS	HN, BS
<i>Hirundo rustica</i>	layang- layang (M)	Barn Swallow	M					SS, DS, lak es	BB, IH, TS, RD1
<i>Hirundo tahitica</i>		Pacific Swallow						SS, RF, lakes	BB, IH, RD1, BS, RD2
<i>Hirundo striolata</i>		Striated Swallow							
<i>Hirundo daurica</i>		Red- rumped Swallow	M					SS	RD1
MOTACILLIDAE									
<i>Motacila flava</i>		Yellow Wagtail							RD2
CAMPEPHAGIDAE									
<i>Coracina striata</i>		Bar- bellied Cuckoo- shrike							BS
<i>Coracina fimbriata</i>		Lesser Cuckoo- shrike						RF, TF, HF	BB, IH, RJ, BS, RD2
<i>Pericrocotus igneus</i>	muas (M)	Fierly Minivet						SS, RF, TF, HF	BB, IH, RJ, BS, RD2
<i>Pericrocotus flammeus</i>	beragai (M)	Scarlet Minivet						HF	BB, TS, BS,

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									RD2
<i>Hemipus hirundina- ceus</i>		Black- winged Hemipus						SS, RF, TF, HF	BB, TS, BS, RD2
<i>Hemipus picatus</i>		Bar- winged Hemipus						SS, RF	IH, BS, RD2 ???- Smy- thics 1981
<i>Tephrodornis gularis</i>		Large Wood- shrike						HF	BB, RJ, RD2
PYCNONOTIDAE									
<i>Pycnonotus eutilotus</i>	empulo (I)	Puff- backed Bulbul						HF	RW
<i>Pycnonotus zeylanicus</i>	kerakau (M)	Straw- headed Bulbul			V			Aq., ?	WG, TS, RD1, BS, RD2
<i>Pycnonotus melanoleucos</i>		Black- and-white Bulbul						HF	RJ, RW, RD2
<i>Pycnonotus atriceps</i>		Black- headed Bulbul						SS, TF, RF, HF	BB, IH, TS, BS, RW, RD2
<i>Pycnonotus cyaniventris</i>		Grey- belliced Bulbul						HF	BB, IH, RJ, BS, RD2
<i>Pycnonotus goiavier</i>		Yellow- vented Bulbul						TF	BB, BS, RD2
<i>Pycnonotus plumosus</i>		Olive- winged Bulbul						SS, DS, TF, RF, HF	BB, BS, RW, RD2
<i>Pycnonotus simplex</i>	empuluk (M)	Cream- vented Bulbul						B, SS, TF, RF, HF	BB, HN, TS, RD1, RW, RD2
<i>Pycnonotus brunneus</i>		Red-eyed Bulbul						SS, TF, RF, HF	BB, IH, TS, RD1, BS, RW, RD2 BS
<i>Pycnonotus melanicterus</i>		Black- crested Bulbul							
<i>Pycnonotus</i>		Spect-						HF	BB, BS,

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<i>erythro- phthalmos</i>		aced Bulbul							RW, RD2
<i>Allophoixus finschii</i>		Finsch's Bulbul					HF		BB, IH, RJ, BS, RD2
<i>Allophoixus phaeo- cephalus</i>		Yellow- bellied Bulbul					HF		BB, IH, RJ, BS, RD2
<i>Allophoixus ochraceous</i>		Ochra- ceous Bulbul							BS
<i>Allophoixus bres</i>		Grey- checked Bulbul					HF		RW
<i>Setornis criniger</i>		Hook- billed Bulbul					HF		RW
<i>Iole charlottae</i>		Buff- vented Bulbul					HF		BB, RJ, BS, RW, RD2
<i>Tricholestes criniger</i>		Hairy- backed Bulbul					HF		BB, RJ, BS, RW, RD2
<i>Ixos malaccensis</i>		Common Streaked Bulbul					HF		BB, IH, RJ, BS, RW, RD2
IRENIDAE									
<i>Aegithina tiphia</i>	punai, jentayu, cicu (M)	Common lora						B,DS,SS, RF, TF, HF	BB,HN, IH,TS, RD1, BS, RW, RD2
<i>Aegithina viridissima</i>	kuncit hijau	Green lora						B,DS,SS, RF, TF, HF	BB, HN, IH, BS, RW, RD2
<i>Chloropsis sonnerati</i>		Greater Green Leafbird						DS, SS, TF, RF, HF	BB, IH, BS, RW, RD2
<i>Chloropsis cyanopogon</i>		Lesser Green Leafbird						SS, HF	BB, IH, RJ, BS, RW, RD2
<i>Irena puella</i>		Asian Fairy Bluebird					HF		BB, RJ, RD1, BS, RW, RD2

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LANIIDAE									
<i>Lanius tigrinus</i>		Tiger Shrike	M					SS	RJ, RD2
<i>Lanius cristatus</i>		Brown Shrike	M					SS	RJ, BS, RD2
TURDIDAE									
<i>Copsychus saularis</i>	tinjau, burak, semalau (M)	Oriental Magpie Robin						B,DS,SS, RF, TF, HF	BB, WG, HN, IH, TS, RD1, BS, RD2
<i>Copsychus malabaricus</i>	nela (M)	White-rumped Shama						DS, SS, RF, TF, HF	BB, WG, IH, TS, BS, RW, RD2
<i>Copsychus pyrrropygus</i>		Rufous-tailed Shama						HF	RJ, RD2
<i>Enicurus ruficapillus</i>		Chestnut-naped Forktail						HF	BB, RJ, RD2
<i>Enicurus leschenaulti</i>	keciang (M)	White-crowned Forktail						RF	IH, RJ, BS, RD2
<i>Myiophonus glaucinus</i>		Sunda Whistling Thrush						?	RJ, RD2???
<i>Saxicola spp.</i>		Chats	V					B, SS	HN
TIMALIIDAE									
<i>Molacocincla malaccense</i>		Short-tailed Babbler						TF, HF	BB, RJ, RD2
<i>Trichastoma rostratum</i>		White-chested Babbler				NT		DS, SS, RF, TF, HF	BB, IH, TS, BS, RD2
<i>Trichastoma bicolor</i>		Ferruginous Babbler				NT		HF	BB, RJ, BS, RD2
<i>Molacocincla abboti</i>		Abbot's Babbler							BB ???, RD2
<i>Malacopteron magnirostre</i>		Moustached Babbler						HF	BB, TS, RJ, BS, RD2
<i>Malacopteron affine</i>		Sooty-capped Babbler						DS, SS, RF, TF, HF	BB, HN, IH, TS, BS, RW, RD2
<i>Malacopteron</i>		Scaly-crowned						TF, HF	BB, IH, RJ, BS,

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<i>cinereum</i>		Babbler							RD2
<i>Malacopteron magnum</i>		Rufous- crowned Babbler						HF	BB, IH, RJ, BS,
<i>Pomatorhinus montanus</i>		Chest- nut- backed S'- babbler						HF	BB, RJ, BS, RD2
<i>Kenopia striata</i>		Striped wren- babbler						HF	BB, RJ, RD2
<i>Stachyris maculata</i>		Chest- nut- rumped Babbler						TF, HF	BB, BS, RW, RD2
<i>Stachyris nigricollis</i>		Black- throated Babbler						HF	BB, BS, RW, RD2
<i>Stachyris erythroptera</i>		Chest- nut- winged Babbler						DS, SS, RF, TF, HF	BB, RD2
<i>Eupetes macrocerus</i>		Rail Babbler							BB ???, RD2
<i>Napothera atrigularis</i>		Black- throated Wren Babbler		E					BB ???, RD2
<i>Macronous gularis</i>	kicang (M)	Striped Tit- babbler						DS, SS, RF, TF, HF	BB, HN, IH, TS, RD1, BS, RD2
<i>Macronous pilosus</i>		Fluffy- backed Babbler						RF, TF, HF	BB, BS, RW, RD2
<i>Timalia pileata</i>		Chestnut- capped Babbler							RD2
<i>Alcippe brunneicauda</i>		Brown Fulvetta						TF, HF	BB, IH, RJ, RD1, BS, RD2
SYLVIIDAE									
<i>Prinia flaviventris</i>		Yellow- bellied Prinia						TF, HF	BB, TS, RD1, BS, RD2
<i>Orthotomus atrogularis</i>	ceriak (M)	Dark- necked Tailor- bird						SS, DS, TF, HF	BB, WG, HN, BS, RD2

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<i>Orthotomus cuculatus</i>	beriak (I)	Mountain Tailor- bird						HF	RW	
<i>Orthotomus sericeus</i>	encrit (M)	Rufous- tailed Tailor- bird						DS, SS, HF	BB, HN, TS, RD1, BS, RW, RD2	
<i>Orthotomus ruficeps</i>	jeruit (M)	Ashy Tailorbird						B,SS,DS, TF, RF, HF	BB, HN, IH, TS, RD1, BS, RD2	
<i>Phylloscopus borealis</i>		Arctic Leaf- warbler	M					SS, DS, TF, RF, HF	BB, RD1, RD2	
<i>Acrocephalus bistrigiceps</i>		Black- Browed Reed- Warbler	M						RD2 ???	
MUSCICAPIDAE										
<i>Rhinomyias olivaceus</i>		Fulvous- chested Rhino- myias							BB???, RD2	
<i>Rhinomyias umbratilis</i>		Grey- chested Rhino- myias						HF	BB, IH, RJ, RD2	
<i>Muscicapa dauurica</i>		Asian Brown Fly- catcher	M					SS	BB, RD2	
<i>Ficedula mugimaki</i>		Mugi- maki Fly- catcher	M						EM, RoD	
<i>Cyanoptila cyanomelana</i>		Blue-and- white Fly- catcher	M					RF	IH, LJ, BS, RD2	
<i>Cyornis turcosus</i>		Malay- sian Blue Fly- catcher				NT			DS, SS, RF, TF, HF	BB, TS, RW, RD2
<i>Cyornis superbus</i>		Bornean Blue Fly- catcher		E					RF	IH, TS ??? RD2
<i>Cyornis banyunas</i>	burung bunga (M)	Hill Blue Fly- catcher						DS	HN, BS	
<i>Cyornis unicolor</i>	burung bunga (M)	Pale Blue Fly- catcher						B, DS	HN, BS	



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MONARCHIDAE									
<i>Philentoma pyrhopterum</i>		Rufous- winged Philen- toma						HF	BB, RJ, RD2
<i>Philentoma velatum</i>		Maroon- breasted Fly- catcher						HF	BB, RJ, RD2
<i>Ficedula westermanni</i>		Little Pied Fly- catcher						BS	
<i>Hypothymis azurea</i>	burung haji (M)	Black- naped Monarch						DS, SS, RF, TF, HF	BB, HN, IH, TS, BS, RW, RD2
<i>Terpsiphone paradisii</i>	tintin lembak (M)	Asian Paradise- flycatcher					S	SS, RF, HF	BB, IH, WG, TS, RJ, BS, RW, RD2 RD2
<i>Rhinomyias ruficauda</i>		Rufous- tailed Jungle- flycatcher							RD2
<i>Eumyias indigo</i>		Indigo Fly- catcher							RD2
<i>Rhipidura javanica</i>	kanji (M)	Pied Fantail					3, 5, 7	B, DS, SS, TF, RF, HF	BB, WG, HN, IH, TS, BS, RD2
<i>Rhipidura perlata</i>	kanjik (M)	Spotted Fantail						HF	BB, LJ, RJ, BS, RD2
<i>Rhipidura albicollis</i>	mono ilai' (l)	White- throated Fantail						HF	BS, RW
PACHYCEPHALIDAE									
<i>Pachycephala grisola</i>		Man- grove Whistler						SS, RF, TF	BB, TS, RD2
PARIDAE									
<i>Parus major</i>	pipit (M)	Great Tit						B	HN, BS
SITTIDAE									
<i>Sitta frontalis</i>	kuncir biru (M)	Velvet- fronted Nuthatch						B, SS, RF, TF, HF	BB, HN, BS, RD2

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DICAEDIDAE										
<i>Prionochilus xanthopygius</i>	kuncit selatan (M)	Yellow- rumped Flower- pecker		E				DS	HN, RW, RD2	
<i>Prionochilus maculatus</i>		Yellow- breasted Flower- pecker						HF	BB, RJ, BS, RW, RD2	
<i>Prionochilus percussus</i>		Crimson- breasted Flower- pecker						DS, SS, TF, HF	BB, TS, BS, RW, RD2	
<i>Prionichilus thoracicus</i>		Scarlet- breasted Flower- pecker						RF, SS, HF	BB, IH, TS, RJ, BS, RW, RD2	
<i>Dicaeum trigono- stigma</i>	kuncit purang (M)	Orange- bellied Flower- pecker						DS, SS, RF, TF, HF	BB, HN, TS, RD1, BS, RW, RD2	
<i>Dicaeum concolor</i>	kuncit bara (M)	Plain Flower- pecker						B, DS, SS, HF	BB, HN, IH, RJ, BS, RW, RD2	
<i>Dicaeum cruentatum</i>	kuncit biasa (M)	Scarlet- backed Flower- pecker						B, DS, SS, RF, TF, HF	BB, HN, IH, RD1, BS, RW, RD2	
<i>Dicaeum chrysor- rheum</i>		Yellow- vented Flower- pecker						HF	BS, RW	
<i>Dicaeum everetti</i>	kuncit coklat (M)	Brown- backed Flower- pecker						SS	HN, BS	
<i>Dicaeum celebicum</i>	kuncit (I)	Grey- sided Flower- pecker						HF	RW	
NECTARI- NIIDAE										
<i>Anthreptes simplex</i>		Plain Sunbird						I	HF	BB, RJ, RD1, BS, RD2

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<i>Anthreptes rhodolaema</i>		Red- throated Sunbird					1	SS	RD1, RD2
<i>Anthreptes malacensis</i>		Plain- throated Sunbird					1	DS, SS, RF, TF, HF	BB, TS, RD1, BS, RD2, EM
<i>Anthreptes singalensis</i>	kuncit ara (M)	Ruby- cheeked Sunbird					1, 7	DS, SS, RF, TF	BB, HN, IH, TS, RD1, RD2
<i>Hypogramma hypogram- micum</i>		Purple- naped Sunbird					1, 7	HF	BB, HN, BS, RD2
<i>Nectarinia sperata</i>		Purple- throated Sunbird					1	SS, RF, TF	BB, BS, RD2
<i>Nectarinia jugularis</i>	kuncit kuning (M)	Olive- backed Sunbird					1, 7	B, DS, SS, RF, TF, HF	BB, HN, IH, TS, RD1, BS, RD2, EM
<i>Nectarinia calcostetha</i>		Copper- throated Sunbird					1	HF	RD1, RD2
<i>Aethopyga siparaja</i>	kuncit merah (M)	Crimson Sunbird					1, 5, 7	B, DS, SS, RF, TF	BB, HN, IH, TS, RD1, BS, RD2
<i>Aethopyga temminckii</i>	kuncit api (M)	Scarlet Sunbird					1, 7	DS, SS, RF, HF	BB, HN, IH, BS ??? RD2
<i>Arachnothera longirostra</i>		Little Spider- hunter					1	RF, TF, HF	BB, BS, RW, RD2
<i>Arachnothera crassirostris</i>		Thick- billed Spider- hunter					1	DS, HF	BB, RJ, RW, RD2
<i>Arachnothera robusta</i>		Long- billed Spider- hunter					1	TF, HF	BB, RJ, RD2
<i>Arachnothera affinis</i>		Grey- breasted Spider- hunter					1		BB??? RD2???
<i>Arachnothera juliae</i>		White- head's Spider- hunter		E			1		BS

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<i>Arachnothera flavigaster</i>		Spec- tacted Spider- hunter					1		BS, RD2
<i>Arachnothera chrysogenys</i>		Yellow- eared Spider- hunter					1, 7	B, RF, TF, HF	BB, HN, RW, RD2
PLOCEIDAE									
<i>Lonchura fuscans</i>		Dusky Munia		E				B, SS, HF	BB, TS, WG, HN, IH, BS, RD2
<i>Lonchura leucogastra</i>		White- bellied Munia						?	WG, BS, RD2
<i>Lonchura malacca</i>		Chestnut Munia						?	WG, RD1, BS, RD2
<i>Passer montanus</i>		Tree Sparrow						?	IH, RD1, BS, RD2
STURNIDAE									
<i>Aplonis panayensis</i>	(perling)	Asian Glossy Starling							RJ, BS, RD2 ???
<i>Gracula religiosa</i>	tiong (M)	Hill Myna					2 / S	B, DS, SS, RF, TF, HF	BB, WG, HN, IH, TS, RD1, BS, RD2
ORIOOLIDAE									
<i>Oriolus xanthonotus</i>		Dark- throated Oriole						HF	BB, WG, RJ, BS, RW, RD2
DICRURIDAE									
<i>Dicrurus aeneus</i>		Bronzed Drongo						?	WG, BS, RD2
<i>Dicrurus paradiseus</i>	keciang (M)	Greater Racquet- tailed Drongo						RF, TF, HF	BB, WG, IH, TS, RD1, BS, RD2

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<i>Dicrurus annectans</i>		Crow- billed Drongo	M						BS
CORVIDAE									
<i>Platylophus galericulatus</i>	gagak (M)	Crested Jay						?	RJ, RD2
<i>Platylophus leucopterus</i>		Black Magpie						SS	RD1, RD2???
<i>Corvus enca</i>		Slender- billed Crow						SS, TF	BB,LJ, HN, IH, TS, RD1, BS, RD2
<i>Corvus macro- rhynchus</i>		Large- billed Crow							TS, RD2, BS, RD2
<i>Pityriasis gymno- cephala</i>		Bornean Bristle- head		E				TF	RD1, BS, RD2, RoD

<sup>i</sup>**Taxonomic reference:** With respect to tortoise and turtle species, both species names and order of listing of species have been adapted from Walter, O. (1996) *A Report on the Freshwater Turtles and Tortoises of Danau Sentarum Wildlife Reserve, West Kalimantan, Borneo: Hunting and Trade*. Project No.5 I-UKTFMP (report No. 210). With reference also being given to Sumarni, S. and Soraya (1996) *Jenis, Habitat and Populasi Labi-Labi (Trionichydea) di Suaka Margasatwa Danau Sentarum, Kabupaten Kapuas Hulu*. Laporan Penelitian, Pontianak, 1996 (project report no. 243). With respect to snake species, taxonomy and order of listing has been taken from Keng F. L. L. and Tat-Mong M. L. (1989) *Fascinating Snakes of South East Asia—An Introduction*. Tropical Press Sdn. Bhd., Kuala Lumpur.

<sup>ii</sup>**Local names:** Local Iban names (I) as collected by Walter (1996).

<sup>iii</sup>**English names:** Adapted from Walter (1996); Das, I (1985) *Indian Turtles: A Field Guide*. WWF—India; and Keng and Tat-Mong (1989).

<sup>iv</sup>**Status:** For turtles and tortoises, the abundance rating is adapted from Walter (1996).

<sup>v</sup>**Endemicity:** No endemic reptiles reported.

<sup>vi</sup>**CITES:** CITES listings derived from Anon (1983) *Lampiran 2: Daftar Flora dan Fauna Langka di Indonesia yang Tecantum Dalam Appendix I dan II CITES (Convention on International Trade in Endangered Spp. of Wild Fauna and Flora)*, per 29 Juli 1983; or as per Walter (1996).

<sup>vii</sup>**IUCN rating:** IUCN rating of global threat to spp.. For all species as per Groombridge (1993) 1994 IUCN Red List of Threatened Animals. For turtles/tortoises as noted in Walter (1995). For Crocodiles as noted in Sebastian, T. (1994) *Towards a Priority Listing for Conservation of Crocodylians in the Indo-Malayan Realm*, Asian Wetland News, Vol.7, No.1. **Ex.**—Extinct; **E**—Endangered; **V**—Vulnerable; **I**—Indeterminate (considered E, V or R); **K**—insufficiently known (suspected Endangered, Vulnerable or Rare) (IUCN Red Data Book 1988 rating). **1**—known threatened spp. in need of conservation action; **2**—species of restricted distribution in need of status investigation; **3**—species requiring conservation projects and/or status surveys (ratings of the IUCN Tortoise and Freshwater Turtle Specialist Group, April 1989 findings)

<sup>viii</sup>**National Law:** Both Indonesian Law and Sarawak Law (Malaysia). **Indonesian Law:** Ref. Anon (1973) Jenis Satwa Dilindungi di Kalimantan Barat, Sub-Balai KSDA, Kalimantan Barat, 1973. Daftar Satwa yang Dilindungi di Indonesia, 10 Juni 1991–List 301/Kpts-II/1991 contained in Anon (?) Kumpulan Peraturan tentang Flora/Fauna dan Bagian Bagainya, Sub-Balai Konservasi Sumber Daya Alam Kalimantan Barat: **1**–Keputusan Menteri Pertanian No. 327/Kpts/U/5/1978; **2**–Keputusan Menteri Pertanian No. 716/Kpts/U/10/1980

**Sarawak Law:** Rcf. Forestry Department of Sarawak (?) Totally Protected Animals of Sarawak. Poster Series–Poster1 and Forestry Department of Sarawak (?) Protected Animals of Sarawak. Poster Series–Poster 2 S–Protected Animal, illegal to hunt, kill, capture, sell, offer for sale, import, export, or be in possession of without a license, any protected animal, or any trophy, flesh, egg or nest there. Native rural residents engaged in traditional hunting for own consumption excluded. SS–Totally Protected Animal, no person may hunt, kill, capture, sell, offer for sale, import, export or be in possession of any totally protected animal, or any trophy, flesh, egg or nest thereof.

<sup>ix</sup>**Habitat (s):** Field observations as to which habitat spp. has been observed: SS–Stunted Swamp Forest, RF–Riparian (river levee) Forest, TS–Tall Swamp (Peat) Forest, Hill Forest–HF, Aq.–Aquatic spp. (wetland, lake or river related), terrestrial–also found on dry land.

<sup>x</sup>**Observers:** Persons who have made observations and/or reports in which the species observations have been recorded. Int.–result of interview (secondary data).

**AR**–Field observation Dr. Anne Russon (1996), visiting scientist; **JA**–Field Observations Julia Aglionby (1994), project staff; **KJ**–field observations Kevin Jeanes (1995–1996), project staff; **OW**–field observations Olivia Walter (1996), visiting scientist, project report No. 210; **WG**–field observations Wim Giesen (1993–94); and (1987), project staff, project I-UKTFMP report No. 1; **HN**–field observations Heri Noveriawan (1992); researcher, project report No. 5; **RW**–Field observations Reed Wadley (1992–93); Ph.D researcher, project reports No.s 99 and 232, **SF**–field observations of Scott Frazier, consultant–project reports No.s 83, 84 and 105; **AR**–field observations of team of Dr. Andi Ross, Jack Cox and Helen Kurniati; visiting scientists, project report No. 186; **SS**–Sri Sumarni and Soraya (1996), student researchers, project report No. 243.

<sup>xi</sup>**Taxonomic reference:** Both species names and order of listing of species have been adapted according to Smythies, B.E. (1981) *The Birds of Borneo* (3<sup>rd</sup>. edition), The Sabah Society and Malayan Nature Society and Andrew, P. (1992) *The Birds of Indonesia: A Checklist (Peter's sequence)*. Kukuila Checklist no. 1. Indonesian Ornithological Society, June 1992, Jakarta. Revised with respect to taxonomic names as per MacKinnon, J. and Phillips, K. (1993) *A Field Guide to the Birds of Borneo, Sumatra, Java and Bali*. Oxford University Press.

<sup>xii</sup>**Local names:** Local Malay names (M), Indonesian ( ) or Iban (I) as collected by Noveriawan (1993), Budi Suriansyah (1995), Wadley (1994 and 1996) and Giesen (1987).

<sup>xiii</sup>**English names:** Adapted from van Balen (1994) and MacKinnon and Phillips (1993).

<sup>xiv</sup>**Status:** M–Migrant, V–Vagrant or R–Resident species. Source data: Gregory-Smith R. (1995) *Birds of Sarawak: A Pocket Checklist*. Institute of Biodiversity and Environmental Conservation. Universiti Malaysia Sarawak; supplemented by detail of MacKinnon and Phillips (1993).

<sup>xv</sup>**Endemicity:** As noted by MacKinnon, K., Hatta, G., Halim, H. and Mangalik, A. (1996) *The Ecology of Kalimantan (Indonesian Borneo)*. The Ecology of Indonesia Series, Vol. III.

<sup>xvi</sup>**CITES:** CITES listings derived from Anon (1983) *Lampiran 2: Daftar Flora dan Fauna Langka di Indonesia yang Tecantum Dalam Appendix I dan II CITES (Convention on International Trade in Endangered Spp. of Wild Fauna and Flora)*, per 29 Juli 1983. Revised by data from Anon (1995) Appendices I and II, CITES (adapted by Conference of Parties 16 April 1993. **I**–Listing under Annex I provided for endangered spp., trade in which is normally prohibited. **II**–Listed Appendix II CITES, Threatened spp., trade in which is controlled by permits.

<sup>xvii</sup>**IUCN rating:** IUCN rating of global threat to spp. as adopted from Shannaz, J., Jepson, P. and Rudyanto (1995) *Burung-Burung Terancam Punah di Indonesia*, Birdlife International–Departemen Kehutanan, Indonesia. Cr–Critical E–endangered; V–vulnerable; NT–near threatened.

<sup>xviii</sup> **National Law:** Both Indonesian Law and Sarawak Law (Malaysia). **Indonesian Law:** Ref. Anon (1973) Jenis Satwa Dilindungi di Kalimantan Barat, Sub-Balai KSDA, Kalimantan Barat, 1973. Daftar Satwa yang Dilindungi di Indonesia, 10 Juni 1991–List 301/Kpts-II/1991 contained in Anon (?) Kumpulan Peraturan tentang Flora/Fauna dan Bagian Bagainya, Sub-Balai Konservasi Sumber Daya Alam Kalimantan Barat. 1–Peraturan Perlindungan Binatang Liar 1931. No. 266; 2–Keputusan Menteri Pertanian 26 Agustus 1970 No. 421/Kpts/Um/8/1970; 3–Keputusan Menteri Pertanian No. 66/Kpts/Um/1973; 4–Keputusan Menteri Pertanian No. 742/Kpts/Um/12/1978; 5–Keputusan Menteri Pertanian No. 757/Kpts/Um/12/1979; 6–Keputusan Menteri Pertanian No. 576/Kpts/Um/8/1980; 7–Keputusan Menteri Kehutanan, 10 Juni 1991 No. 301/Kpts-II/1991. **Sarawak Law:** Reference Gregory-Smith R. (1995) *Birds of Sarawak: A Pocket Checklist*. Institute of Biodiversity and Environmental Conservation. Universiti Malaysia Sarawak. S–Protected Animal, illegal to hunt, kill, capture, sell, offer for sale, import, export, or be in possession of without a license, any protected animal, or any trophy, flesh, egg or nest there. Native rural residents engaged in traditional hunting for own consumption excluded. SS–Totally Protected Animal, no person may hunt, kill, capture, sell, offer for sale, import, export or be in possession of any totally protected animal, or any trophy, flesh, egg or nest thereof.

<sup>xix</sup> **Habitat (s):** Field observations as to which habitat spp. has been observed: B–Burnt area regrowth (lakeside), DS–Dwarf Swamp Forest, SS–Stunted Swamp Forest, RF–Riparian (river levee) Forest, TS–Tall Swamp (Peat) Forest, Hill Forest–HF, Aq.–Aquatic spp. (wetland, lake or river related).

<sup>xx</sup> **Observers:** Persons who have made observations and/or reports in which the species observations have been recorded. **Int.**–result of interview (secondary data); **Obs.**–personal observation; **WG**–Wim Giesen (1987), project report 1; **LJ**–observations of Lambertus Jembu, KSDA, Sintang reported in Giesen (1987); **IH**–Ian Hood (1993), project report 14; **TS**–Tony Sebastian (1993), project reports 46 and 67; **RD1**–Roy Dennis (1994), project report 53; **HN**–Heri Noveriawan (1992-93), project report 57; **BB**–Bas van Balen (1993-94), project reports 52 and 104; **RJ**–Rolf Jensen (1993-94) field observations and project report 77; **BS**–field observations Budi Suriansyah (1993-95), project I-UKTFMP field staff; **AJ**–field observations Ade Jumhur (1996), Project I-UKTFMP field staff; **EM**–Field observations Eric Meijaard (1996); **RoD**–Rona Dennis field observations (1995-95); **RD2**–Roy Dennis *et.al.* (1996) and (1997), project reports 237 and 269; **RW**–Field Observations Reed Wadley (1992-93); in Wadley, Pierce-Colfer and Hood (1994) and (1996), project reports 99, 162 and 232.

## ANNEX 4

ORDER/ FAMILY/ Species <sup>d</sup>	Local Name (Lan- guage) <sup>ii</sup>	English Name <sup>iii</sup>	Abund <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habi- tat(s) <sup>ix</sup>	Ob- serva- tion Notes <sup>x</sup>
<b>INSECTIVORA</b>									
<b>ERINACEIDAE</b>									
<i>Echino- sorex gymnurus</i>	Aji Jelu, Aji Bulan (I), Haji Bulan, Tikus bulan (M)	Moonrat	u					HF, TSF	Obs.- KJ, EM Int.-IH, SH, AE2, AE3
<i>Hylomys suillus</i>	Aji Jelu Celum (I)	Lesser Gym- nure						HF	Int.- AE3
<b>SORICIDAE</b>									
<i>Suncus murinus</i>	Cuit (M) [Kestu- ri]	House Shrew	c					HF	Obs.- BS
<i>Suncus ater</i>	Tikus	Black Shrew		*				RF, Padi	Int.- AE3
<i>Crocidura fuliginosa</i>	Aji	Tooth- ed Shrew						TSF, RF	Int.- AE3
<i>Chirar- rogale himalayica</i>	Padi Baru (I)	Hima- layan Water- Shrew						RF, TSF, Padi	Int.- AE3
<b>SCANDENTIA</b>									
<b>TUPAIIDAE</b>									
<i>Tupaia minor</i>	Tupai (I) Pencen (M)	Lesser Tree- shrew					S	HF, TSF	Obs.- BS Int.- CW2, AE3
<i>Tupaia glis</i>	Tupai (I)	Com- mon Tree- shrew					S	HF, TSF	Obs.- BS,TS Int.- CW2
<i>Tupaia montana</i>	Tupai (I)	Moun- tain Tree- shrew		*			S	HF	Int.- CW2, AE3
<i>Tupaia gracilis</i>	Tupai tandi (I)	Slender Tree- shrew		*			S	HF	Int.- CW2, AE2, AE3
<i>Tupaia tana</i>	Dumang (I)	Large Tree- shrew					S	HF, TSF	Int.- AE2, AE3
<i>Tupaia picta</i>	Tupai	Painted		*			S	HF	Int.-



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	Engkera	Tree- shrew							AE3
<i>Tupaia splendida</i>	Tupai sabang (I)	Ruddy Tree- shrew		*			S	RF, SS	Int.- AE3
<i>Tupaia dorsalis</i>	Tupai pekek (I)	Striped Tree- shrew		*			S	TSF, HF	Int.- AE3
<i>Dendro-gale melanura</i>	Tupai pekek, Tupai tanah (I)	Small- Tailed Tree- shrew		*			S	HF	Int.- CW1, CW2, AE3
<i>Ptilocercus lowii</i>	Tupai	Pentail Tree- shrew					S	TSF, HF	Int.- AE3
<b>DERMOPTERA</b>									
CYNOCEPHALIDAE									
<i>Cyno- cephalus variegatus</i>	Kubung (M) [Kubung Pelan- duk]	Flying Lemur/ Colugo	r				4, S	HF	Int.- BS, IH, SH, AE3
<b>CHIROPTERA</b>									
PTEROPODIDAE									
<i>Pteropus vampyrus</i>	Kelu- ang (M) Entam- bah, Enta- nah (I) [Ka- long]	Large Flying Fox	c					HF, TSF	Obs.- BS, HN, SH, Int.-IH, AE2, AE3, TS
<i>Rousettus amplexicaud- atus</i>	Kusing Seng- gang (I)	Geof- froy's Rousette							Int.- BS?, AE3
<i>Rousettus spinalatus</i>	Entama- bah, Kusing (I)	Bare- Backed Rousette						HF	Int.- CW2, AE3
<i>Cyanopterus brachyotis</i>	Kusing (I)	Short- nosed Fruit Bat						HF	Int.- AE3
<i>Cyanopterus horsefieldi</i>	Entawai (I)	Horse- field's Fruit Bat						TSF, HF	Int.- AE3
<i>Dyaco- pterus spadiceus</i>	Kesinap (I)	Dayak Fruit Bat				K		TSF, RF	Int.- AE3
<i>Chironax melanoceph- alus</i>	Kelela- war (M)	Black- Capped Fruit Bat						HF	Obs.- BS? Int.-

ORDER/ FAMILY/ Species'	Local Name (Language) <sup>ii</sup>	English Name <sup>iii</sup>	Abund <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habi- tat(s) <sup>ix</sup>	Ob- serva- tion Notes <sup>x</sup> AE3
<i>Penthetor lucasi</i>	Kusing Dalam Lubang (I)	Dusky Fruit Bat	c					HF	Obs.-BS?, CW2 Int.-AE3
<i>Balionycteris maculata</i>	Kesinap, Pedan, Entawai (I)	Spotted-winged Fruit Bat						RF, SSF, TSF	Int.-AE3
<i>Macroglossus minimus</i>	Kusing (I)	Long-tongued Nectar Bat						TSF, HF	Int.-AE3
<i>Emballonura monticola</i>	Kesindap (I)	Lesser Sheath-Tailed Bat	u					HF	Obs.-CW2
<i>Taphozous saccolaimus</i>	Kelawar (I)	Pouched Tomb Bat						SSF, TSF	Int.-AE3
<i>Taphozous melanogon</i>	Entawai (I)	Black-bearded Tomb Bat						TSF, HF	Int.-AE3
<i>Nycteris javanica</i>	Buyah (I)	Hollow-faced Bat						HF	Int.-AE3
<i>Megaderma spasma</i>	Buyah (I)	Lesser False Vampire Bat						HF	Int.-AE3
<i>Rhinolophus luctus</i>	Keluncau (I)	Great Woolly Horse-shoe Bat						TSF, HF	Int.-AE3
<i>Rhinolophus philippinensis</i>	Entawai (I)	Philippine Horse-shoe Bat						TSF, RF, HF	Int.-AE3
<i>Hipposideros cervinus</i>		Fawn Round-leaf Bat	c					HF	Obs.-CW2, TS
<i>Hipposideros larvatus</i>	Keluncau	Intermediate Round-leaf Bat						TSF, HF	Int.-AE3
<i>Hipposideros diadema</i>	Kesinap Mawang	Diadem Round-leaf Bat						HF	Int.-AE3
<i>Myotis muricola</i>	Kesinap (I)	Whiskered Myotis						SSF, TSF, HF	Int.-AE3

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<i>Scotophilus kuhlii</i>	Kesinap mawang (I)	Yellow House- Bat						HF	Int.- AE3
<i>Tylonycteris pochypus</i>	Kesinap (I)	Lesser Bamboo Bat						HF	Int.- AE3
<i>Tylonycteris robustula</i>	Dumung buluh, Kesin- dap (I)	Greater Bamboo Bat						TSF, SSF, HF	Int.- CW2, AE3
<i>Pipistrellus vordermanni</i>	Cinap cermin (I)	White- winged Pipis- trella						HF	Int.- AE3
<i>Miniopterus magnater</i>	Kusing (I)	Large Bent Bat						HF	Int.- AE3
<i>Harpiocephalus harpia</i>	Kusing (I)	Hairy- winged Bat						TSF, HF	Int.- AE3
<i>Kerivoula papillosa</i>		Papil- lose Woolly Bat	c					HF	Obs.- CW2 'Int.- AE3
<i>Cheiromeles torquatus</i>	Entawai (I)	Naked Bat					SS	TSF, HF	Int.- AE3
<i>Tadarida mops</i>	Kusing Batu (I)	Free- tailed Bat						HF	Int.- AE3
<b>PRIMATES</b>									
LORISIDAE									
<i>Nycticebus coucang</i>	Kukang (M) Beng- kang (I) [Malu- Malu]	Slow Loris	r				3, SS	HF	Obs.- BS,GZ A; Int.- IH, AE2, AE3
TARSHIDAE									
<i>Tarsius bancanus</i>	Inggat (I) Singa- puar (M) [Singa Puar]	Western Tarsier	u				1, SS	HF, TSF	Obs.- BS; Int.-IH, SH, AE2, AE3
CERCOPITHECIDAE									
<i>Macaca fascicularis</i>	Kera <sup>7</sup> (M,I) [Kera Ekor Panjang]	Long- Tailed Ma- caque	c		II			SSF, RF, TSF, HF	Obs.- BS, IH, SH, TS Int.- CW2, KJ, AE3 Obs.-
<i>Macaca</i>	Nyum-	Pig-	c		II		4	HF	Obs.-

ORDER/ FAMILY/ Species <sup>i</sup>	Local Name (Lan- guage) <sup>ii</sup>	English Name <sup>iii</sup>	Abund <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habi- tat(s) <sup>ix</sup>	Ob- serva- tion Notes <sup>x</sup>
<i>nemestrina</i>	boh, Nyu- muh, Match (I) Beruk (M)	Tailed Ma- caque							BS, IH, CW2 Int.- CW1,S H,AE2 , KJ, AE3
<i>Nasalis larvatus</i>	Bekan- tan, Pikah (M) Rasong (I) [Bekan- tan]	Probos- cis Monkey	c	*	I	V	1, SS	RF, SSF, TSF	Obs.- BS, IH, SH, KJ, AE1, AE2, AE3, TS
<i>Presbytis frontata</i>	Puan (I) [Lutung]	White- Fronted Langur		*	II		6, SS	HF	Obs.- CW1,C W2 Int.- BS, KJ, AE3
<i>Presbytis rubicunda</i>	Kela- siau (M) Jeluh Merah, Matih (I) [Kelasi]	Red Leaf Mon- key, Maroon Langur	u	*	II		5, SS	HF, TSF	Int.- BS, IH, SH, AE2, AE3
<i>Presbytis metalophos cruciger</i>	Kepuh (M) Kera Celum, Batch, Jelu Merah (I)	Banded Langur	u		II		4, SS	TSF, HF	Obs.- BS, KJ, CW2; Int.-IH, SH, AE3
<i>Presbytis cristata*</i>	Biguh (I)	Silver- ed Langur	r		II		SS	HF	Int.- AE3
HYLOBATIDAE									
<i>Hylobates agilis</i>	Lem- piau (M) Empe- liau (I) [Klem- piau]	Agile Gibbon	u		I		I	HF	Obs.- AE1; Int.- BS, IH,CW I?,KJ
<i>Hylobates muelleri</i>	Lem- piau (M) Peliau Arang, Empe- liau Arang	Bornean Gibbon	u	*	I		1, SS	HF, TSF	Obs.- AE1 SH CW2, TS; Int.- BS, IH,

ORDER/ FAMILY/ Species'	Local Name (Lan- guage) <sup>ii</sup> (I) [Ke- lem- piau]	English Name <sup>iii</sup>	Abund <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habi- tat(s) <sup>ix</sup>	Ob- serva- tion Notes <sup>t</sup>
<b>PONGIDAE</b>									
<i>Pongo pygmaeus</i>	Mayas Timbau (large sp.?) & Mayas Kesak (small sp.?). Maias (I) [Orang Utan]	Orang Utan	u		I	E	I, SS	TSF, HF	Obs.- AE1, SH; Int.- BS, IH, CW1, AE2
<b>PHOLIDOTA</b>									
<b>MANIDAE</b>									
<i>Manis javanica</i>	Balon/ Teng- giling (I) [Tereng- giling]	Pango- lin	u		II		I, S	HF, TSF, RF	Int.- BS, IH, WG, SH, AE2, AE3
<b>RODENTIA</b>									
<b>SCIURIDAE</b>									
<i>Ratufa affinis sandaka- nensis</i>	Engkere bak (M,I), Ke- rampu (I), Bajing (M)	Giant Squirrel	c		II		SS	HF, RF, TSF, SSF	Obs.- BS, IH, HN Int.- CW1, SH, AE2
<i>Ratufa affinis cothurnata</i>	Eng- kerebak (M,I), Ke- rampu (I)	Giant Squirrel	u		II		SS	HF, TSF	Obs.- BS, CW2 Int.- AE2
<i>Ratufa affinis baramensis</i>		Giant Squirrel						RF, SSF	Int.- AE3
<i>Callo- sciurus prevostii</i>	Tupai beka- rang (I) Bajing (M)	Pre- vost's Squirrel	u					RF, SSF, TSF	Obs.- BS, IH, TS Int.- CW2, SH, AE3
<i>Callo- sciurus</i>	Tupai bekaran	Kina- balu						HF, TSF	Obs.- BS

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<i>baluensis</i>	g (I) [Tupai]	Squirrel							Int.- CW1, AE2, AE3
<i>Callosciurus notatus</i>	Tupai sibau (I) Bajing (M)	Plantain Squirrel	c					SSF, RF, TSF, HF	Obs.- BS, IH, TS int.- CW1,C W2, SH
<i>Callosciurus orestes</i>	Tupai (I)	Banded Squirrel		*				TSF, RF	Int.- AE3
<i>Callosciurus adamsi</i>	Tupai Melidi (I)	Ear-Spot Squirrel		*				TSF, HF	Int.- AE3
<i>Callosciurus nigrovittatus</i>	Tupai tanah (I)	Borne- an Black- Banded Squirrel						TSF, HF	Int.- AE3
<i>Sundasciurus jentinki</i>	Tupai pantok (I)	Jen- tink's Squirrel		*				HF	Int.- CW2, AE3
<i>Sundasciurus hippurus</i>	Tupai (I)	Horse- Tailed Squirrel	u					RF, HF, TSF	Obs.- IH Int.- CW2, SH, AE3
<i>Sundasciurus brookei</i>	Tupai	Brooke's Squirrel	u	*				SSF, RF	Obs.- IH Int.- SH
<i>Sundasciurus lowii</i>	Tupai (I)	Low's Squirrel						HF	Obs.- CW1 Int.- CW2
<i>Sundasciurus tenuis</i>	Tupai pekek (I) [Tupai]	Slender Squirrel						HF	Int.- AE2, AE3
<i>Lariscus insignis</i>	Tupai sabang, Tupai pukang (I), Bajing tanah (M)	Three- Striped Ground Squirrel					5	HF, TSF	Obs.- BS Int.- CW2, AE2, AE3
<i>Lariscus hosei</i>	Tupai sabang, Tupai pukang (I),	Four- Striped Ground Squirrel		*	II		6	HF	Int.- CW2, AE2, AE3

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<i>Dremomys everetti</i>	Bajing tanah (M) Tupai pekek (I) [Tupai]	Bornean Mountain Ground Squirrel		*				HF	Int.-CW1
<i>Rhinosciurus laticaudatus</i>	Tupai tanah (I)	Shrew-faced Ground Squirrel						HF	Int.-CW2
<i>Rheithrosciurus macrotis</i>	Keram-pau (I)	Tufted Ground Squirrel					S	HF	Int.-AE3
<i>Excilisciurus exilis</i>	Pencen (M) Pukang (I)	Plain Pigmy Squirrel	u	*				HF, TSF	Obs.-BS, IH, SH Int.-CW2, AE3
<i>Excilisciurus whiteheadi</i>	Tupai	White-head's Pygmy Squirrel	u	*				HF	Int.-CW1
<i>Nannosciurus melanotis</i>	Pencen (M) Pukang (I)	Black-eared Pigmy Squirrel	c					TSF	Obs.-BS, WG, TS Int.-AE3
<i>Rheithrosciurus macrotis</i>	Eng-keram-pu' (I)	Tufted Ground Squirrel	u	*			S	HF, TSF	Obs.-IH Int.-CW2, SH
<i>Iomys horsfieldi</i>	Kubung (M,I)	Hors-field's Flying Squirrel					6, S	HF	Int.-BS, IH?
<i>Hylomys spadiceus</i>	Kubung Pelan-duk (I)	Red-Cheek-ed Flying Squirrel					S	HF, TSF	Int.-AE2, AE3
<i>Pteromyscus pulverulentus</i>	Kubung Mayau (I)	Smoky Flying Squirrel					S	HF, TSF	Int.-AE2, AE3
<i>Petaurista elegans</i>	Kubung Merah (I)	Spotted Giant Flying Squirrel					5, S	HF, TSF	Int.-AE2
<i>Petaurista petaurista</i>	Kubung jelu	Red Giant					S	HF	Int.-AE3

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<i>Petaurillus hosei</i>	marah (I) Kubung (I)	Flying Squirrel Hose's Pygmy Flying Squirrel		*			S	HF, TSF	Int.- AE3
<i>Petinomys vordermanni</i>	Kubung (I)	Vorder- mann's Flying Squirrel					S	HF	Int.- AE3
<i>Petinomys genibarbis</i>	Kubung Musang (I)	Whisk- ered Flying Squirrel					S	HF	Int.- AE3
<i>Petinomys setosus</i>	Pinau, Kubung Tupai (I)	Tem- minck's Flying Squirrel					S	HF	Int.- AE3
<i>Aeromys thomasi</i>	Kubung jelu (I)	Thomas' s Flying Squirrel		*			S	HF	Int.- AE3
MURIDAE									
<i>Rattus rattus</i>	Cit (I) [Tikus Rumah]	House Rat	c					All	Obs.- BS, IH, SH Int.- CW2
<i>Rattus norvegicus</i>	Cuit	Nor- wegian Rat						Padi	Int.- AE3
<i>Rattus exulans</i>	-	Poly- nesian Rat						RF, TSF, padi	Int.- AE3
<i>Rattus baluensis</i>	Cit baguk (I)	Summit Rat						Padi	Int.- AE3
<i>Rattus argentiventer</i>	Cit Tanah (I)	Rice- field Rat	u					HF (field)	Obs.- CW2 Int.- AE3
<i>Rattus tiomonicus</i>	-	Malay- sian Field Rat						HF, padi	Int.- AE3
<i>Maxomys surifer</i>	Tikus	Red Spiny Rat						HF	Int.- AE2, AE3
<i>Maxomys baeodori</i>	Tikus	Moun- tain Spiny Rat						TSF, RF	Int.- AE3
<i>Sundamys muelleri</i>	-	Muller's Rat						Padi	Int.- AE3



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<i>Sundamys infraluteus</i>	-	Moun- tain Giant Rat						Padi	Int.- AE3	
<i>Lenothrix canus</i>	Cit	Grey Tree Rat						TSF, HF	Int.- AE3	
<i>Chiropo- domys gliroides</i>	Tikus Pohon (M)	Com- mon Pencil- Tailed Tree- Mouse						HF	Obs.- BS?	
<i>Chiropo- domys major</i>	Cit	Large Pencil- Tailed Tree- Mouse		*				TSF, RF	Int.- AE3	
<i>Mus castaneus</i>	-	House Mouse						Padi	Int.- AE3	
<i>Mus caroli</i>	-	Rice- field Mouse						Padi	Int.- AE3	
HYSTERICIDAE										
<i>Hystrix branchyura</i>	Landak (M) [Lan- dak]	Com- mon Porcu- pine	u				6, S	HF, RF, TSF	Obs.- BS Int.-IH, SH, AE2, AE3	
<i>Trichys fasciculata</i>	Angkeh (I) Landak (M) [Lan- dak]	Long- Tailed Porcu- pine	c				S	HF, TSF	Obs.- BS Int.-IH, SH, AE2, AE3	
<i>Hystrix crassi-spinis</i>	Landak Nibung (I) [Lan- dak]	Thick- Spined Porcu- pine		*			S	HF, TSF	Obs.- CW2 Int.- AE2, AE3	
CARNIVORA										
URSIDAE										
<i>Helarctos malayanus</i>	Beru- ang (M), Jugam, Rambai (larger), Sompak (normal) (I)	Sun Bear	u		I	V	3, S	HF, TSF	Obs.- BS,SH Int.-IH, WG, CW1, CW2, AE2, AE3	
MUSTELIDAE										
<i>Martes</i>	Busau	Yellow-						I	TSF	Int.-

ORDER/ FAMILY/ Species'	Local Name (Lan- guage) <sup>ii</sup>	English Name <sup>iii</sup>	Abund <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habi- tat(s) <sup>ix</sup>	Ob- serva- tion Notes <sup>x</sup>
<i>flavigula</i>	(I)	Throat- ed Marten							AE2, AE3
<i>Melogale personata</i>	Busau (I)	Ferret- Badger				K		HF	Int.- AE3
<i>Mustela nudipes</i>	Musang Pisang (M)	Malay Weasel						RF, TSF	Int.- AE3
<i>Mydaus javanensis</i>	Aji (M) [Ke- sadu]	Teledu or Malay Badger							Inf.-BS
<i>Lutra perspicil- lata</i>	Pusuh, Pusoh labek, Berang- berang (M), Ringin kuban (I)	Smooth Otter	c		II	K	S	HF,SSF, RF,TSF, Aq	Obs.- IH, BS, GZA Int.- SH, AE2, AE3
<i>Lutra sumatrana</i>	Ringin (M) [Berang- Berang]	Hairy- Nosed Otter	u		II	K	S	TSF, Aq.	Obs.- BS
<i>Aonyx cinerea</i>	Pusuh (M) [Be- rang-Be- rang]	Oriental Small- Clawed Otter	c		II	K	S	HF,RF,S SF,TSF, Aq	Obs.- BS, GZA, EM, TS Int.- WG, SH, AE3
VIVERRIDAE									
<i>Viverra tangalunga</i>	Engku- lik Raras, Sinan, Nkok (I) [Mu- sang Teng- galung]	Malay Civet or Tanga- lung	u					HF, TSF	Int.- BS, IH, SH, AE2, AE3
<i>Prionodon linsang</i>	Pang- kong Along (I)	Banded Linsang	r		II		6, S	HF, TSF	Int.- IH, AE2, AE3
<i>Para- doxurus herma- phroditus</i>	Mun- sang (I) Musang ruman (M) [Mu-	Com- mon Palm Civet	c					HF, SSF, TSF, RF	Obs.- KJ, SH Int.- CW1, CW2, BS,

ORDER/ FAMILY/ Species <sup>1</sup>	Local Name (Lan- guage) <sup>ii</sup> [Lang- sung]	English Name <sup>iii</sup>	Abund <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habi- tat(s) <sup>ix</sup>	Ob- serva- tion Notes <sup>x</sup> AE3
<i>Paguma larvata</i>	Galing, Mere- jang (I) Musang jurai (M)	Masked Palm Civet	c					HF, TSF	Int.- BS, CW2, SH, AE2, AE3
<i>Arctictis binturong</i>	Enturun Kait (I) [Bin- turong]	Bintu- rong or Bearcat	r				6, S	HF	Obs.- BS, CW2, AE2, AE3
<i>Arctogalidia trivirgata</i>	Mun- sang malong (I)	Small- Toothed Palm Civet	r			I		HF, TSF	Obs.- WG, CW1, CW2 Int.- AE2
<i>Hemigalus hosei</i>	Pang- kong Along (I)	Hose's Civet	r	*			S	TSF	Int.- AE2, AE3
<i>Hemigalus derbyanus</i>	Pang- kong Along (I)	Banded Palm Civet	r		II			HF, TSF	Int.- AE2, AE3
<i>Cynogale bennettii</i>	Nturun (I) Mu- sang air (M)	Otter- Civet	u		II	K	2	HF, TSF, SSF, RF, Aq	Int.- WG, SH, KJ
<i>Herpestes hosei</i>	Pantuk (I)	Hose's Mon- goose		*				TSF, HF	Obs.- BS Int.- AE3
<i>Herpestes semi- torquatus</i>	Pantuk (I)	Col- lared Mon- goose						HF	Int.- AE3
FELIDAE									
<i>Prio- nailurus planiiceps</i>	Jelu Mayau (I), Kucing Dampak (M)	Flat- Headed Cat			I	I	6, SS	HF, TSF	Int.- BS, AE2, AE3
<i>Pardofelis marmorata</i>	Jelu Mayau (I), Kucing hutan (M)	Marbled Cat	r		I	I	5, SS	HF, TSF	Int.- SH, AE2, AE3
<i>Prionailurus bengalensis</i>	Kucing batu,	Leopard Cat	c		I/II	I	3	SSF, TSF, HF	Obs.- SH

ORDER/ FAMILY/ <i>Species</i>	Local Name (Language) <sup>ii</sup>	English Name <sup>iii</sup>	Abund <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>i</sup>	IUCN <sup>vi</sup>	Nat. Law <sup>viii</sup>	Habi- tat(s) <sup>ix</sup>	Ob- serva- tion Notes <sup>x</sup>
	Kera- bak, Eng- kulek (M)								Int.- K1, AE3
<i>Catopuma badia</i>	Jelu Mayau (I), Kucing Merah (M)	Bay Cat		*	II	R	6, SS	HF, TSF	Int.- AE2, AE3
<i>Neofelis nebulosa</i>	Harimau Akar (M) [Macan Dahan]	Clouded Leopard	c		I	V	3, SS	HF, TSF	Obs.- SH, TS Int.- BS, WG, SH, K1, AE3
<b>ARTIODACTYLA</b>									
<b>SUIDAE</b>									
<i>Sus barbatus</i>	Babi Tambau, Jane' (I) [Babi Hutan]	Bearded Pig	c					TSF, SSF, HF	Obs.- BS, IH, WG, C W1, C W2, SH Int.- AE2, AE3
<i>Sus scoufa</i>	Janik (I) Babi Alang- Alang	"Feral/ Wild Pig" ?						TSF, HF	Int.-BS
<b>TRAGULIDAE</b>									
<i>Tragulus javanicus</i>	Pelan- duk Ke- rangas (M), P. gagas (I) [Kancil]	Lesser Mouse- Deer	c				1	HF, TSF	Obs.- BS, CW2, SH Int.- IH, WG , CW2, AE2, K I, AE3
<i>Tragulus napu</i>	Pelan- duk (M), P. Tam- pin (I) [Napu]	Greater Mouse- Deer					1	HF, TSF	Obs.- BS, CW2 Int.-IH, CW1, SH, AE3
<b>CERVIDAE</b>									
<i>Muntiacus</i>	Kijang	Bornean	c				1	HF, TSF	Obs.-

ORDER/ FAMILY/ Species <sup>d</sup>	Local Name (Lan- guage) <sup>ii</sup>	English Name <sup>iii</sup>	Abund <sup>iv</sup>	En- demic <sup>v</sup>	CITES <sup>vi</sup>	IUCN <sup>vii</sup>	Nat. Law <sup>viii</sup>	Habi- tat(s) <sup>ix</sup>	Ob- serva- tion Notes <sup>x</sup>
<i>muntjac</i>	(I) [Ki- jang]	Red Muntjac							CW1, CW2, SH Int.- BS, IH, AE2,K J,AE3
<i>Muntiacus atherodes</i>	Kijan bera' (I) [Kijang]	Bornean Yellow Muntjac	u	*				HF, TSF	Obs.- BS Int.-IH, CW2, SH, AE2, AE3
<i>Cervus timorensis</i>	Payau	Javan Rusa					I	HF, TSF	Obs.- BS Int.- AE2, KJ
<i>Cervus unicolor</i>	Rusa' (I), Payau (M) [Rusa Sambar]	Sambar Deer	u				I	HF, TSF	Obs.- BS, IH, WG Int.- CW2, AE3

<sup>i</sup> **Taxonomic reference:** Both species names and order of listing of species have been adapted according to Payne, J. Francis, C. M. and Phillipps (1985) *A Field Guide to the Mammals of Borneo*. The Sabah Society and WWF-Malaysia. Revised with respect to taxonomic names as per Corbet, G.B. and Hill, J.E. (1992) *The Mammals of the Indomalayan Region*. Natural History Museum Publications, Oxford University Press.

<sup>ii</sup> **Local names:** As collected by the field observers listed on-site. M–Malay; I–Iban; [ ]–Bahasa Indonesia.

<sup>iii</sup> **English names:** Adapted from Payne, J. Francis, C. M. and Phillipps (1985) *A Field Guide to the Mammals of Borneo*. The Sabah Society and WWF-Malaysia.

<sup>iv</sup> **Abundance:** Abundance on-site (DSWR) as remarked by observers listed. r–rare; u–uncommon; c–common.

<sup>v</sup> **Endemicity:** As noted by Payne et.al. (1985); Corbet and Hill (1992); and MacKinnon, K., Hatta, G., Halim, H. and Mangalik, A. (1996) *The Ecology of Kalimantan (Indonesian Borneo)*. The Ecology of Indonesia Series, Vol. III. Periplus.

<sup>vi</sup> **CITES:** CITES listings derived from Anon (1983) Lampiran 2: Daftar Flora dan Fauna Langka di Indonesia yang Tecantum Dalam Appendix I dan II CITES (Convention on International Trade in Endangered Spp. of Wild Fauna and Flora), per 29 Juli 1983. Revised by data from Corbet and Hill (1992). I–Listed in Appendix I CITES, endangered spp., trade in which is normally prohibited. II–Listed Appendix II CITES, Threatened spp., trade in which is controlled by permits.

<sup>vii</sup> **IUCN rating:** IUCN rating of global threat to spp. as adopted from Groombridge, B. (1993) *1994 IUCN Red List of Threatened Animals. Compiled by the World Conservation Monitoring Centre, Cambridge*. U.K. IUCN–The World Conservation Union. E–endangered; V–vulnerable; R–rare; I–indeterminate (considered E, V or R); K–insufficiently known (suspected E, V or R).

<sup>viii</sup> **National Law:** Both Indonesian Law and Sarawak Law (Malaysia). **Indonesian Law:** Ref. Anon (1973) Jenis Satwa Dilindungi di Kalimantan Barat, Sub-Balai KSDA, Kalimantan Barat, 1973. Daftar Satwa yang Dilindungi di Indonesia, 10 Juni 1991–List 301/Kpts-II/1991 contained in Anon (?) Kumpulan Peraturan tentang Flora/Fauna dan Bagian Bagainya, Sub-Balai Konservasi Sumber Daya Alam Kalimantan Barat. 1–Peraturan Perlindungan Binatang Liar 1931. No. 266; 2–Keputusan Menteri Pertanian No. 327/Kpts/Um/7/1972; 3–Keputusan Menteri Pertanian No. 66/Kpts/Um/1973; 4–Keputusan Menteri Pertanian No. 35/Kpts/Um/1/1975; 5–Keputusan Menteri Pertanian No. 537/Kpts/Um/12/1977; 6–Keputusan Menteri Pertanian No. 247/Kpts/Um/4/1979.

**Sarawak Law:** Ref. Forestry Department of Sarawak (?) *Totally Protected Animals of Sarawak. Poster Series*–Poster 1 and Forestry Department of Sarawak (?) *Protected Animals of Sarawak. Poster Series*–Poster 2 S–Protected Animal, illegal to hunt, kill, capture, sell, offer for sale, import, export, or be in possession of without a license, any protected animal, or any trophy, flesh, egg or nest there. Native rural residents engaged in traditional hunting for own consumption excluded. SS–Totally Protected Animal, no person may hunt, kill, capture, sell, offer for sale, import, export or be in possession of any totally protected animal, or any trophy, flesh, egg or nest thereof.

<sup>ix</sup> **Habitats:** The habitats in which species were observed. **DSF**–Dwarf Swamp Forest; **SSF**–Stunted Swamp Forest; **RF**–Riparian (levee) Swamp Forest; **TSF**–Tall (peat) Swamp Forest; **HF**–Hill Forest; **Aq**–Aquatic species.

<sup>x</sup> **Observers:** **Obs.**–personal observation. **Int.**–data from interview of local communities. **WG**–Wim Giesen (1987); project report 1; **IH**–Ian Hood (1993); project report 14; **HN**–Heri Novriawan (1992); project report 20; **TS**–Tony Sebastain (1984), project report 67; **BS**–Field observations Budi Suriansyah (1993-1995); **CW1**–Carol Colfer, Reed Wadley, P. Sinaga and Ian Hood (1993g), project report 33; **CW2**–Reed Wadley, Carol Colfer and Ian Hood (1994), project report 99; **CW3**–Reed Wadley, Carol Colfer and Ian Hood (1996), project report 232; **EM**–Field observations Eric Meijaard (1995-1996); **KJ**–field observations Kevin Jeanes (1995-1997); **GZA**–Field observations Gusti Zakaria Anshari (1995); **SH**–Srie Harmaya (1996), project report 204; **AE1**–Field observations Andi Erman (1992-1997); **AE2**–Andi Erman (1997); project report 244; **AE3**–Andi Erman (1997); project report 272.

## DANAU SENTARUM'S WILDLIFE

PART 2. HABITAT CHARACTERISTICS AND BIODIVERSITY  
DISTRIBUTION WITHIN AND SURROUNDING DANAU SENTARUM

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This paper presents a broad analysis of wildlife habitat usage and the need for habitat conservation within and surrounding Danau Sentarum National Park, West Kalimantan, Indonesia. Flood and dry season habitat analysis reveal that intact Peat Swamp and Hill Forests, largely outside DSNP's boundaries, support much greater bird and mammal species numbers, and endemic and threatened species, than the Stunted Swamp Forests of the DSNP central lakes basin. Peat Swamp Forest and hill stream habitats also act as key year-round habitats for the majority of the site's endemic fish, and threatened crocodile, tortoise, turtle, waterbird and fish populations. Furthermore, these habitats provide a vital dry season refuge to fish fauna migrating up-catchment to escape the dry season drying up of the central basin lakes. Comparatively the extensive "within-reserve" lake basin habitat offers key year-round habitat only to terrestrial fauna ecologically restricted to the area (i.e. Proboscis Monkey), and only a flood season habitat for the diverse fish fauna of the central basin lakes and rivers. These patterns suggest that the inclusion in the Park of all the forests that surround the lakes would significantly increase the Park's biodiversity. Finally, available data form an adequate basis to initiate a "blanket approach" to habitat and faunal community conservation, i.e. exercising the assumption that habitat conservation measures will by default also conserve the fauna species shown to use these habitats. Yet, the ecological detail concerning wildlife nutrition, breeding, habitat use, ranging and migration, as needed to initiate firmer "species-focused" conservation programs, is still lacking. This data gap is becoming increasingly crucial as the risk of site and regional species extinction mounts in the face of accelerating habitat destruction and uncontrolled harvest and trade impacts.

**Introduction**

In view of the bioregional and global importance of the wildlife diversity in Danau Sentarum National Park (DSNP) (see Jeanes and Meijaard, 2000), and against a background of increasing human population and development pressure, there is currently a pressing need to initiate concerted conservation action to head-off the mounting risks of local and regional species extinction. Effective wildlife management can only be

successful if based on accurate knowledge of the ecological requirements of the target species in the area. This is especially the case because many wildlife species in the area are threatened in their survival and it is unlikely that these species will survive if their ecological needs are not specifically addressed. What is needed, therefore, are data on wildlife habitat preferences, ranging needs, feeding ecology and species population dynamics. This paper summarizes and discusses ecological data that have been gathered by a variety of researchers working in DSNP. Relatively little research has been done on the ecology of Danau Sentarum's wildlife, and this overview of species ecology is necessarily brief. Still we hope that this account of the more recent findings concerning habitat importance, wildlife ecology and population distributions will assist in improving wildlife management in DSNP.

### Methods

Detailed methodology of the publications and reports on wildlife ecology will not be described here, unless specific mention is required to explain certain findings. As a fundamental data requirement for any in-situ fauna conservation program, a clear definition is needed of the relationship between animal species and habitats, most notably how faunal biodiversity is distributed within the site and where it is found in greatest concentrations. As a first step in the analysis a classification of terrestrial and aquatic habitats is needed.

### Terrestrial

Derived from the ecological studies of Giesen (1987, 1994, 1996, 2000) and Jensen, *et al.* (1994)—(reported in Giesen (2000)), and based on the associated floristic, phenology, structural, soil, flood pattern, classification and mapping detail generated concerning DSNP's vegetation types, a simplified mapping of the major terrestrial habitat types of DSNP and near-catchment surrounds has been made (see Jeanes, 1997; source Dennis, 1996, 1997) defining six major terrestrial habitat types as follows:

- A. Surrounding Uplands with shifting cultivation;
- B. Elevated River Levees with shifting cultivation;
- C. Hills and Hill Forest;
- D. Peat lands and Tall Swamp Forest;
- E. Fresh water Swamp and Stunted / Dwarf Swamp Forest; and
- F. Fresh water Swamp and Riparian Swamp Forest.

The initial two cleared landscapes were not mapped, but are identified as the boundary between the lake basin fresh water swamps (D and E) and the Kapuas river levee to the south (B); the boundary between Tall Peat Swamp Forest (D) and the well-drained uplands (A) to the north east, north and west; and the tongues of cleared land on river levees of the catchment tributaries (B) extending into the Tall Swamp Forest belts from the east, north and west. All other habitat units are clearly mapped; with the hills divided into forested (C) and secondary regrowth/ladang (r) belts, and the lake basin habitats mapped as a complex of lakes, water ways, Dwarf Swamp Forest and Stunted Swamp Forest (E). The few remaining un-cleared sites of Riparian Swamp forest (F) are marked as strips along the Tawang, Tengkidap, Belitung and Belitung Hulu Rivers.



### Aquatic

Despite a lack of systematic data there is ample evidence in the analysis of site data to suggest that numerous differing “aquatic habitats” exist in the DSNP lake basin. Based studies of water quality data, differing hydrology, flooding patterns, and periods of flooding within and surrounding DSNP (reported in Giesen (1987, 1996; Jeanes, 1997), nine potentially differing “aquatic habitats” have been defined in DSNP as outlined in Table I.

A. The main Kapuas river.

B and C. The two classes of hydrological connection between the Kapuas the lake basin (i.e. main and peak flood season water flow routes).

D and E. Catchment tributaries (generally “white” water).

F, G and H. three classes of lake (two seasonal; and one permanent).

I. the black-water swamp and forest streams.

**Table I. Aquatic habitats and characteristics of DSWR.**

CLASS	HABITAT TYPE	HYDROLOGICAL DETAILS	WATER QUALITY	HABITAT LOCATION
<b>A</b>	Main River	Riverine; uni-directional and large volume flow; widely fluctuating flood levels; main water supply for lake basin system	White water; nutrient rich (eutrophic)	Kapuas river and fringing ox-bows.
<b>B</b>	Main Floodplain Distributaries	Riverine; reversible flow direction; large volume flow; widely fluctuating flood levels. Main routes of water input and drainage to lake basin system.	White/black water mix good to medium nutrient levels	S. Tawang; S. Belitung-Danau Bekuan-S. Batang Putus
<b>C</b>	Secondary Floodplain Distributaries	Rivers; streams, and lakes; reversible flows. Secondary input routes for Kapuas as waters to lake basin; low flow volumes (mainly overland and small streams); wide to medium fluctuation in flood levels.	White/black water mix; good to medium nutrient levels	Danau Gandal-S. Gandal-S. Sebuayak; S. Tengkidap-Batang Sekentut-S. Mentibal; S. Telaga-S. Batang Serawak-Danau Bekuan; S. Tanjung Petak-S. Batang Sekuang-S. Belitung Hulu-Danau Sekawi.
<b>D</b>	Main Catchment Tributaries	Riverine; uni-directional flow; medium to no flow volume; medium fluctuation in flood levels. Secondary supply of water to floodplain/lake system.	White water; medium nutrient levels	Leboyan, Empanang, Seriang, Sebadin, Piyam, Ensanak, Empanang.

<b>E</b>	Minor Upland Drainage Lines	Streams; uni-directional flow; low to no flow volume. Negligible water input to lakes system.	White water; high nutrient levels	Streams/drainage of Bukit's Tekenang, Semujuan, Meyukung ranges, Lanjak-Meliau ranges, Empaik-Seligi range, Bukit's Segerat-Setubu.
<b>F</b>	Central Lakes (seasonal)	Lacustrine; widely fluctuating flood levels; main storage area for floodplain waters; medium to no flow.	Black water mix; medium to low nutrient levels	Danau's Seriang, Turus Duata, Belida, Pengembung, Genali, Luar and surrounds
<b>G</b>	Peripheral Forest Lakes (seasonal)	Lacustrine; wide fluctuation of flood levels; mixed storage of floodplain/forest drainage waters; low to no flow.	Black water; low nutrient levels (oligotrophic)	All minor tributary lakes within forested terraces adjacent the Central Lakes zone (e.g. Pemcrak, Seliban, Semangit).
<b>H</b>	Catchment Lakes (permanent)	Lacustrine; medium to low fluctuation of flood levels; mixed storage of swamp forest/upland/catchment river drainage; no flow.	Black and white (?) water lakes; probably changing nutrient levels	D. Telatap; D. Lukuk-Kemati-Melieu Tujuh complex; D. Santak and Merasu; D. Berasau.
<b>I</b>	Swamp Forest Drainage Lines	Streams and forest pools; medium (?) to wide fluctuation in flood levels; storage and drainage of forest/swamp waters; high dry season flow.	Black water; low nutrient levels (oligotrophic)	All peat swamp forest areas (fresh water and peat) and black-water streams (e.g S. Piyam, S. Senunuk, S. Air Mcrah, S. Tangit) draining to the lake basin

Despite the lack of details on aquatic species ecology and population distributions (particularly for fish), such a limnology-based habitat classification remains the best basis for further strategic study concerning aquatic wildlife ecology, hydrological patterns, and water quality.

## Results

Beyond consideration of habitat type, analysis must progress to define patterns of habitat use by individual species, the concentrations of biodiversity in differing habitats, and consideration of how these patterns influence species ecology.

## Fish

Vaas (1952) provides some limited data concerning feeding habits and habitat distribution of DSNP and adjacent Kapuas River fish species. Suryaningsih (1993) adds data on the feeding behavior and length to weight ratios of five DSNP fish species. Such work on selected DSNP fish species (i.e. feeding behavior and breeding cycles) has also been carried out by staff of the Freshwater Fisheries Research Institute (Palembang) in mid-1996 (unpublished data). Widjanarti (1996), and Kottelat (1993) to a lesser extent,

provide brief notes on fish species distribution and ecology for most of their 218 listed fish species. As such, knowledge of fish habitat preferences and requirements remains sketchy. Only the work of Kottelat (1993) notes some trends in fish biodiversity distribution with 125 species found in the central lakes basin, 175 species in the “lakes area” plus fringing forest lakes, and 185 species from the total DSNP site and near catchment. Kottelat (1993) suggested, and recent surveys proved, that over 200 fish species could inhabit the DSNP central lakes basin and peripheral lakes, making it the most biodiverse habitat complex for DSNP fish fauna. However, he also notes that the addition of the tall swamp forest zone surrounding DSNP, would add at least 50 species, translating into a 25% increase in the Park’s fish biodiversity. Particularly, if the extension zone would include the priority habitats of upland, headwater and hill streams, oligotrophic blackwater habitats, and other perennial fish habitats, a significant increase in the number of species is expected. Upland streams are known to have a distinctive fauna, which is usually very rich in endemics. Similarly, oligotrophic blackwater habitats are known to host a poorer fauna in terms of biomass, but a much richer one in terms of species diversity and endemicity rate, when compared to the usually nutrient-rich “white” (silt-loaded) waters (such as the Kapuas river) (Kottelat, 1993).

Subsequent buffer zone, hill stream and black-water habitat surveys suggest Kottelat’s (1993) predictions to hold true at DSNP (see Kottelat, 1995; Martin-Smith, 1996; Ng and Kottelat, 1996; Widjanarti, 1996). These surveys show that habitats of nine of the 14 newly discovered fish species at DSNP, and nine of the 13 new fish species collection sites, are in black-water (tall peat swamp) or upland/headwater stream sites. This suggests that a large percentage of DSNP’s population of the rare, endemic and new species (see Table 1 in Jeanes and Meijaard, 2000) do not inhabit the central lakes basin, but inhabit the peat swamps and near-catchment surrounds. This includes the Arowana (*Scleropages formosus*), a key conservation species, which now appears to be largely restricted to remote swamp forest areas due to high fishing pressure elsewhere in the lake basin.

### Reptiles

As with fish species, data concerning the ecology, population numbers and distribution of reptile species within the DSNP basin is incomplete. However, the work of Frazier (1994, 2000) and Ross *et al.* (1996) does give some quantitative (transects) and general data on crocodile species distribution, population levels, and crocodile ecology within and around DSNP. Furthermore, the work of Walter (1996, 2000) and Sumarni and Soraya (1996) does provide some basic data on habitat, ecological requirements and distribution of fresh water turtle and tortoise species, while Walter (1996, 2000) also provides indirect quantitative data on population levels (i.e., trade volumes).

Concerning the crocodylians, both Frazier (1994, 2000) and Ross *et al.* (1996) note extremely low crocodile densities in the rivers (middle and lower courses) and lakes of the DSNP central lake basin. High human population density, high incidence of boat traffic, intensive fishing activity, use of poison, effective but destructive fishing gear (i.e. drowning crocodiles), hunting pressure and fires destroying nesting habitat, are all quoted as reasons why crocodiles were absent or scarce in these areas. The situation with crocodile species (both *Crocodylus porosus* and *Tomistoma schlegelii*) appears much the same as with the rarer and more threatened fish species (e.g. *Scleropages formosus*). Particularly in dry season, during low water and peak fishing activity, the remaining

crocodiles escape to refuges in head water areas, and in holes (*kerinan*) in the forest and lake beds, larger pools (*lubuk*) in up-river locations and remote permanent lakes.

The crocodile distribution map, derived from local interview and field observations (Mr. A. Erman, I-UKTFMP, 1996, personal communication; also see Jeanes, 1997), clearly shows a pattern of crocodiles concentrating in the Tall Peat Swamp edges, permanent lake areas (Habitat H, Table 1) and more inaccessible and remote forest areas (Habitat I, Table 1). The same distribution also applies to the elusive “buaya kodok” (*Crocodylus raninus*) said by local informants to formerly only inhabit headwaters of remote forest streams.

As to other reptiles, little information is currently available about their distribution. CITES listed monitor lizards (*Varanus salvator* and *V. bornensis*) and the reticulated python (*Python reticulatus*) are known to exist in DSNP. Yet, it is not known if they prefer the central lakes basin or the peripheral swamp forests for habitat. For turtles and tortoises, Walter (1996, 2000) verified that out of the eight tortoise and three soft-shelled turtle species within and around DSNP, eight species appear to rely on relatively undisturbed Tall and Stunted Swamp Forest and forest streams as habitat. They do so as they require to lay eggs next to streams or lakes in undisturbed areas. Sumarni and Soraya (1996) added that the soft-shelled turtle species, in particular, appear to rely on refuge areas of permanent water to survive (e.g. permanent lakes, and streams at hill bases).

### Birds

A general idea about the ecology, population and distribution of DSNP’s bird species can be obtained from general data of other sites. Yet, little is known about either bird population numbers or frequencies of occurrence in DSNP, or of species distributions and habitat preferences. Hood (1993), van Balen (1993), van Balen and Jensen (1994) and van Balen and Dennis (2000) provided most data, in defining the distribution of bird species and total species numbers between habitat types. Noveriawan (1993), also added data on species differences between Dwarf Swamp, Stunted Swamp and Burnt Regrowth vegetation types. Table 2 summarizes the findings of various authors with respect to distribution of bird species numbers between the main habitats of DSNP and surrounds.

**Table 2: Bird Species Numbers per Habitat.**

Observers	Burnt Area Regrowth	Dwarf Swamp	Stunted Swamp	Riparian Swamp	Tall (Peat) Swamp	Hill Forest
Hood	6	15	27	53	23	47
van Balen	30	17-43	← 53 →		50-62	85-100
Noveriawan		40	40			
Wadley		← 58 →				75
Estimate of Potential	30	40-45	45-50	50-60	60-70	>100

Observers: Hood (1993)—Hood; van Balen and Jensen (1994)—van Balen; Noveriawan (1993)—Noveriawan; Wadley *et al.* (1996)—Wadley.

As can be seen, the main habitats of the central lakes basin are “low bird diversity” areas. Noveriawan (1993) recorded only 58 bird species in these habitats during intensive dry season survey. Burnt area regrowth vegetation is the poorest bird habitat with

potential 30 species estimated, followed by Dwarf Swamp Forest and Stunted Swamp Forest (both 45 to 50 species). Peak flood season bird species counts are even lower as recorded by Hood (1993) (Table 2). Riparian Forests (with 50 to 60 species), and surrounding Tall (Peat) Swamp Forests (with 60 to 70 species), are relatively richer “medium value” habitats, due to their taller structure and higher plant species diversity. The remaining pockets of intact Upland and Hill Forest are by far the richest “high value” bird biodiversity habitat. More than 100 species have been found here, with at least 40 bird species exclusively restricted to this habitat (van Balen and Jensen, 1994; van Balen and Dennis, 2000).

Of the “key conservation” species (Table 3 in Jeanes and Meijaard, 2000), field observations suggest that very few of DSNP’s threatened and endemic bird species inhabit the low, deeply flooded, Fresh Water Swamp Forest habitats of the central lake basin (i.e. Dwarf, Stunted or Riparian Swamp Forests). Only seven of the 33 threatened species listed (Wallace’s Hawk Eagle, Jerdon’s Baza, Black Hornbill, Red-Crowned Barbet, White-Bellied Woodpecker, Straw-Headed Bulbul and White Chested Babbler), or 21% of the total, would appear to overlap in habitat range into the central lakes basin habitats. The same is true with endemic species where only four out of 13 listed species appear to use central lake basin habitats. White-headed Spider Hunter and Dusky Munia range into the central lake basin habitats, yet use Tall Swamp Forest and Hill Forests as well. The Yellow-rumped Flowerpecker and Bornean Blue Flycatcher are recorded only from dwarf swamp and riparian swamp forest respectively.

This leaves the bulk of DSNP’s threatened and endemic species to be largely found in the tall (peat) swamp forest and hill forests, outside the main central lakes area. Threatened hornbills, threatened and endemic pheasants, and the endemic Whitehead’s Trogon and Golden-naped Barbet, all tend to be restricted to hill forests. Tall Swamp Forest habitats (and water bodies) support, in turn, at least six endemic species (Bornean Bristlehead in tall swamp forest only, and five other species shared with hill forest), and 20 threatened species.

Figure 1 outlines the habitat trends for threatened water birds, showing the distribution (i.e. key habitats) of the globally endangered Storm’s Stork (*Ciconia stormii*) (Dennis *et al.* 1996; A. Erman, pers.comm.). The species appears to prefer isolated areas of Tall Swamp Forest or Riparian Forest (i.e. tall tree habitats) next to permanent dry season water bodies (rivers and lakes). In these areas it has been seen to nest between April-July. Other water birds, such as egret species, Great-billed Heron (*Ardea sumatrana*), Purple Herons (*Ardea purpurea*) and Lesser Adjutant Stork (*Leptoptilos javanicus*), as shown in Figure 1, also have a restricted local distribution ranges. Generally their local breeding areas are only known from a few isolated swamp and lake locations south of the lakes basin; where thick reed beds and other protective vegetation grow close to the lake edges.

**Table 3: Mammal Species Numbers per Habitat.**

Observers	Burnt Area Regrowth	Dwarf Swamp	Stunted Swamp	Riparian Swamp	Tall (Peat) Swamp	Hill Forest
Hood	0	0	4	6	5	36
Harmaya					28	
Erman/ Sudrajat					34	30
Wadley						41
Estimate of Potential	0 (?)	< 5	5	10-15	30-40	>50

**Observers:** Hood (1993)—**Hood**; Pierce-Colfer *et al.* (1993), Wadley *et al.* (1994; 1995; 1996)—**Wadley**; Harmaya (1996)—**Harmaya**; Erman and Sudrajat (1997)—**Erman/Sudrajat**.

### **Mammals**

Via studies from elsewhere it has been possible to obtain a general idea of the ecology of most of DSNP's mammal species, yet very little is known of population numbers or frequencies of occurrence of all but a few species. Population data at DSNP is only available for Orangutan (*Pongo pymaeus*) (Meijaard and Dennis 1995; Meijaard *et al.*, 1996; Russon *et al.* 1996, 2000) and Proboscis Monkey (*Nasalis larvatus*) (Meijaard and Nijman, 1999: 15-24; Sebastian, 1993; Sebastian, 1994, 2000). The surveys by Russon *et al.* (1996) have yielded adjusted population estimates of 600-700 Orangutans from within the Park boundaries and 1600-1700 from within the Park plus buffer zone. This was, however, considered too high by Rijksen and Meijaard (1999). Based on detailed surveys, Sebastian (1993, 1994, 2000) estimated a population of 630 Proboscis monkeys for the initial 80,000 ha Wildlife Reserve and its buffer surrounds.

As to data on the distribution of mammal species in general, the work of Hood (1993), Harmaya (1996) and Erman and Sudrajat (1997) provides useful input. Furthermore, specific surveys by Sebastian (1993, 1994, 2000), supported by feeding and behavioral studies of Woods (1995) and Fadillah (1995), have provided good data on the ecology and distribution of Proboscis Monkeys. Observations and village interview data by Erman (1997) further supported knowledge on the distribution of Proboscis Monkey, Orangutan and Gibbons within and around DSNP.

A summary of the field survey findings of the above authors with respect to distribution of mammal species biodiversity within DSNP and surrounds is provided in Table 3. As can be seen the main habitats of the central lakes basin (Habitat E; Table 1) are again "low diversity" areas, with flood season surveys of Hood (1993) showing very low species numbers. Burnt area regrowth is the area poorest in mammal species (possibly zero species potential), followed by dwarf swamp forest (<five species) and stunted swamp forest (around five species). The taller, plant species rich, riparian forests (Habitat F; Table 1) only show a marginally higher diversity (10 to 15 species potential). Yet, it is not until reaching the surrounding tall (peat) swamp forests (Habitat D, Table 1), that mammal species biodiversity begins to sharply increase (30 to 40 species). Reaching maximum diversity in the tall, plant species rich, non-flooding, hill forest habitats (Habitat C, Table 1) (>50 species potentially).

The pattern of distribution of threatened and endemic mammal species resembles that of birds (see above). Namely, very few "key conservation species" are found in the central lakes basin dwarf, stunted and riparian forest habitats. Of the 16 threatened species, only five, the Proboscis Monkey, Otter Civet, and probably two Otter species (the Hairy-nosed and Oriental Small-clawed) may be found in the central lakes basin area in the flood season. Of the 29 endemic species, only three, the Proboscis monkey, Ruddy Tree-shrew and Brooke's Squirrel utilize the Dwarf, Stunted and Riparian Swamp Forests of the central lakes basin, while two other species, the Black Shrew and Large Pencil-tailed Tree-mouse, are found in Riparian Swamp Forests. The remaining threatened and endemic species are restricted to the Tall (Peat) Swamp Forest and Hill Forest habitats. Annex 4 (in Jeanes and Meijaard, 2000) shows that 11 IUCN threat-listed species and 22

endemics use the Hill Forest habitat, and 14 IUCN threat-listed species and 16 endemics use the Tall (Peat) Swamp Forest habitat.

Only four DSNP mammal species, the Proboscis Monkey, the Orangutan and the Gibbon species (*Hylobates muelleri* and *H. agilis*) have received any habitat mapping and population distribution effort. The general distribution of DSNP's threatened and endemic Proboscis Monkey, is described in Sebastian (1993, 1994, 2000). This indicates that the species is restricted to the central lakes basin and river-edge habitats. Observations of Sebastian (1993, 1994, 2000), Woods (1995) and Fadillah (1995) suggest the species to have a dry- and flood-season reliance on tall canopy forests (i.e. 10m above water level), along river and lake edges. Sebastian (1994) further noted that key dry season Proboscis Monkey habitats are the lake basin Riparian Forests and remaining tall Stunted Swamp Forest sites. Yet in peak flood season, due to flood heights and food availability, the Proboscis Monkeys needs to move into the peripheral Tall Swamp Forest areas out of the central lakes basin, or to key tall Stunted (*Shorea belangeran*) Swamp Forests sites along the Belitung and Tawang rivers. Sebastian (1994) identified five key habitat sites. His species conservation proposal included a "strict sanctuary" (Site A), and four "core conservation zones" (Sites 1, 2, 3-4-C and 5-D), as the focus areas for Proboscis Monkey populations and habitat conservation effort.

Finally, for more detailed information on Orangutan population distribution in DSNP refer to Russon *et al.* (2000), while, with regards to Gibbons, surveys by A. Erman (pers.comm.) suggest that areas with undisturbed Hill Forest habitat adjacent to isolated and undisturbed Tall Peat Swamp Forests are the key (if not only) habitat for this species.

### Discussion

A discussion of the relative importance of vegetation types in DSNP needs to take the considerable seasonality into account, i.e. a flood season (9 to 10 months/year; with up to 12m water level fluctuation) and a dry season. Results suggest that the peat swamp and hill forests, largely in the Park's buffer zone, represent the key habitats for terrestrial biodiversity during the flood season period. Numbers of bird and mammal species, and incidence of globally threatened and endemic species, are all much higher in these habitats than within the stunted swamp forests of the central lakes basin. The same can also be said for the majority of the threatened and endemic aquatic fauna. The majority of endemic fish species and globally threatened crocodile, tortoise, freshwater turtle, waterbird and fish species, are now found only within the more remote peat swamp forest and hill stream habitats, rather than in the populated and heavily fished central lake basin. The central lake basin, and the majority of the existing DSNP, is thus left only as prime habitat for those specialized terrestrial species which rely on it as critical year-round habitat (i.e. possibly only the Proboscis Monkey - *Nasalis larvatus*) and for the majority of freshwater fish species.

Significant evidence exists to suggest that during the dry season (two to three months/year), the majority of terrestrial wildlife (birds, mammals and reptiles) remain largely confined to the hills and peat swamp forests due to the high incidence of human activity (peak fishing season) in the lake basin area. A possible exception to this may be nocturnal forays by larger mammals in search of drinking water, and monitor lizards, whose tracks are commonly seen. Furthermore, some cat and otter species may be attracted to the relative abundance of fish in the drying out lakes basin. The same is true of aquatic species, with endemic and threatened fish, reptile and waterbird species retreating further into the isolated peat swamp forests in search of refuge and permanent

water. Also, the remaining fish fauna of the lake basin follows this migration, or moves further up into the catchment or to the Kapuas river, to escape the drying out of the lake basin. Again, the dry season lake basin habitats remain only crucial for those terrestrial species ecologically restricted to the area (i.e. Proboscis Monkey).

In terms of Park management it is important to know the value of various vegetation types in and around the protected site. Table 4 sums up the various management options that have been available for DSNP, in terms of boundary revisions and protected area extensions, and the effects that this has had or could have for the viability of DSNP's wildlife.

**Table 4. Relative importance of past, existing, and proposed boundaries for the Danau Sentarum conservation area.**

Species \ Boundary Options <sup>1</sup>	Original Wildlife Reserve boundary (80,000 ha)	DSNP (132,000 ha) <sup>2</sup>	DSNP-extension (197,000) <sup>3</sup>	Linking DSNP with Bentuang Karimun NP <sup>4</sup>
Lakes and river fish	good, year-round habitat	most likely extension of breeding areas	added protection of migration routes to Kapuas	probably few added benefits
Fish of hill streams	probably no habitat available	small inclusion of hill stream habitat	small inclusion of hill stream habitat	considerable inclusion of hill stream habitat
Fish of peat swamp rivers	little habitat available	some peat swamp habitat available	considerable amount of peat swamp habitat available	large extension of the contiguous protected area of both peat and freshwater swamp
Crocodiles	little dry season habitat available	some dry season and refuge habitat	considerable amount of dry season and refuge habitat available	probably no added benefits
Water birds	good, year-round habitat	Extension of breeding and feeding areas	considerable extension of breeding and refuge sites for Storms Stork	probably few added benefits
Hill forest birds	very little habitat available	some small areas available	some small areas available	a very significant increase in available year-round habitat
Swamp forest birds	some habitat available	small increase in available habitat	considerable increase in available habitat	very large increase of the peat and freshwater swamp habitat
Mammals	very little habitat available	small increase in available	considerable increase in available habitat	very large increase of the



		habitat		peat and freshwater swamp habitats, and migration opportunities to hill forests
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<sup>1</sup>For a discussion on these boundaries and their locations see Russon *et al.* (2000).

<sup>2</sup>Proposal forwarded by PHPA (1996a) to Ministry of Forestry for formalisation of Danau Sentarum Wildlife Reserve boundary as based on the earlier boundary extension recommendations of Giesen, et al. (1994).

<sup>3</sup>As derived from buffer zone and boundary extension proposal of Jeanes (1996).

<sup>4</sup>Unpublished 1997 proposal (Jeanes and Meijaard) suggesting reserve extension or the establishment of a corridor that would link the Danau Sentarum lowlands with the upland forests of the Bentuang Karimun National Park, to allow a considerable increase in seasonal migration possibilities within the area.

Thus in summing-up the wildlife data in hand, and those still needed, significant data already exists for DSNP with which to start generalized wildlife and habitat conservation programs. Yet, significant data gaps remain with respect to individual species conservation. For example, very limited knowledge exists concerning the seasonal movement, and related feeding and breeding ecology, of the vast majority of terrestrial and aquatic wildlife species of DSNP. An exception to this is the reasonable study detail on the seasonal habitat requirements and migratory patterns of the Proboscis Monkey<sup>1</sup> and to a lesser extent for the Crocodile species (Frazier, 1994, 2000), Storm's Stork (*Ciconia stormii*) and Lesser Adjutant Stork (*Leptoptilos javanicus*). No useful knowledge at all exists concerning invertebrates, amphibians, snakes and lizards. There is some basic knowledge of the freshwater turtles and tortoises. Yet, habitat and breeding requirements are still not clear. Dry season bird surveys need to be carried out to confirm the importance of lakeside habitats for migratory birds, while more detailed population ecology and habitat surveys are needed for the site's seven threatened and/or endemic pheasant species. Add to this the lack of knowledge of population distributions, population numbers and ranging needs for virtually all of the site's threatened mammal species (e.g. cats, otters, otter-civet and Malayan sun bear) and endemic mammal species, the need for more detailed research is clear.

Thus in conclusion the DSNP site's importance for wildlife biodiversity conservation is clear, enough data exists to determine where the bulk of species exist for most of the time, and hence form the basis for a "blanket approach" to habitat and species conservation (i.e. exercising the assumption that habitat conservation measures will by default also conserve the fauna species shown to use these habitats). Yet much remains to be done concerning clarification of the ecological details of individual species, which would provide a firmer basis for the individual species conservation efforts. Such efforts becoming increasingly needed in DSNP and near-catchment sites to ensure that a significant proportion of the sites endemic and threatened species do not become locally extinct in near future due to habitat destruction and excessive local harvesting and trading pressures.

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<sup>1</sup>Studies of Sebastian (1993 and 1994), Woods (1995) and Fadillah (1995).

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In 1996 the Danau Sentarum Wildlife Reserve was visited for the purpose of reconfirming the traditional honey and wax collection practices of *Apis dorsata* colonies by the local population. This so-called *tikung* practice was found mainly performed by the Malay population. In the low submerged lake forests, hardwood planks (*tikung*) are attached in trees 1.5-4 m above the water level in the wet season. Some 20 to 25% of these planks become occupied. Combs are collected during dark moon nights in the honey season once a year. Families may own up to 500 *tikung* or more, but the average is around 80. Hundreds of families throughout the DSWR engage in *tikung* honey harvesting. A set of traditional regulations is respected by various groups of *tikung* owners.

Among the Dayak population, honey collection from *lalau* trees is more common: 30-40 m high bee trees that can host more than 100 *A. dorsata* colonies, for which honey collection and tree ownership follows practices as described elsewhere in SE Asia. Collection from *repak* trees, i.e. trees usually having one or a few colonies, which are not owned, is intermediate and of lesser importance.

Honey and beeswax collection activities and improvements were part of the Danau Sentarum Wildlife Reserve conservation project's conservation products enterprise and are briefly described.

### Introduction

Traditionally in Asia nests of *Apis dorsata* or the “Giant Asian Honeybee” have been exploited to produce the bulk of honey and wax, which have been traded for ages. In most cases *Apis dorsata* nests are hunted, the bees chased away with smoke, and the comb completely cut away for collection. Famous are traditional honeyhunters who in many areas climb steep cliffs or ascend tall “bee trees” by hand-made ladders, using local tools.

In 1989 the existence of managed honey and wax collection from this bee was confirmed to be a still common practice among beekeepers in U Minh, Southern Vietnam (Crane 1994). References and early notes confirm that the system, referred to as rafter beekeeping, has existed for more than a hundred years.

An old Dutch reference from 1851 on an expedition in Kalimantan reported the existence of a similar management system for honeybees, locally called *tikung* beekeeping, which was later described in more detail by de Mol (Lijnden 1851) and (de Mol 1933). As in U Minh, the bee management system described for Kalimantan occurred in an area of submerged forest, with a lack of tall trees (or rock faces) to which bees can hang their nests.

(Giesen 1987) reported that this management practice in the DSWR area had declined, probably due to low prices for honey.

This report is the result of a study visit to the upper Kapuas Lake region in January 1996, which surprisingly revealed the *tikung* system to still be popularly practised by a relative large group of the local population. Much use was made of recent studies made by project staff of the ODA sponsored Danau Sentarum Wildlife Reserve Conservation project active since 1992 in the DSWR.<sup>1</sup> Among several studies, some described the local honey and wax business (Colfer, Erman and Zulkamain 1993; Rouquette 1995), on which a Community Based Income Generating Programme was designed of which honey and beeswax were an important component (Wickham 1995).

This account makes use of the various data collected during the project, especially the studies by Rouquette and Colfer's team.

### Danau Sentarum Lake Region: Population and Vegetation

The majority of the DSWR population are Malays, whose main activity is fishing. They live in boathouses or permanent houses in villages built on stilts. Besides Malays, around 10% of the population consists of Dayak groups, mainly Iban, who live at somewhat higher sites, mostly with several families living together in longhouses. Their activities, besides fishing, include collecting and selling forest products, hunting, and some agriculture.

Since the 1700s, the Muslim Malay population started moving into the area as traders or settlers from downstream. Establishing small kingdoms, the local Dayak groups were driven into more forested areas. Due to famines between 1830 and 1880, Iban Dayaks from Sarawak came into the area (Jensen 1994).

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<sup>1</sup>This is one project under the Indonesia-UK Tropical Forest Management Programme. The DSWR Conservation Project was implemented by Wetlands International-Indonesia Programme.



There is a seasonal migration of various floating fishing communities in and out of the lake area. In the dry season, with low water, fishing is most profitable, whereas during most of the year when the water is high, catches are smaller.

Commodity trading is done mainly by Chinese boatmen who move up and down the Kapuas River. Barter trade, buying and selling is their frequent activity. Most of the produce from the region is exported out of the lakes through these Chinese traders as well. Men from the area (mainly Iban) travel to Sarawak where they work as laborers.

With 3,600-mm rainfall per year the lakes are almost continuously filled with fresh water flowing into the Kapuas. Only during a short period from July to September does the water retreat causing some lakes to completely dry out. Water levels may rise and fall some 8 to 14 meters during average years. However, some years, like 1995 and 1996, no dry season occurred keeping water levels high.

This seasonality has great consequences for the vegetation. As a result most of the forests in the area are stunted forests, submerged for most of the year. In the dry season there is a great danger of forest fires, as relatively dense canopies dry out, and dried fallen leaves and wood act as a fuel layer on the soil. In the hillsides surrounding the reserve, forests continue to be cleared for shifting cultivation.

The end of the dry season is followed by a rise in water level, which leads to bud induction and a massive blooming from December to February. This period of flower abundance is vital to the honeybee colonies. Due to the absence of a dry season in 1995 there was almost no honey harvest in early 1996. Beekeepers recalled the same phenomenon happening in 1969 and 1970. De Mol reported that 1931 was such a "wet" year (de Mol 1933).

The flooded forest vegetation consists of a dense system of thin branches and twigs, its canopy rises 6m (during the high water season) to 12 m (low water season) above the water level.

Unlike the submerged forests of U Minh in Vietnam where *Melaleuca leucadendron* is the single dominant species, the Danau Sentarum flooded forest contains a variety of tree species. According to the honey collectors around 20 species are important for honey production. However, *tembesu* (*Fagrea fragrans*) is most important as it is used for making the *tikung* or honey planks. At present beekeepers recognise the following important nectar (i.e. honey) source trees:

*Masung* (*Syzygium claviflora*), *tahun* (*Carallia bracteata*), *tengelam* (*Syzygium sp.*), *putat* (*Barringtonia acutangula*), *kawi* (*Shorea balangeran*), *pecaras* or *bakras* (*Homalium caryophyllum*), *samak* (*Syzygium sp.*) *ubah* (*Syzygium ducifolium*) and *lebang* (*Vitex pinnata*). The most popular are honeys from *masung* and *tahun*, which confirms the findings of de Mol (1933).

Superior honey is said to be produced from nectar of the *ransa* palm (*Eugeissona ambigua*) but this plant is very rare nowadays. The palm was heavily exploited in times of famine for its starch content.

Honey from *putat*, *kawi*, and *timba tawang* (*Crudia teysmannia*) are known for their bitter taste and, therefore, are less favored.

*Tembesu* wood and rattan (e.g. *Calamus schizoarranthus*) are among the most exploited products in the reserve. *Tembesu* hardwood from the wetland is preferred over dryland *tembesu* (Giesen 1987).

However, timber and rattan exploitation account for only 7% of the total overall income of the total population (6 and 1 percent respectively). By far the largest portion of

income for the Malay is generated via fish resources: 89% (lake and river fish: 50%; caged fish: 30% and ornamental fish 9%). Honey production, though variable from year to year, contributes roughly 1% (Wickham 1995).

### Honey Hunting Practice<sup>2</sup>

Although the *tikung* system is the most typical honey production method practised in the reserve, honey hunting from tall bee trees—a practice common to Asia and most probably much older than *tikung*—is also popular in this region.

This technique is locally called *Lalau* in Malay, or *Tapang* which is Iban for bee tree.<sup>3</sup> On elevated land and riverbanks adjacent to the lake area these tall trees often stand alone, due to clearing for agriculture on the levees. This marks the fact that these *lalau* or *tapang* are respected trees due to ownership, religious beliefs, or simply economic value. Between 10-50 and often up to 200 bees nests of *Apis dorsata* can be seen hanging from the thicker branches at 15-30 m high from the trunk forming a wide canopy. Although the bee colonies seasonally migrate to settle on the *lalau* tree, some trees have nests all year round. Others may only show abandoned combs during part of the year. Swarms (*kaban*) settle from December to February and are said to come from the hills or stone mountains that can be seen at a distance surrounding the lakes. A second arrival of bees is said to occur each year from July until October. Honey is harvested on moonless nights in February. Starting in January some colonies from these *lalau* trees are said to move to the *tikung* area—the dwarf or stunted forests in the lakes.

Although local customary laws (*hukum adat*) protect *lalau* trees, the number of these prominent trees is said to be decreasing due to the incidence of lightning and thunderstorm.<sup>4</sup> Also the cutting of bee trees is reported.<sup>5</sup> Due to clearance of the forest on the riverbanks no trees are available to the bees, as no new *lalau* have been planted. In primary forest sites young *lalau* trees are recognised by the people and protected.

Ownership of a *lalau* tree is maintained for life and can be inherited. Local customary laws define ownership, which has to be recognised by the local leadership. If accepted, the whole community is informed; no marks are made on the tree. Determining the right time of harvest is important, and once it is decided, the village head communicates this to all *lalau* owners and families that have the right to share part of the harvest. In the past, in the Kapuas River delta this communication sometimes required overnight travel for the

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<sup>2</sup>In this paper we only deal with *Apis dorsata* (*mwonji*) that produces almost all of the honey in the area. However *Apis florea/andreniformis* (*Mwonji lalat*) is present in the area and is only occasionally hunted. *Apis cerana* (*nyerungan*) is rare for the lake region, but is found in tree cavities in the higher rain forest surrounding the reserve. Also stingless bees (*engke lului*) are known to produce small amounts of honey.

<sup>3</sup>Tree species that bees occupy in this area are predominantly: *rengas*: *Gluta reinghas*; *tempurau*: *Dipterocarpus gracilis*; *ran*: *D. tempehes*; and *menungau*: *Vatica menungau*.

<sup>4</sup>In Meliau 22 *lalau* 6 persons currently own trees. 10 years ago this number of trees was 30, 8 have been felled by storm and/or lightning.

<sup>5</sup>Around 1960 183 *lalau* trees were cut by their Iban owners near Semalah village, for purpose of shifting cultivation. At present only 6 trees remain. Reasons for cutting here also include low honey prices or area disputes. Such latter conflicts, mainly between Iban and Malay groups date back more than a hundred years, when little kingdoms tried to increase their territories (see Colfer et al, 1993).

messenger who carried a piece of knotted rattan, indicating the number of days remaining until the night of harvest (Dunselman 1959).

Harvest is done at or around the new moon. In most cases a group of local shamans—specialised bee hunters—gather for this activity. A few days before the harvest they start making a ladder (*tatok* or *tatole*) along the trunk of the bee tree up to the branches. Wooden pegs 30 cm long (*pakau* or *jantak*) made of bamboo are hammered (by a *palu*, *pemalu* or *tukul*) into the tree trunk at a distance of 1.5-2 m. A long pole (*sengayan*) is attached to the end of each peg by rattan. When the ladder is finished, the harvest can commence. Usually around 7 pm, one or two honeyhunters ascend the ladder with a smouldering torch (*tebauk* or *sempon*) made of dried roots of *jabai* (*Ficus microcarpa*), a wooden knife (*beladai*) and a basket (*rintong* or *terenong*) attached to the hunter's waist by a long piece of rope.

The hunters sing songs at various stages of the harvest. There appears to be a basic text formula, which is sung in 5 stages: (1) finishing the ladder; (2) clearing the bees from the nest; (3) cutting the comb; (4) hoisting the basket; and (5) descending the ladder. The songs pass from fathers to sons and are sung to the spirits of the trees to make them friendly.

The songs are humorous and tease the crowd below, who respond with a whooping yell. Often honey is mentioned in reference to a women or young girl's beauty and their sexual attractiveness. Local and regional politics can also receive mention in the spontaneous lyrics of the creative singers/honey hunters (Anonymous 1996, Dunselman 1959, and de Vries 1994).

We recorded one such song by a Malay honey hunter from Semalah<sup>6</sup>:

#### TUNTUNG JANTAK

Tempukung sekuta bangan  
Oh nemiak belahar nyumpit  
Pakau ku tuntung tapang dan  
Udah ku anjak enda bergerak  
Udah ku init enda beretit  
Paya lucak ulu Tempunak  
Ningkam di dalam ulu Sekayam  
O...o...o...

#### NEPAS

Bukan emas sembarang emas  
Emas pelinggang se dari Jawa  
Bukan tepas sembarang tepas  
Serdap di diam si jaga rengas  
O...o...o...

#### THE LADDER IS READY

There are nests of ants in the jungle.  
Children learn to shoot the *sumpit* (blow darts).  
I have already made the *pakau* (ladder steps) on  
the *tapang* tree.  
I climbed, but the ladder didn't move.  
Mud in the upper Tempunak river.  
And in the upper Sekayam river  
O...o...o... (yelling by the crowd)

#### CLEARING AWAY THE BEES

Not just any gold.  
This gold pan is from Java.  
Not just to clear away the bees.  
But to make the spirits of the *rengas* tree  
friendly.  
O...o...o...

<sup>6</sup>Thanks to the singer Mr Abdullah Sani. He sang this song in the presence of many villagers in the house while it was recorded on video.

## MINTA MADU

Tetak kayu si tetak kayu  
 Tetak kayu secapit Ubah  
 Anang nuan scisi' madu  
 Pecit susu dara di rumah  
 O...o...o...

## NGULUR

Ngiang-ngiang akar genali  
 Unjung di rumpu' setabah tabah  
 Jaga nuan ini' Sengiang Tali  
 Kami ngulur lingang bunga lingang kebaca  
 O...o...o...

## PULANG

Perang alu, perang kelelap  
 Perang di lengkong si kayu ara  
 Pulang ayu, pulang semengat  
 Pulang semua kita berdua  
 O...o...o...

## TAKING THE HONEY

Cut the log, cut the log.  
 The logs are cut from the *ubah* tree.  
 Don't have any honey.  
 Else I'll squeeze the girl's breast in the house.  
 O...o...o...

## BRINGING DOWN THE HONEY

Hanging around the roots of the *genali* tree.  
 Don't be afraid to bring it to the grass.  
 Ask Grandmother Sengiang Tali to protect you.  
 We are bringing down some honey from the  
*kebaca* tree's flower.  
 O...o...o...

## GOING HOME

We've fought against the bees.  
 We've fought against the *ara* tree's twisted  
 bumps.  
 Go home spirits.  
 Let's go home all of us.  
 O...o...o...

Once the honey hunter reaches the branch above a comb, a wooden knife is used to cut the comb. With a smouldering torch the bees are brushed away from the comb, after which they disappear as falling sparks.<sup>7</sup> It is believed that an iron knife should not be used in order not to wound the bark of the tree, after which the bees will not return. In some cases the broodcomb (*sarang anak*) is cut separately and thrown below. The honeycomb is then cut and put into the basket that is lowered to the ground. Traditionally a piece of honeycomb is also thrown to the ground in order to please any bad spirits (*pedara*).

Honey collected from a single *lalau* tree may be hundreds of kilograms, depending on the number of nests. Rouquette (1995) witnessed a crop of 140 kg from more than 20 nests on one *lalau* tree. In this case 16 people, owners and hunters alike, shared the honey. Division of harvests seems to vary with every situation. Agreements are most probably made *ad hoc* prior to harvest.

Bee nests in *lalau* trees are said to contain more honey compared with *tikung* nests. However, losses due to spillage are higher with *lalau*. The actual honey crop from a nest of a *lalau* tree is much less than 10 kg. As mentioned above, in the lake region honey harvest from *lalau* trees is of less importance than from *tikung*. In recent years the

<sup>7</sup>A video made by Michael Gries, (Inst. für Bienenkunde Oberursel, Germany) on such bee tree harvesting, was shown during the 3rd Asian Apicultural Association Conference in Hanoi and shows such nocturnal activity in great detail, using infrared camera recording techniques. It can clearly be observed that some bees fall down as sparks, others falling without being affected by the flames, though not able to fly and orient itself.

proportion of *lalau* honey has declined due to the decreasing number of *lalau* trees. Furthermore, *tikung* is more popular as it is an easier and safer way to crop honey.

Apart from honey, beeswax is also collected, mainly refined from the honeycombs. The combs are boiled after which the liquid is filtered. A nest with 6 kg of honey would also render about 0.5 kg of wax. Prices were relatively high in January 1996 due to scarcity: about 2,500 Rp. (about 1.20 US\$) for 1 kg of honey and 3,000 Rp. for 1 kg of wax. Bee brood (mainly larvae and first stage pupae) from a harvested comb is consumed instantaneously by the villagers.

### Repak

Besides *Apis dorsata* nests on *lalau* trees, another type of wild nests is referred to as *repak* or *terepak*: trees in the forests that host single or only a few nests without the assurance of colonies coming back to the same tree in subsequent years.

Such trees can be of any size and are found as tall trees in the rainforest as well as in stunted trees. Instead of the tree, the finder claims ownership of the nest. In order to do so they temporarily mark the tree (*pal*), or place a board (*kecilik*) indicating their ownership of the nest, after which they give notice to the village headman. In regions where much honey is collected from *repak*, (in stunted submerged forests) *tikung* production is also high. In the higher forests some tall *repak* trees may become *lalau* trees (i.e., trees to which bee colonies return to make their nest year after year).<sup>8</sup>

### Tikung

Among the honey hunters that collect honey using the *lalau* and *repak* systems, many (mostly Malays living along the lakes) also collect honey using the *tikung* technique. *Tikung* is the name of a carved hardwood plank (approximately 0.8-2.5 m long by 25-40 cm wide); one side has a convex and the other side a concave shape. It is made of *tembesu* (*Fagraea fragrans*) or sometimes *medang* (*Litsea sp.*). It takes a man more than one day to make a *tikung* plank.

Such planks are attached to tree branches in the stunted submerged forests. The ends of the planks are carved with notches (mainly rectangular, but sometimes V-shaped) to which a wooden peg is inserted, thus attaching it to a branch.

*Tikung* planks are positioned with a slope of about 30° with the upper part oriented towards the open sky. The concave side faces downward, so the upper convex side can facilitate rainwater runoff. Sometimes a pole is horizontally attached about 2 m below the *tikung* to permit the owners to stand on it while attaching and/or harvesting it.

*Tikung* planks can last over 2 generations (40 years), and can still be used after enduring a serious forest fire.

Ownership of a *tikung* is indicated by an owner's mark (*tikap*), usually a series of indentations at the side of the plank, recognised as the family mark. Each new generation adds a new indent (*taka*). This mark system is complicated, but well understood by all *tikung* holders in the same area.

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<sup>8</sup>Typical *repak* tree species are: *engkunik*: *Antidesma stipulare*; *engkupak*: *Baccaurea racemosa*; *Rengas*: *Gluta renghas*; and *tengkuring asam*: *Microcos ceramensis* (Rouquette 1995. Honey Harvesting: Developing Alternative Sources of Income in the Danau Sentarum Wildlife Reserve, West Kalimantan, Indonesia., Pontianak: Danau Sentarum Wildlife Conservation Project: Indonesia-UK Tropical Forest Management Programme).

In one day 5 to 6 *tikung* planks can be positioned in the submerged forest, which is usually 2 meters above the highest water level during rainy season. Trees preferred to hang *tikung* planks are *kamsia* (*Mesua hexapetala*), *masung* (*Syzygium claviflora*) and *empai* (*Crudia teysmannia*).

Bee swarms arrive at *tikung* areas during the same period as the *lalau* (i.e., December to February), which also depends on the timing of the preceding dry season. However, the *tikung* harvest period is always after a *lalau* harvest. Prior to the arrival of the swarms, some minor clearance of the *tikung* undergrowth and a small boat channel to the *tikung* may be made. The last blossoms from the *tahun* (*Carallia bracteata*) indicate that honey is ready for harvest.

Honey collection from *tikung* resembles that from *lalau*. However, no songs are sung, as no spirits are believed to live in *tikung* trees. It is a collective practice. Harvest is done on moonless nights, usually from 7 p.m. till 4-5 am during which more than 20 *tikung* can be harvested.<sup>9</sup> Harvest tools are similar to those for *lalau*. At present a plastic or tin container is used instead of the traditional bark/rattan basket. A wooden knife (never an iron one) is used to cut the comb. *Tikung* honey collectors believe that if the comb is cut with iron, the bees won't return to the site next season. Also there is a fear for wounding each other in the dark when harvesting with a sharp iron knife. No protective clothing is worn.

The nests are approached in small boats (*sampan*). A man reaches up close to the *tikung* to smoke away the bees. All bees either fall into the water and drown or crawl up to branches and leaves, as it is too dark to navigate and fly. In order to ensure floating bees do not crawl into the boat, other men in the boat use paddles (or their hands) to move the water away from the boat. Usually the brood comb (*sarang anak*) is first cut and put on top of the *tikung* plank. Then the honeycomb, usually at the head of the *tikung* is cut and put into a basket.

Bees are not likely to return to the *tikung* the following day and are believed to return to the mountain area. All *tikung* nests in the same vicinity must be harvested the same night to avoid some remaining nests being robbed by other bees.

*Tikung* owners are mainly Malay men, however, during harvest nights women and children may join as well. Traditionally the *tikung* owners within the same area formed groups (*kelompok tikung*), who abide by their own rules and regulations (*hukum adat*) These groups also put their *tikung* in the same area. Both that area and the groups are called *priyau*. In the past each *priyau* belonged to headmen, who gave his subordinates rights to place the *tikung*. The *priyau* area was hereditary and sometimes subdivided to each one of the inheritants. The owner marks on the *tikung* reflect these interdependencies of *tikung* holders in the same *priyau* caused by inheritance.<sup>10</sup>

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<sup>9</sup>In discussions with beekeepers, they said to harvest during the daytime would be very dangerous as bees sting fiercely during this time. However, in the village of Belibis we were told that in recent years a small group of *tikung* holders had started daytime collecting, using large quantities of smoke. They now seemed to favour daytime harvest as it could be done more rapidly, due to better visibility. After a harvest, the bees returned to the *tikung* for some days, after which they would swarm away.

<sup>10</sup>We found such mark lineages among *priyau* members in Belibis. As a rule a new *tikung* owner adds one more indents to the mark from which he inherited ownership.

At present rules applying to *tikung* owners in the same *priyau* include: a minimum number of *tikung* to be put up (e.g. 25 in Leboyan); obligation to put all *tikung* in one *priyau* only; a minimum distance between two *tikung* positions (e.g. 15m in Leboyan); and report the number and positions of *tikung* to the head of the *priyau* ("ketua *priyau*"<sup>11</sup>).

Rouquette's report (1995) gives data on the number of families, *tikung* holders and number of *tikung* per family for selected villages in five main *tikung* areas: 30% of the families owned *tikung*, one family having from 10-500 (in Leboyan the average was 81 per family<sup>12</sup>). The number of *tikung* occupied by bee nests for that season (1994) was around 23%.

Average honey yield per nest was around 6 kg. This figure was similar to individual beekeepers' responses when interviewed.

Based on extrapolation, Rouquette calculated a total production figure for all of the Danau Sentarum Lake area for that year to be between 20 and 25 tons. As such 1994 was believed a normal year. This is contrary to 1996, in which due to the absence of a dry (low water) season in 1995 almost no honey from *tikung* was collected. Based on her figures between 150 and 250 families engage in *tikung* honey collection, which roughly translates to 25% of the population. De Mol (1932) estimated 500 families engaged in *tikung*, i.e., approximately 50% of the lake's population during the time of research.

#### **Honey and Beeswax Related Activities of the DSWR Conservation Project**

In late 1994, the DSWR Conservation Project began a series of community-based income generating activities to act as "entry-points" to gain local interest in participating in other management and conservation initiatives of the project.

The rationale behind this work was that by facilitating alternative or improved community incomes for products made/harvested on a sustainable basis, the project would establish a greater incentive for communities to actively conserve and improve the management of the Reserve's resources. Through skills training, assistance in product development and design and improved marketing for previously unused or under-utilised natural resources, the DSWR Project helped increase the value of these resources and products for the benefit of both the natural resources and communities of DSWR.

This work initially began with a plan to bottle locally collected DSWR honey and market it directly to consumers in Pontianak. As honey was generally sold through a variety of traders before reaching the market, honey harvesters received a meagre portion of its end-sale value. By selling direct to Pontianak, the project hoped to significantly increase the value of the honey for the producers.<sup>13</sup> Based on the same principles, the project also embarked upon similar activities involving the design, production, and marketing of beeswax candles.<sup>14</sup>

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<sup>11</sup>De Mol (1933) uses the name *Kepala tikung*, who would only be in charge seasonally, as the fishing communities during part of the year moved elsewhere.

<sup>12</sup>By contrast, in 1932 De Mol found an average of 90 *tikung* per family in Leboyan.

<sup>13</sup>The initial stages of this work are reported in Rouquette. (1995. Honey Harvesting: Developing Alternative Sources of Income in the Danau Sentarum Wildlife Reserve, West Kalimantan, Indonesia. Pontianak: Danau Sentarum Wildlife Conservation Project: Indonesia-UK Tropical Forest Management Programme).

<sup>14</sup>A more thorough description of these and similar products produced by the residents of DSWR and the development of a DSWR Conservation Products Enterprise are

Largely owing to the remote location and conservation status of the Reserve, the honey collected in the DSWR is organic and free of additives. This combined with the honey's unique natural flavors and characteristics, traditional harvesting techniques and its association as a non-timber forest product supporting local community development make this product highly marketable. In fact in the 18-month period from March 1995 to October 1996, the DSWR Project marketed over 2,000 kg in Pontianak, Jakarta, Riau, and Singapore. Demonstrating the broad marketability of this product—an additional 1,000-kg was also shipped to the UK in 1997.

Largely due to the similarity between the *tikung* collection system practised by the honeyhunters in the flooded forests of DSWR and the rafter honeyboard system in southern Vietnam, the DSWR project was approached by Vincent Mulder (a representative of CIDSE—a Dutch development NGO and NECTAR—the Netherlands Centre for Tropical Apicultural Resources) to facilitate an exchange between DSWR honey collectors and their counterparts who collect honey in the seasonally flooded melaleuca forests of the U Minh Forest in the Minh Hai Province of southern Vietnam.

The first part of the exchange took place in January 1996 with Mulder and Koon de'Barber attending.<sup>15</sup> The visit identified numerous similarities between the two traditional systems, but also highlighted techniques that could improve bee and colony management, honey harvesting, and wax processing in DSWR. Addressing some of these issues would help ensure the long-term sustainability of the bee colonies, increase the quantity and quality of the yields, and thereby advance the goals of conservation by improving the financial viability of the honey and beeswax enterprises.

These and other issues were discussed with honey harvesters from eight villages during the Mulder/de'Barber visit.<sup>16</sup> However, because honey collection techniques have been practised in the same way for generations, most individuals remained sceptical

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described in Wickham, Trevor. 1997b. Two Years of Community-Based Participation in Wetland Conservation—A Review of the Activities and Challenges of the Danau Sentarum Wildlife Reserve Conservation Project, West Kalimantan, Indonesia. Pontianak, West Kalimantan, Indonesia: Danau Sentarum Wildlife Reserve Conservation Project, Project 5: Conservation, Indonesia-UK Tropical Forest Management Programme. and Wickham, Trevor. 1997a. Continuing the Development of the Danau Sentarum Conservation Products Trading Enterprise (1997-2000). Danau Sentarum Wildlife Reserve, West Kalimantan, Indonesia: Danau Sentarum Wildlife Reserve Conservation Project, Project 5: Conservation, Indonesia-UK Tropical Forest Management Programme. A review of the continuation of these initiatives by Yayasan Dian Tama following the end of the Indonesia-UK sponsored DSWR Conservation Project activities in 1997 is contained in Heri, Valentinus, Ade Juhur, and Tri Renya Altaria. 2000. "Laporan Akhir Proyek-Kegiatan Pembinaan Hasil-Hasil Hutan Bukan Kayu di Taman Nasional Danau Sentarum Juli 1997-Juni 2000. Pontianak: Yayasan Dian Tama..

<sup>15</sup>Unfortunately, due to visa difficulties, the Vietnamese honey harvesters from U Minh could not attend.

<sup>16</sup>The results of this study tour are contained in Mulder, Vincent. 1996a. Summary of the Results of the Study Visit to the Upper Kapuas Lake Region, West Kalimantan on *Tikung* Beekeeping (9-19 January, 1996) and Mulder, Vincent. 1996b. Traditional Honey and Wax Collection with *Apis dorsata* in the Upper Kapuas Lake Region, West Kalimantan. in *3rd Asian Apiculture Association Conference*. Hanoi, Vietnam.



about the advantages of Mulder and de'Barber's advice. To overcome this, it was suggested that a field visit to the U Minh Forest, where honey collectors from DSWR could see concrete examples of the recommended changes in management and harvesting practices for themselves, would be an excellent way to promote improvement to the *tikung* system in DSWR.

#### **DSWR Honey Collectors' Study Tour to Vietnam**

Three individuals from DSWR attended the study tour—this included two honey collectors from DSWR and one Project staff member experienced in bees. A representative of the Indonesian Ministry of Forests also joined. The group was lead by the Natural Resources Advisor of the DSWR Conservation Project.

During the Vietnamese Study Tour, the DSWR delegates attended a 2-day seminar and field trip where they exchanged their experiences in honeyboard placement, honeycomb management, harvesting, quality control production, and marketing of honey and beeswax with their Vietnamese counterparts.

The delegates also attended the 3<sup>rd</sup> Annual Apicultural Association Conference in Hanoi where they learned about the beekeeping systems of other Asia and Pacific Rim countries.

#### **Lessons Learned to Improve the Traditional *Tikung* Honey Collections System of DSWR**

In general, the DSWR participants gained a greater understanding about the value of bees and bee products and the various types of beekeeping and management systems throughout Asia. More importantly, they became more aware of the significant interest in, and importance of, their honey harvesting system. In particular, they were exposed to many ideas, techniques, and concepts which have the potential to produce larger quantities of improved quality honey and beeswax and so generate additional income for their communities, while also supporting principles of sustainable development.

Below are some of the techniques that the DSWR project field staff initiated with the honey harvesters of Danau Sentarum. Following the completion of the DSWR Conservation Project, these initiatives continued to be implemented by the Yayasan Dian Tama field staff.<sup>17</sup>

**Table 1 Techniques for Improved *Tikung* Beekeeping and Honey/Beeswax Yields**

<b>Current Practice in DSWR (<i>tikung</i>)</b>	<b>Problems with Practice</b>	<b>Suggested Improvement</b>	<b>Advantage</b>
1. Honey combs are collected at night when bees are most docile	<ul style="list-style-type: none"> <li>• Bees need daylight to navigate</li> <li>• Night harvest results in bees</li> </ul>	<ul style="list-style-type: none"> <li>• If daytime harvesting is combined with "selective cutting" (see #3)</li> </ul>	<ul style="list-style-type: none"> <li>• Lower bee mortality during harvest</li> <li>• Increased sustainability of</li> </ul>

<sup>17</sup>Following the completion of the Indonesia/UK Tropical Forest Management Programme's support to the DSWR Conservation Project, a Pontianak-based NGO—Yayasan Dian Tama—with the financial assistance of the British Embassy (Jakarta) and Global Concern (Singapore)—continued to develop and implement many of the activities of the DSWR Conservation Products Trading Enterprise (Heri, Valentinus, Ade Jumbuh, and Tri Renya Altaria. 2000, Laporan Akhir Proyek—Kegiatan Pembinaan Hasil-Hasil Hutan Bukan Kayu di Taman Nasional Danau Sentarum Juli 1997-Juni 2000. Pontianak: Yayasan Dian Tama).

	<p>loosing orientation, falling in water and dying</p> <ul style="list-style-type: none"> <li>• Remaining bees scatter and do not build new combs or produce more honey</li> </ul>	<p>it allows bees to navigate and return to the comb to continue producing honey.</p>	<p>bee colonies</p>
2. Bees are distracted from combs with smoke from smouldering torches with exposed/ burning embers.	<ul style="list-style-type: none"> <li>• High bee mortality as a result of bees being burned</li> <li>• Potential forest fire hazard</li> </ul>	<ul style="list-style-type: none"> <li>• Hand-held "smokers" can be used to ward off bees with no direct exposure to burning embers.</li> </ul>	<ul style="list-style-type: none"> <li>• Lower bee mortality</li> <li>• Reduced risk of forest fire</li> </ul>
3. Honeycombs are harvested only once per season.	<ul style="list-style-type: none"> <li>• Potential quality of honey harvest is under-utilised</li> <li>• Full financial value of wax and honey is lost</li> </ul>	<ul style="list-style-type: none"> <li>• Selected cutting of only the honey portion of the comb (leaving the brood intact) would permit 2-3 harvests per season</li> </ul>	<ul style="list-style-type: none"> <li>• Quantity of honey harvest increases</li> <li>• Income to community increases</li> <li>• Incentive to protect forest increases</li> </ul>
4. Honeycombs are traditionally harvested by cutting with wooden knives.	<ul style="list-style-type: none"> <li>• Imprecise cutting of comb leads to unnecessary comb damage and reduced honey production</li> </ul>	<ul style="list-style-type: none"> <li>• Using metal knife would ensure only honey-portion of comb is harvested</li> <li>• Remaining comb can be left to yield more honey</li> </ul>	<ul style="list-style-type: none"> <li>• Allows combs to be harvested multiple times in same season</li> <li>• Additional benefits as above</li> </ul>
5. Honeycombs are harvested without protective gear.	<ul style="list-style-type: none"> <li>• Results in rapid harvesting and increased damage to combs</li> <li>• Greater likelihood for bee mortality</li> </ul>	<ul style="list-style-type: none"> <li>• Some protective gear could be used from simple head-nets to gloves</li> </ul>	<ul style="list-style-type: none"> <li>• More time and care can be taken during harvest</li> <li>• Reduced damage to comb and bees</li> <li>• May ensure fewer hives remain unharvested</li> </ul>
6. Honey is generally extracted from	<ul style="list-style-type: none"> <li>• Pollen is mixed with honey resulting in</li> </ul>	<ul style="list-style-type: none"> <li>• Combs should be cut into small pieces, placed</li> </ul>	<ul style="list-style-type: none"> <li>• Quality of honey increases</li> <li>• Incomes to</li> </ul>

the combs by squeezing entire combs by hand.	cloudy honey with less market appeal <ul style="list-style-type: none"> <li>• Unhygienic</li> </ul>	on clean cloth and allowed to drain over night	communities increases <ul style="list-style-type: none"> <li>• Incentive to protect forest increases</li> </ul>
7. Beeswax is often contaminated, discarded, or incompletely harvested.	<ul style="list-style-type: none"> <li>• Potential quantity of wax harvest is under-utilised</li> <li>• Additional financial value to collector is lost</li> </ul>	<ul style="list-style-type: none"> <li>• A system of melting the wax in boiling water, cloth strained and processing with a stick-wax-press can yield up to 47% more wax</li> </ul>	<ul style="list-style-type: none"> <li>• Quality and quantity of wax increases</li> <li>• Incomes to community increases</li> <li>• Incentive to protect forest increases</li> </ul>

Following the Vietnamese Study Tour, Project staff undertook basic training workshops and discussions with honey harvesters on how to improve their harvesting and processing techniques. Some of these techniques (i.e. 1 and 3) involved harvesting demonstrations in the field, while other techniques (i.e. 6 and 7) were best taught through the design and distribution of a simple poster showing a step-by-step approach to each technique. For other techniques (i.e. 2, 4 and 5) basic proto-types were constructed and shared among honey harvesters to help demonstrate their advantages.

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## THE FISHERY OF DANAU SENTARUM

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Management of the Danau Sentarum National Park for ecosystem and species conservation must accommodate fishing activity by thousands of villagers living there. Fishery investigations helped determine how this might be accomplished. Fishing gear surveys revealed that villagers use 800 km of gill net, 20,000 traps and 500,000 hooks in 80,000 ha of lakes, rivers and flooded forest within the park. Data from 4,000 catches were collected by local people during 1992 through 1995. Fishing gear use surveys determined fishing intensity and season. The estimated annual catch of between 7,800 and 13,000 tons (or 97.5 to 162.5 kg ha<sup>-1</sup>) is caught by cylindrical rattan traps 23%, gillnets 20%, cast nets 18%, other traps 15%, hooks 14%, and funnel nets 9%. These data provide insight into what changes might make fishing activity more compatible with conservation.

Villagers and data indicate some species are less abundant and smaller than in previous years, but needed management via direct government regulation is unlikely to succeed. A promising approach would emphasize management by villagers. Regulations at the village level exist, as does understanding of the need for better management. Developing this potential into an officially recognized fishery management system could improve conservation of this important wetland.

Suggested management starting points include the concept of trading exclusive resource use rights for compliance with conservation regulations, and the establishment of a residence permit system for the park. Suggestions for mesh size regulations and other gear changes, to be used as starting points for discussions with villagers, are also presented.

### **Introduction**

Fishing is the most important human commercial and subsistence activity carried out within the Danau Sentarum National Park (DSNP) in terms of participation and income. Both fishing activity and other activities of fishing people affect fishes, wildlife, and the surrounding aquatic and terrestrial ecosystems. Management of the park for conservation purposes is impossible without an understanding of the fishery and the human population's dependence on it.

This paper provides details about the fishery within DSNP including estimates of catch rates and catch composition from each fishing gear type. Where possible this information is presented on a seasonal basis. Also provided is a general estimate of total fish catch from DSNP with a breakdown by fishing gear type. Suggestions for improving fishery management are also presented.

### **General Description of the Fishery**

Fish species found in DSNP and nearby areas have been reported by Roberts (1989), Kottelat (1993, 1995) and Widjanarti (1996). The number of fish species recorded from

the Kapuas basin is about 315 (Kottelat 1995). Kottelat (1993) reported 175 fish species from the “lakes area” and 125 from within DSNP boundaries. Subsequently, Widjanarti (1996) reported 210 species from within DSNP.

The fishery was described by Giesen (1987). Earlier reports include those of Vaas (1952) and Sachlan (1957). Additional information related to the fishery within DSNP has been provided in several short reports (Aglionby 1995, Dudley *et al.* 1993, Dudley and Widjanarti 1993) and an undergraduate thesis (Suryaningsih 1993).

The fishery is a small-scale artisanal fishery making use of a large number of gear types to capture many different species. However, most fishing activity makes use of gill nets, hooks, traps, and cast nets although specialized gears are also used. Most fishermen use small (2.5 to 4 m) canoes. About half the fishing families own a small (less than 5 horsepower) outboard engine.

A seasonal flooding regime significantly affects fishing activity. Although fishing takes place all year round, peaks in activity during dropping water, April to August, and early rising water, usually in September and October. Water levels within the park typically exhibit an annual fluctuation of about 12 m. The rise and fall of the river follows a seasonal pattern, with water starting to rise in either September or October and continuing to rise rapidly during November, and more slowly during December and January. This is followed by a period of lesser fluctuations with the peak level usually occurring between January and April. Water levels drop gradually at first and more rapidly in July and August. This pattern can vary considerably from year to year. In 1995 the water level dropped less than 4 m prior to rising again at the start of the 1995-96 flood year. The large area of the floodplain moderates rapid rises in water, and changes of more than 10 cm per day are rare. For a discussion of hydrology of the area see Klepper (1994) and Klepper *et al.* (1994).

Human residence within the park is limited by the lack of land during high water. Permanent houses built on stilts are found on river levees. Some families live in floating houses or house boats. As water drops, additional people move into the park to fish, and fishing activity intensifies. Special seasons occur for certain species such as the ornamental fish, *ulang uli*<sup>1</sup>, which is much sought after between December and May.

Between 1,000 and 3,000 families<sup>2</sup> are dependent on the fishery within DSNP for their livelihood. In addition to subsistence needs, the fishery supplies fish for export from the area in the form of dried and smoked fish products, especially from *belida* and *lais*, live fish to be used as food (*toman*), high priced specialty food fish also shipped live (*ketutut*), and ornamental (aquarium) fish (especially *ulang uli*). Juvenile *toman* and *jelawat* are also actively sought for raising in cages. In the past the DSNP area was also a primary source for the red phase of *siluk* (the Asian arowana), a high priced (up to \$3,000 per fish) ornamental fish. However, this species is now extremely rare.<sup>3</sup>

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<sup>1</sup>Throughout this report I have used fish names commonly used at DSNP. See Appendix A for the corresponding scientific names.

<sup>2</sup>The exact number of families varies with season, and is also dependent on the extent of the area under discussion (see footnote 5).

<sup>3</sup>Culture techniques have made “domestic” *siluk* available to the market. Nevertheless, even though it is illegal to capture *siluk* from the wild, few fishermen would pass up the chance to capture and sell one, even at the reduced price of several hundred US dollars.

The value of the fishery has been reported at about US\$1.5 million from captured fish (including ornamentals) plus over US\$0.7 million from fishes raised in cages<sup>4</sup> within the park. Approximately 75% of income for park residents, and 48% for those living near the park, is from fishing. (Aglionby 1995).

## Methods

### Fishing Gear Ownership Surveys

Between 21 October 1992 and 30 March 1993 local data collectors visited 12 villages within the park and collected information on fishing gear ownership from 442 families. Later, in June and July of 1995, a second survey was carried out as part of a program to estimate costs associated with fishing. This second program surveyed 10 families in each of 10 villages within and near the park (Aglionby 1995). A comparison of the data from the two surveys is summarized in Table 1 and Table 2. Data from the 1992-3 survey is used herein.

Village	Number of Families Sampled	
	1993 Survey	1995 Survey
Genting	26	
Kenelang	55	10
L. Pengaei		10
Lanjak		10
Leboyan	37	
Ng. Sauk	17	
P. Majang	61	10
Pega		10
Pemerak		10
Pengembung	41	
Samar	33	
Sekentut	50	
Sekulat	53	
Semangit		10
Sengkarut	14	
Sumbuk	37	
Tekenang	18	
Tempurau		10
Temukup		10
Tengkidap		10
<b>Total</b>	<b>442</b>	<b>100</b>

**Table 1. Villages and number of families sampled during two fishing gear ownership surveys. Data for 1995 reported in Aglionby (1995).**

### Catch Survey

Catch data were derived from a very simple catch sampling system first tested in late 1992. Because few personnel were available, and, in keeping with the desire to involve local personnel in the project, local people were hired on a part-time basis to carry out an ongoing survey of fish catches. The intention was to formalize and intensify this survey, but such modifications were not possible. Nevertheless, the survey has provided a stream

<sup>4</sup>The fish raised in cages are initially captured from the wild, as juveniles, as is the fish fed to them.



of data covering about 4,000 fish catches from a variety of fishing gears in a variety of locations over a three-year period. The data included here cover the period from November 1992 through November 1995.

Gear Type	1993 Survey n=442 families	1995 Survey n=100 families
Jermal	0.21	0.28
Rattan Traps	7.68*	5.00
Small lift nets	1.07	0.80
hooks	413	466
gill nets (bals)	7.89	8.30**
cast nets	2.61	2.81
canoes	2.03	2.50
outboard motor	0.57	0.81
houseboat	0.31	0.56

Notes:

\*The 1992-3 survey distinguished between several types of traps. The number shown here is the total of "bubu" (1.94) and "pengilar" (5.74).

\*\*The 1995 survey recorded 16.6 gill nets per family. Since each "bal" of netting is usually divided lengthwise into two nets, the 16.6 nets are assumed to represent 8.3 bals per family.

**Table 2. Comparison of numbers of fishing gears per family within DSNP based on two fishing gear surveys.**

Sampling was designed to be simple and to avoid hampering fishing activity. A data sampler traveled within an assigned area with a small boat, at a time when fishing gear was being retrieved, to locate people fishing. At the site of fishing the catch was examined and data recorded. Data collected included information about the people fishing, location, date, type of gear, and length of time it had been used, an estimate of the total fish catch, the percentage species composition of the catch, and in some cases the number of individuals of each species as well as the average, maximum, and minimum lengths of the most common species. Local names of fishes were used in recording data. To a large extent local names correspond to scientifically defined species.

The data collection system, tested by the author in 1992, was first carried out by local people employed by the project for other purposes (e.g. boat drivers). It was later extended to part-time samplers in the "key villages" of Ng. Pengembung, Pulau Majang, Kenelang, Sekulat, and Ng. Laboyan.

The DSNP fishery represents a difficult sampling situation. It is a multi-gear, multi-species fishery, with a very dispersed and migratory fishing population and a great seasonal variation in catch. Greater statistical accuracy would require a sampling regime stratified by time, area and fishing gears. Considering limitations such as the limited supervision given to the data collectors, the data reported herein give a reasonably good picture of the fishery.

### Fishing Gear Seasonality Survey

A group survey technique was used to determine the seasonality of fishing gear use in 26 villages during June and July of 1996. A list of 45 fishing gear types was established based on information from project personnel, and on fishing gear names recorded during the catch survey. Photographs provided visual cues during group interviews. During each interview villagers discussed the use of each gear type and agreed on one of six statements (Table 3) for each month or group of months. Months were grouped into seasons as indicated in Table 4. For each village a code was recorded for each month for each fishing gear. These codes were later converted into percent use categories (Table 3).

Statement About Gear Use	Clarification	Code on Forms	Percent Use Used in Calculations
Not used in this village	Never used	1	not included
Not used during this season	Used, but not during the month or season under discussion	2	0
Used almost every day during this month / season	Used more than 21 days per month	3	85
Often used during this month / season	Used fewer than 21 days but more than 13 days per month	4	55
Seldom used during this month / season	Used fewer than 13 days but more than 6 days per month	5	29
Very seldom used during this month / season	Used fewer than 6 days per month	6	9

**Table 3. Coding used during gear use surveys.**

Season	Months Included
Rising Water, Start of High Water	October, November
High Water	December, January, February, March
Beginning of the Dry Season	April, May, June
Dry Season	July, August, September

**Table 4. Grouping of months into seasons as used during fishing gear use survey.**

Villages surveyed were categorized into one of six areas of the park: Lower Tawang River, Upper Tawang River, Mid-Park, Belitung River drainage, Pulau Majang area, the Laboyan River area and the Kapuas River. The villages within each park area are given in Table 5. Average fishing gear use percentages were then calculated for each area. Then the overall percentage use for each fishing gear for each month was calculated by taking the weighted average of the percentages from each park area. Weighting was based on the number of families living in each area. Weighting for gill nets, very large dip nets, and *jermal* were adjusted to eliminate data for villages where those gears are not permitted or never used. An example is illustrated in Figure 1. In the following discussion only weighted means are presented. Fishing gear types were also grouped for analysis. These groupings corresponded to categories used in the analysis of catch rates.

Area	Village	Number of Families
Kapuas (not used in calculations)	Nibung	
	Piasak	
	Suhaid	
Lower Tawang (and Tengkidap)	Sumbuk	37
	Tengkidap	40
Upper Tawang	Kenelang	83
	Pemerak	20
	Pengembung	42
	Tekenang	16
Majang	Belibis Panjang	40
	Pulau Majang	155
	Radai	30
Mid	Lubuk Lawah	20
	Lubuk Pengael	27
	Sambar	40
	Temukup	19
Belitung	Bekuan	47
	Lubuk Mawang	15
	Pega	80
	Pungau	78
	Sekulat	127
Laboyan	Leboyan	95
	Meliau	30
	Semalah	63
	Semangit	46

**Table 5. Grouping of villages used in calculation of fishing gear use percentages.**

### Approach to Analysis

Fishery data available are suitable for a general analysis, but care must be used in their interpretation. The catch data were not collected randomly within time, location, and gear strata. Thus general information collected via the catch survey needs to be examined in conjunction with other information about the fishery.

In the following sections data concerning catch rate, seasonality of use, and species composition are summarized by fishing gear type. The fishing gear survey provides information about the numbers of each gear.<sup>5</sup> Information about catch rates (e.g. kg per unit of gear) and species composition are provided by the catch survey, which also provides an idea of the size of major species caught. Following that summary is an estimate of total catch which is based on data about the catch rate, quantity of each type

<sup>5</sup>An additional complication is that the area comprising DSNP has changed. At the time the fishery surveys were started (1992) the park covered 80,000 ha. When fishery data was first being analyzed the park had been expanded to 120,000 ha. Data herein are most representative of the original 80,000 ha where most fishing takes place, and may not adequately describe fishing activity in other parts of the park.

of gear, and intensity of use. Within each month an estimate of catch for a particular gear type is obtained by multiplying the following: weighted mean intensity of use, catch rate, estimated number of gear units, possible maximum number of trips.

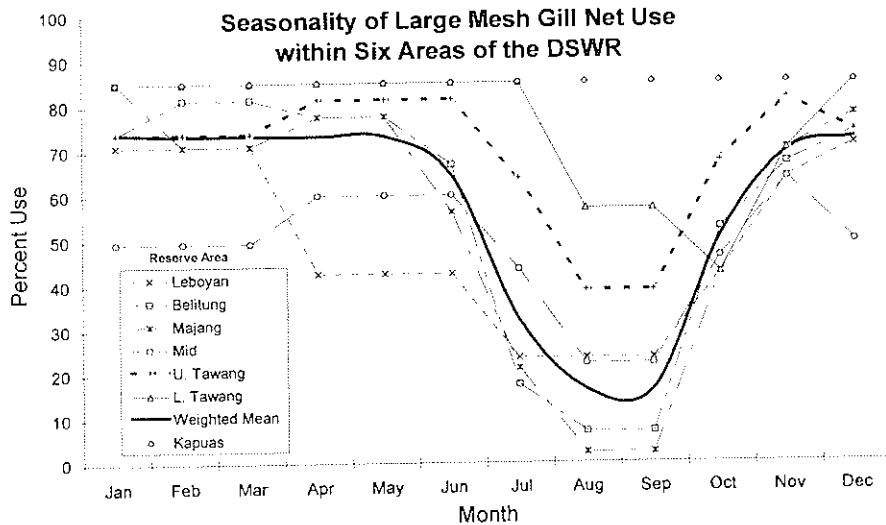


Figure 1. An example of intensity of use data. This information represents the responses of villagers to inquiries regarding how often they used large-mesh gill nets during each month. The weighted mean value, excluding the Kapuas area, was used in calculating catch estimates. In most cases weighting was based on number of villagers living in each region.

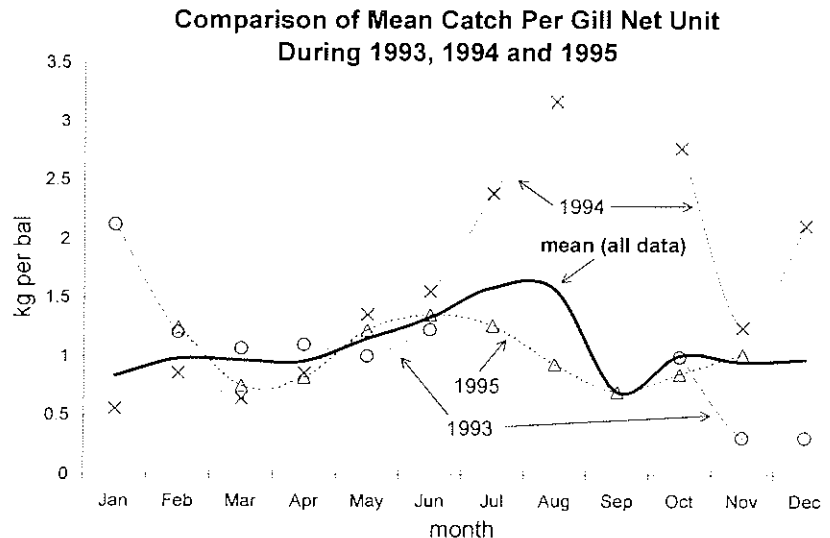
### Fishing Gear, Catch Rates and Species Composition

#### Gill nets

Data from gill nets (known locally as *pukat*) were standardized on a per unit basis. A *bal* is an amount of netting which, when set, becomes an approximately 40 m net. However, in most cases fishermen divide each *bal* in half lengthwise to make a net totaling 80 m. The *bal* is used herein as the standard unit of netting.

On the average, DSNP villagers have 7.89 *bals* of gill net per family. There are about 10,375 *bals*, or just over 800 km, of gill net available for use within the park. Some villages, (e.g. Nanga Laboyan) prohibit gill nets, perhaps because they are viewed as overly efficient. Typical "gill net sets"<sup>6</sup> encountered during the catch survey consisted of approximately 10 *bals* of netting but included anywhere from one to over 30 *bals*.

<sup>6</sup>The term "gill net set" refers to a connected group of gill nets placed, and left to fish, at one location. These may include several pieces of netting of different mesh sizes.



**Figure 2. Monthly mean catch rate from gill nets during a three year period. Mean for each month within each year shown separately. Overall within month means spanning three years are shown by the bold line. Mean for September is based only on data from 1995, thus a higher average value of perhaps 1.0 kg per *bal* might be assumed for an across-year average for that month.**

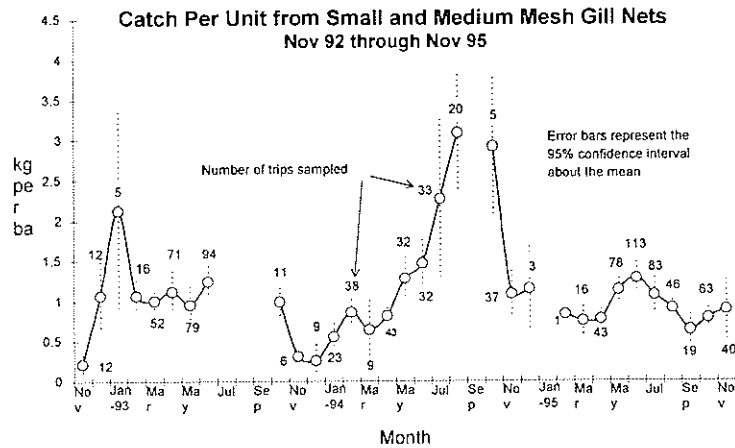
Gill net mesh sizes reported as part of the catch data and gear surveys ranged from 0.5 inch to 7.0 inch.<sup>7</sup> For catch analysis mesh sizes were grouped into large (4.5 inches and larger), medium (3 to 4 inches), small (1.5 to 2.75 inches) and very small (less than 1.5 inch). Almost 80% of gill nets encountered during our work were between 1.5 and 2.75 inches stretch measure, and this pattern varied little among the villages sampled.

Gill nets are a common fishing gear and are used throughout the year. Large mesh gill nets are regularly fished across river channels, a method which becomes less practical as water drops resulting in less use of large mesh gill nets during the dry season (Figure 4).

Typically, villagers caught between 5 and 15 kg of fish per gill net set. The data are strongly skewed, and although some catches over 50 kg were reported, 92.1% were smaller than 25 kg. On a kg per unit basis, catch rates over 6.5 kg per *bal* occurred, but 89.5% of catches yielded less than 2.5 kg per *bal*. The mean catch rate reported from gill nets was 1.17 kg per *bal* of netting.

Gill net catch rates varied with season and mesh size, but limited data makes analysis of patterns difficult. Combining data for all years, gill net catch rates exhibit an increasing trend during April through July, and then drop in September through December. This pattern is apparent in the 1994 (and perhaps the incomplete 1993) data. In 1995, when water levels did not drop, the pattern is absent. (Figure 2).

<sup>7</sup>The sizes of gillnets used in DSNP are generally referred to by their stretch mesh size in inches (*inci*). Stretch measure is the distance between corners of a single mesh when the mesh is pulled diagonally corner to corner.



**Figure 3. Monthly catch rates from small and medium mesh gillnets. Each point represents the mean catch per fishing gear unit (*bal*) from the number of fishing trips shown. The number of *bals* within each trip varied.**

Catch rates from the commonly used small and medium mesh gill nets, are typically between 0.5 and 1.5 kg per *bal*. During periods of dropping water catch rates can be three times as high as indicated by catches recorded during July through October 1994.<sup>8</sup> In 1995 floodplain waters did not recede and no increased catches during those months were apparent (Figure 3).

Catch rates for large mesh gill nets are higher than catch rates from medium and small meshes, but because relatively few large mesh gill nets were sampled a comparison on a quarterly, rather than monthly, basis was necessary (Figure 5).

Large mesh nets caught almost 80% *belida* with occasional *tebirin*, *tapah*, or *lais jungang* (Figure 6). Catches from medium mesh nets were dominated by *lais* and *patik* which typically comprised 30 to 40 percent of the catch. Several other species were regularly caught including *kelabau*, *umpan*, *buin* and *juara*, while other species seemed to be more seasonal (Figure 7).

Over 40 percent of the catches from small mesh nets were typically various types of *lais*, and *patik*. Other species recorded regularly included, *umpan* and *kelabau*, while species such as *belida*, *kerandang*, *tebirin*, and *biawan* seemed more seasonal (Figure 8).

Very small mesh nets tended to catch the same species as the small mesh nets although they tended to have more representatives of some small species (e. g., *engkarit*, *temunit*).

### Hooks

Several types of fishing gears employing hooks are used in DSNP. These comprise three categories: long lines, consisting of many short lines with hooks attached to a longer line (called *utas*, *rabai*, *ulur*, *takan*); set hooks consisting of hooks tied to tree branches or attached to sticks stuck into the ground (usually called *kail*); and hand-lines held in a person's hand as they fish (called *kail* or just *pancing*).

<sup>8</sup>Unfortunately, samples were not obtained during the same period in 1993.

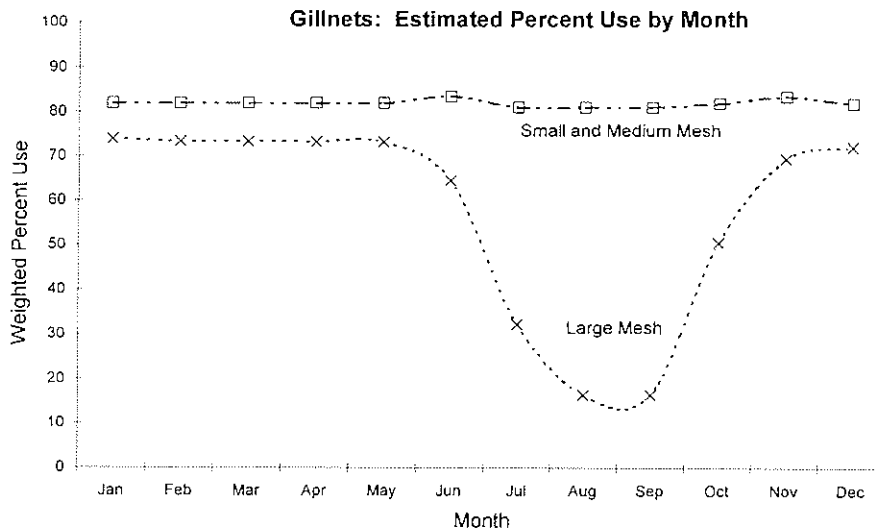


Figure 4. Seasonality of gill net use.

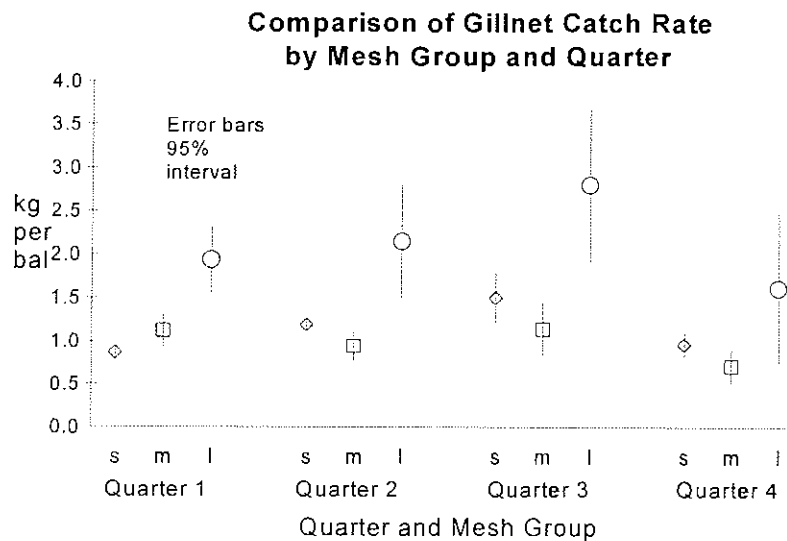


Figure 5. A comparison of catch rates by gill nets of differing mesh size groups. Because of the relatively small number of large mesh nets sampled, the rates have been compared on a quarterly basis. Mesh sizes: s=small, m=medium, l=large.

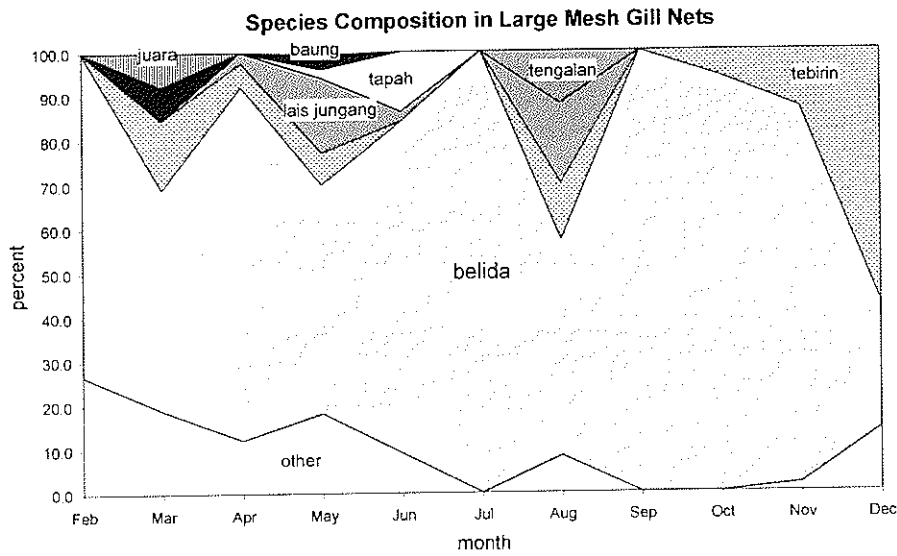


Figure 6. Species composition in large mesh gill nets by month.

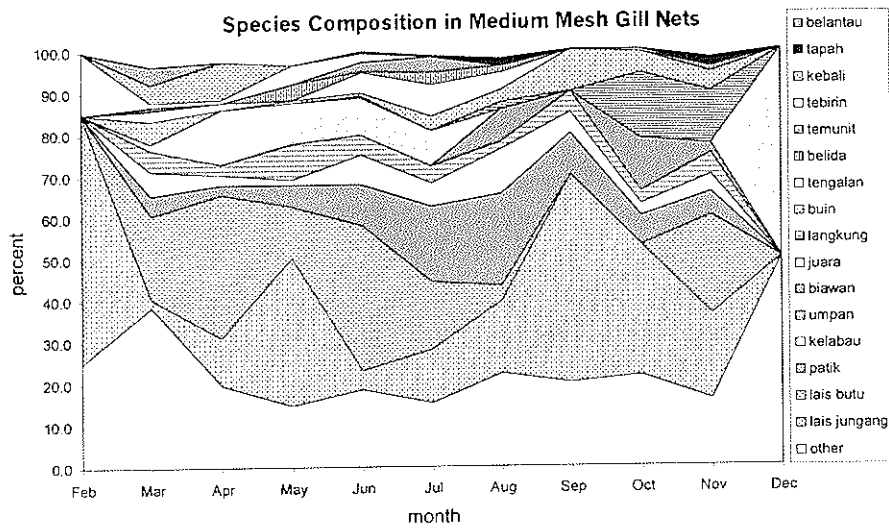
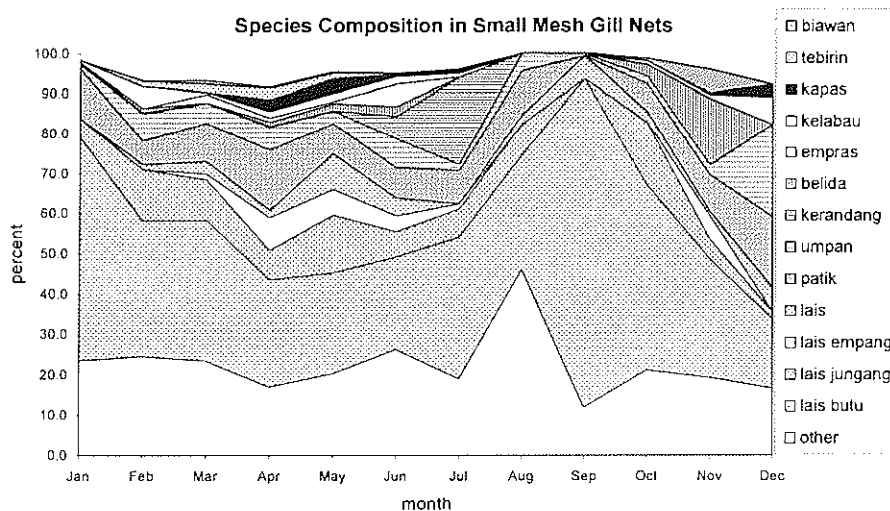


Figure 7. Species composition in medium mesh gill nets by month.





**Figure 8. Species composition in small mesh gill nets by month.**

For analysis these were grouped into two types: hooks set and left unattended, hereafter referred to as set hooks, and hooks actively used by a person hereafter referred to as hand-lines. Set hooks were also categorized based on hook size: large (hook sizes 5, 6, 7, and 8), medium (size 9, 10, and 11) and small (12, 13, 14, 15 and 16).

Hooks are common within DSNP, and on the average, DSNP villagers have 413 hooks per family or over 540,000 hooks available for use. Based on data from the catch survey 65% of trips making use of set hooks used small hooks, 15% medium hooks and 20% large hooks<sup>9</sup>.

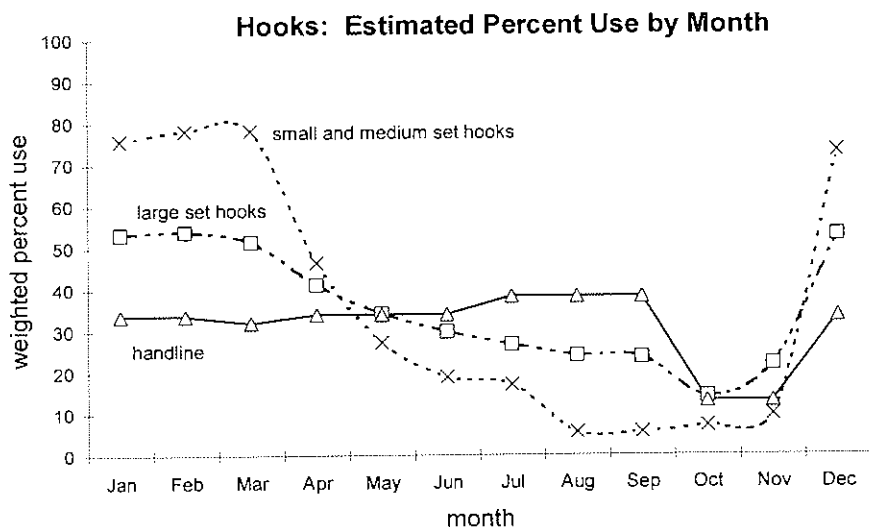
Fisherfolk reported that set hooks tend to be used more during high water periods from December through March when hooks can be set and left in quiet backwaters. Hand lines had a more uniform use pattern with a decrease in use occurring only during October and November (Figure 9).

Catches from hook gears are expressed in kg per 100 hooks to standardize the catch per fishing trip.<sup>10</sup> Standardized catch rate varied from less than 0.5 kg per 100 hooks to more than 60 kg. The catch rate from small size hooks was considerably lower than that from large and medium hooks. Most catches from small hooks were less than 2 kg per 100 hooks. Large hooks tended to catch between 10 and 40 kg per 100 hooks while

<sup>9</sup>Based on 841 records, not including records for which hook size was not recorded.

<sup>10</sup>Considerable difficulty was encountered with the data from hook gears because of a lack of standardization of the fishing gear information entered on the data forms. Sometimes the number of hooks was entered, and sometimes the number unit of fishing gear units (usually called "rols") was entered. In a few cases both the number of hooks and the number of rols was recorded, and this information was used to calculate the number of hooks used for those records which had no information for number of hooks. However the number of hooks per rol varied with the gear type and location. Also, even in cases when the number of hooks was recorded on the data form, that number is an estimate provided by the fisher.

medium size hooks caught slightly less (Figure 10). No clear seasonal patterns were apparent. Catches from large hooks dropped during low water in 1994 but did not drop during that period of the year in 1995 when water remained high.



**Figure 9. Seasonality of set hook and hand line use.**

Catches from hooks were less diverse than catches from other types of gear. The most common species (in terms of weight) reported in catches from large hooks were *toman* (50%) and *tapah* (35%). *Toman* also made up over 70% of the catches recorded from medium size hooks. In contrast catches reported from small size hooks were dominated by *patik* (78%) and *delak* (13%) with *lais butu* common during September through November. Species composition by month is shown in Figure 11.

Hand-lines are particularly common in the village of Leboyan, and are also used regularly by a small group of fishers from Pulau Majang, but few hand-line data were collected during the survey. Hand-lines catches have been expressed as catch per hook-hour. Catches averaged 0.93 kg per hook hour with a possible trend toward higher catches during periods of low water. Hand-line catches consisted of 67% *patik* with no other species making up more than about 7%.

### Cast Nets

A number of different types of cast, or throw, nets (*jala*) are identified by villagers based on the size, mesh size, and target species. For convenience these can be grouped by mesh size, though consideration must also be given to the species being sought. DSNP families own, on the average, 2.61 cast nets per family. The number of cast nets in DSNP was estimated at 3,430.

The fishing gear survey identified four types of cast nets: *jala bilis*, *jala toman*, *jala bauk* and *jala perumpan*. However, during the three year catch survey 19 different names were recorded for cast nets. Consequently, the data were grouped based on the mesh size recorded during the catch survey: small (less than 0.5 inches), medium (larger than 0.5

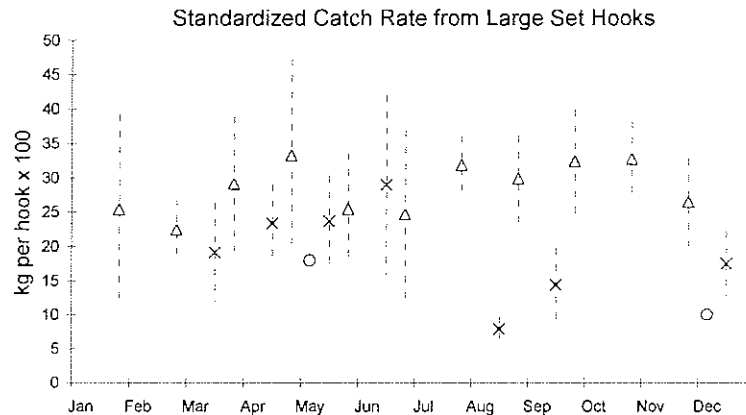
and less than 3.0 inches) and large (3 inches and greater). During the catch survey 44% of cast nets encountered were small mesh, 48% medium mesh and only 8% large mesh.

Large mesh cast nets are used primarily during July through September, while the smaller meshed types are most typically used during high water periods between November and April (Figure 12).

Catches from 887 trips using cast nets were examined. Catches exhibit a mode between 1.0 and 2.5 kg per hour. Mean catch rate from large mesh nets varied with season from a low of 1 to 2 kg per hour to between 7 and 8 kg per hr during July and August.<sup>11</sup> Catch rates from medium mesh cast nets ranged from 1 to over 6 kg per hr with a trend toward higher catches during May through September. Mean catch rates from small mesh cast nets tended to be less than those from medium mesh nets sampled in the same month, ranged from 1 to 5 kg per hr and tended to be higher during June through August (Figure 13).

Species caught in cast nets were dependent on the mesh size used. Large mesh cast nets sampled in August caught mostly *biawan* and a mixture of other species. *Umpan* was very common in large mesh nets sampled in January, February, May and June while *bauk ketup* and *entukan* also formed a large part of the catch sampled in February.

Medium mesh cast nets caught a wide variety of species especially various types of *bauk* and *entukan*, as well as *umpan*, *menyadin*, *bilis* and *patik*. Small mesh cast nets caught a smaller selection of species, and catches from them consisted mostly of *bilis*, *ritak* as well as a variety of other species (Figure 14).



<sup>11</sup>Only 57 trips made by fisherfolk using large mesh cast nets were sampled limiting the analysis of data from this gear type.

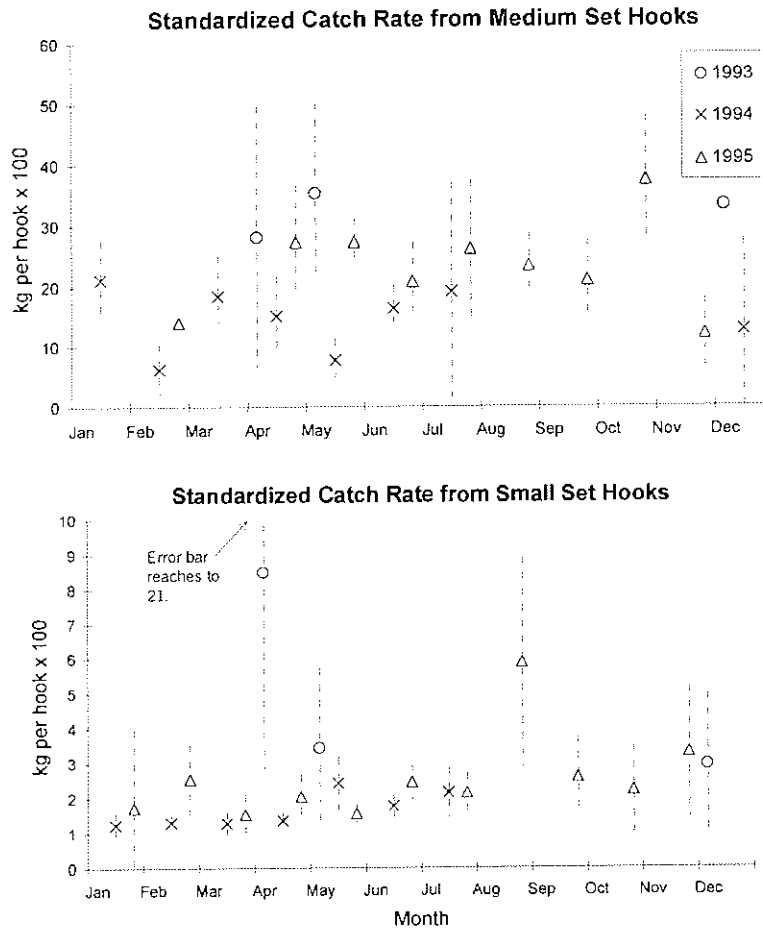


Figure 10 a, b, c. Catch rates from set hooks.

### Funnel Nets

*Jermal* are stationary, open topped, funnel-like nets used to catch migrating fish. They are typically 4 to 6 m across the mouth and 10 to 20 m long, but can be larger. They are left for several to many hours and then are checked by gradually lifting the floor of the net, starting at the mouth, trapping the fish in the back of the net where the meshes are smallest (mosquito mesh). The fishing gear survey reported 92 within our sample resulting in an estimate of 275 *jermal*<sup>2</sup> in use within DSNP. However, our survey emphasized data from an area where *jermal* are more commonly used and may have overestimated *jermal* numbers.<sup>12</sup> *Jermal* are used during all seasons, but the season of use

<sup>12</sup>The Selimbau Fisheries Office reported (in 1992) that there was a limit of 177 *jermal*, and that permits from the Fisheries Office were required, but that in 1991 there were 186 *jermal* in the Selimbau sub-regeancy (*kecamatan*) as well as 377 within the Kapuas Hulu regeancy (*kabupaten*). (Author's field notes 24 September 1992).

varies with location. Their use is most common during high water, and during dropping and rising water (Figure 15). *Jermal* catches vary considerably with time of year, and are most productive during dropping water. The catch survey data indicate that catches varied considerably from less than 1 kg to more than 70 kg per hour. Catches reported in our data were particularly high during October and November 1995, when catches averaged 36 and 70 kg per hour respectively (Figure 16).

By weight, species composition in *jermal* is dominated by *bauk* and *entukan*, but a wide variety of other species are caught, and the dominant species may vary from month to month (Figure 17).

*Jermal* are important for catching live ornamental fishes, especially *ulang uli* which make up a small portion of the catch by weight but are the most valuable species caught. Mean catch rates reported for *ulang uli* usually ranged from fewer than 2 to over 40 per individuals per hour but could be as high 140 fish per as in May 1998.

## Traps

### Gear Description and Numbers and Seasonality

Brief descriptions of the several types of traps are used within DSNP are included below. For full descriptions of fishing gear in the area see Anon. (1992) and Giesen (1987). Numbers of traps within DSNP were estimated at: 2,550 cylindrical rattan traps (*bubu*), 7,550 rectangular traps (*pengilar*)<sup>13</sup>, 16,500 *seruak* and 3,970 *bubu keli* and 22,680 bamboo tube traps (*tabung*).

Catch data from traps were standardized on a kg per hour basis. Data from *tabung* are expressed in number of *ulang uli* per unit.

### Normal Traps (*Bubu, Pengilar and Temilar*)

*Bubu* are fairly large, cylindrical traps woven from rattan. They are usually 2 to 3 m long and 0.6 to 1.0 m diameter. *Pengilar* and *temilar* are smaller rectangular traps (approximately 0.7 x 0.7 x 0.5m). These traps, especially *bubu*, are often used in conjunction with fence-like leads or fish barriers.

Both the cylindrical and rectangular "normal" traps are used primarily during dropping water from April through November, although the rectangular type is also used during other months (Figure 15). Data from normal traps were collected from only 77 trips (which included catches from 809 traps) over the three-year period covered by this report.

*Bubu* catch rate averaged just over 1.0 kg per hour. In some instances the catches were significantly higher but typically ranged from low catches (below 0.2 kg per hour) during high water periods to catches averaging almost 1.5 kg per hour during dropping water. Catches from only 20 trips employing *pengilar* and *temilar* were examined although these included catches from 555 such traps.<sup>14</sup> Catches were generally below 0.05 kg per hour. The data were insufficient to determine a seasonal trend.

Catches from both *bubu* and *pengilar* were dominated by *biawan* and *patik*, but a mixture of other species accounted for about 60% of the catch. Occasional large catches of *biawan* are common during dropping water.

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<sup>13</sup>Including *temilar* and similar rectangular traps.

<sup>14</sup>It was not possible to record the catch from each trap separately because each fisher does not keep the catch from each trap separate.

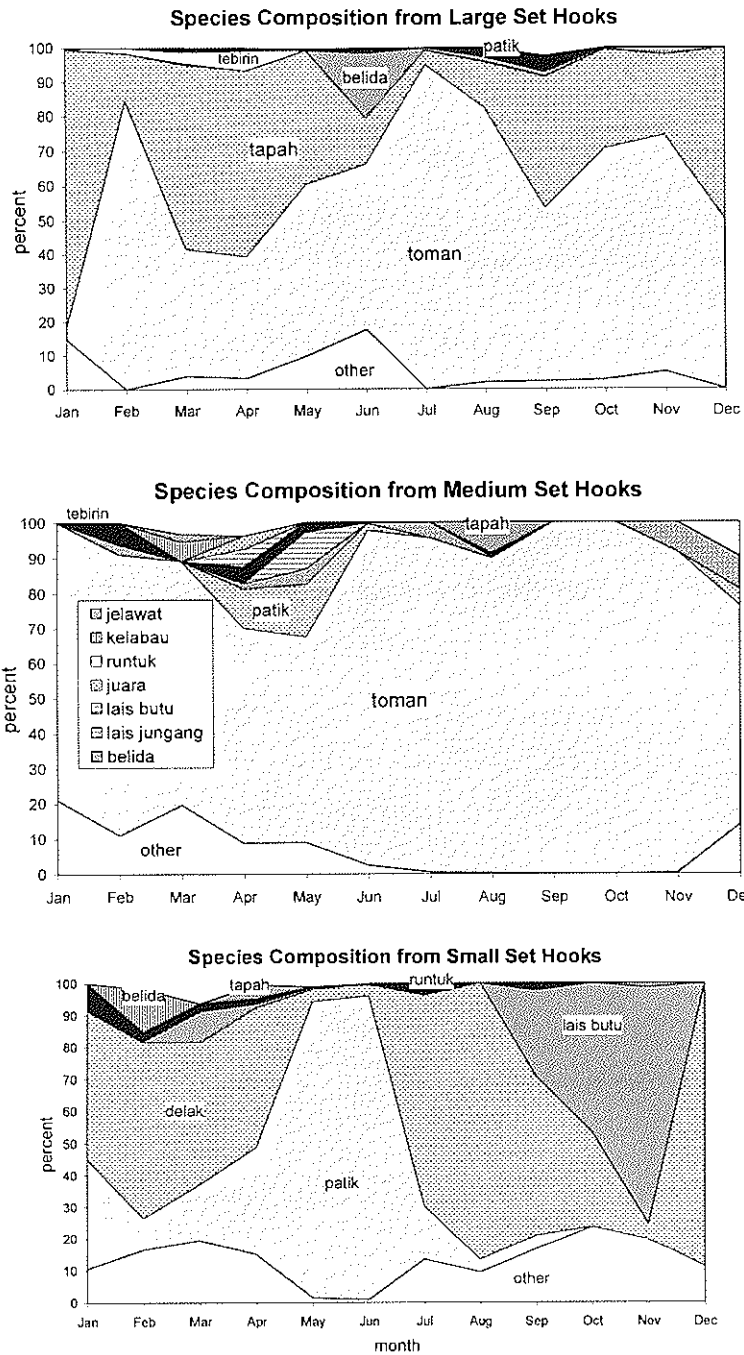


Figure 11 a, b. Species composition from set hooks.

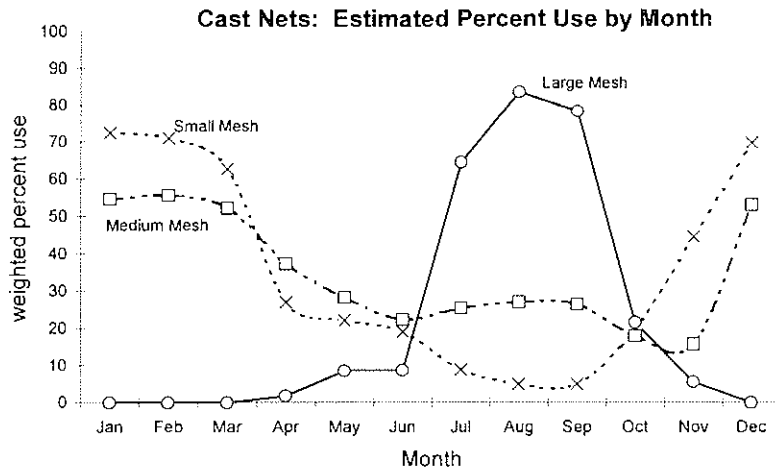


Figure 12. Seasonality of fishing effort with cast nets of differing mesh sizes.

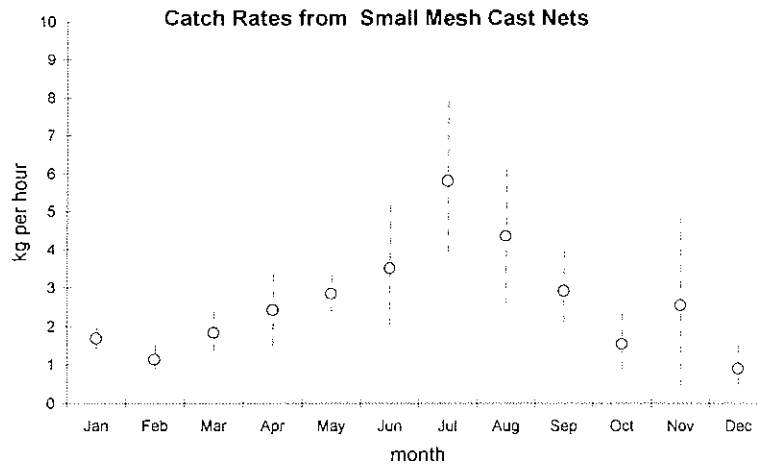


Figure 13. Catch rates from cast nets.

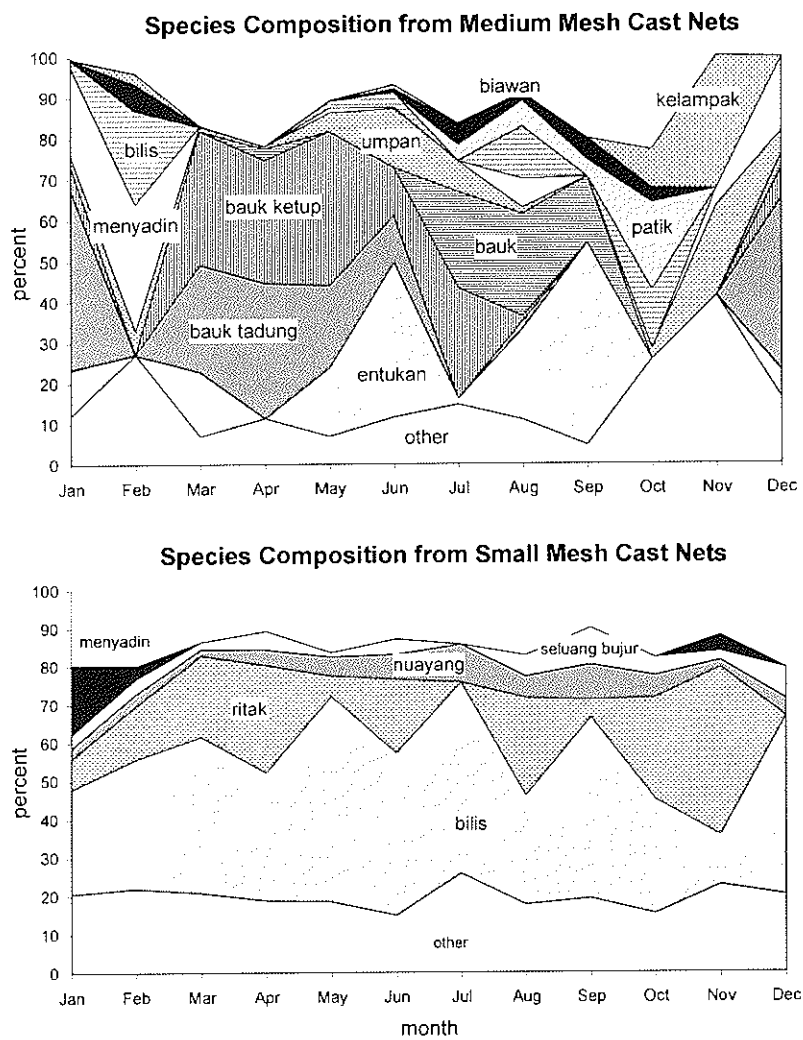


Figure 14. Species composition from cast nets.



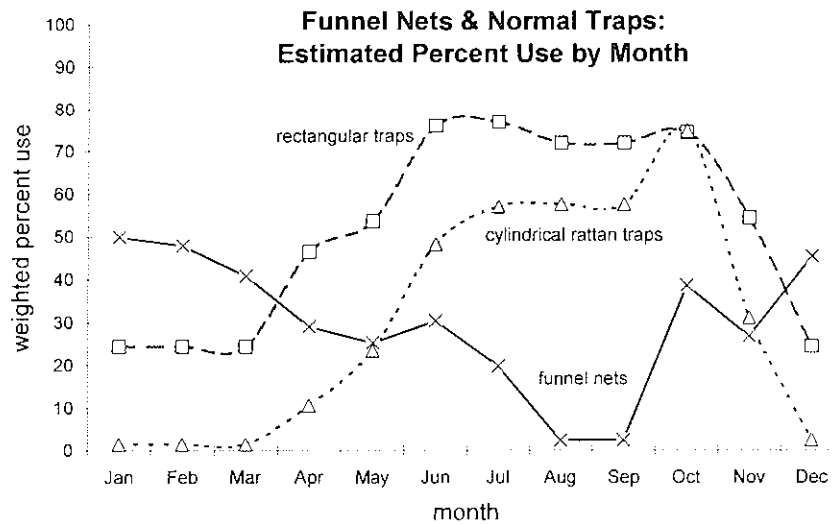


Figure 15. Seasonality of fishing effort with *jermal* and normal traps.

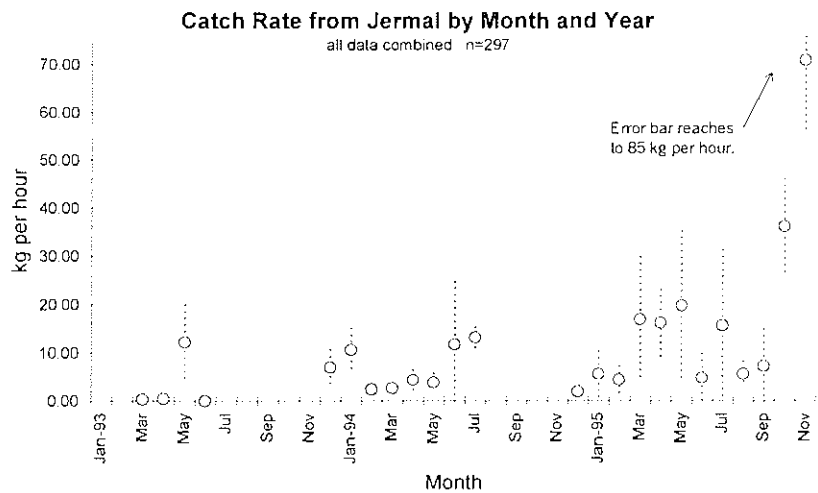


Figure 16. Mean monthly catch rates from *jermal*.

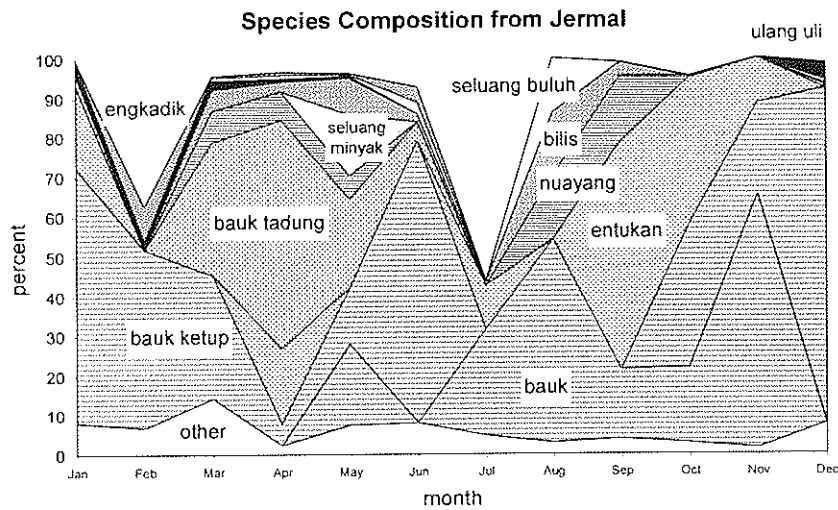


Figure 17. Species composition in *jermal* catches.

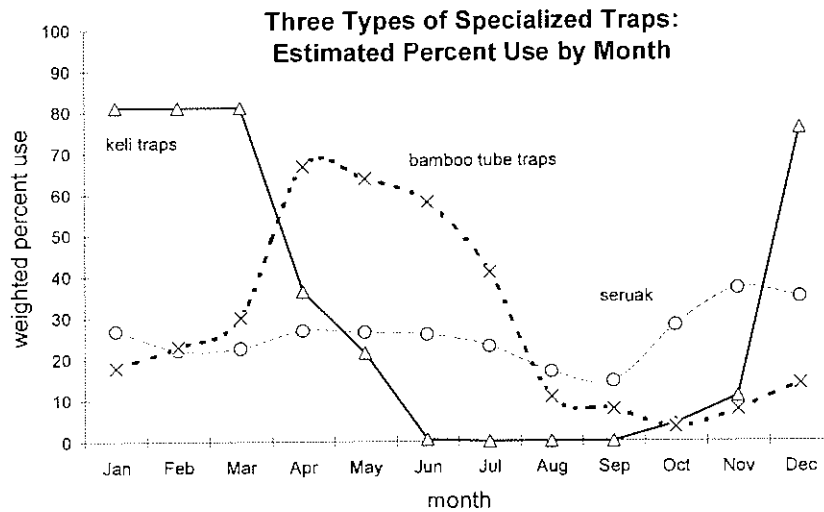


Figure 18. Seasonality of fishing effort with three types of specialized traps.

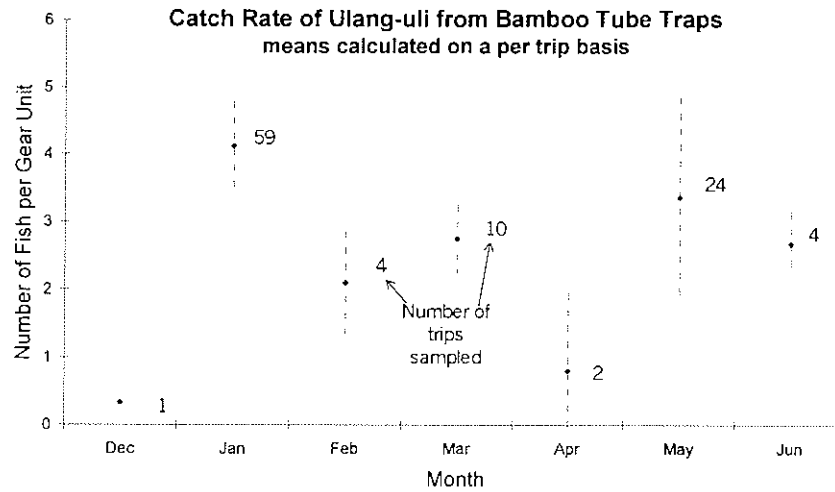


Figure 19. Catch rate of *ulang uli* from bamboo tube traps.

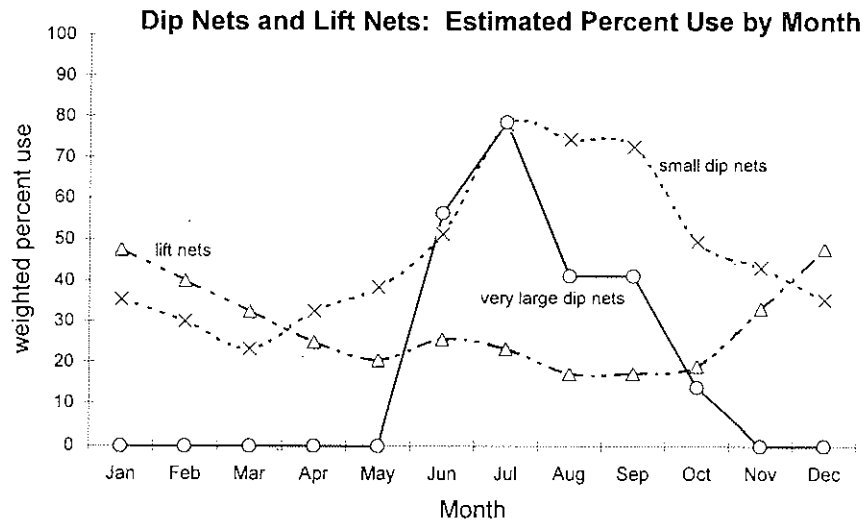


Figure 20. Seasonality of use of dip and lift nets.

### *Bubu Keli*

*Bubu keli* (also called *seruak keli*) are similar to *seruak* (see below), but larger (up to 50 cm diameter), with a different type of opening. These are deployed specifically to catch *keli*.

Fisherfolk use these traps during October through May and especially during high water (Figure 18). Catch survey data from 59 trips (818 traps) indicate a catch rate typically less than 0.04 kg per hour with somewhat higher catches during March, April and May. *Bubu keli* catch mostly *keli*—over 60% by weight and numbers.

### *Seruak*

*Seruak* are small (about 35 cm x 35 cm) cylindrical traps made from split bamboo with bamboo tube entrances. *Seruak* appear to be used throughout the year to catch juvenile *jelawat*. Very limited information about this gear indicates a catch rate of 0.06 kg per hour. *Seruak* caught an average of 12.8 juvenile *jelawat* per trap.<sup>15</sup> Young *jelawat* make up more than 25% of the catch by number, but a mixture of other species are also caught.

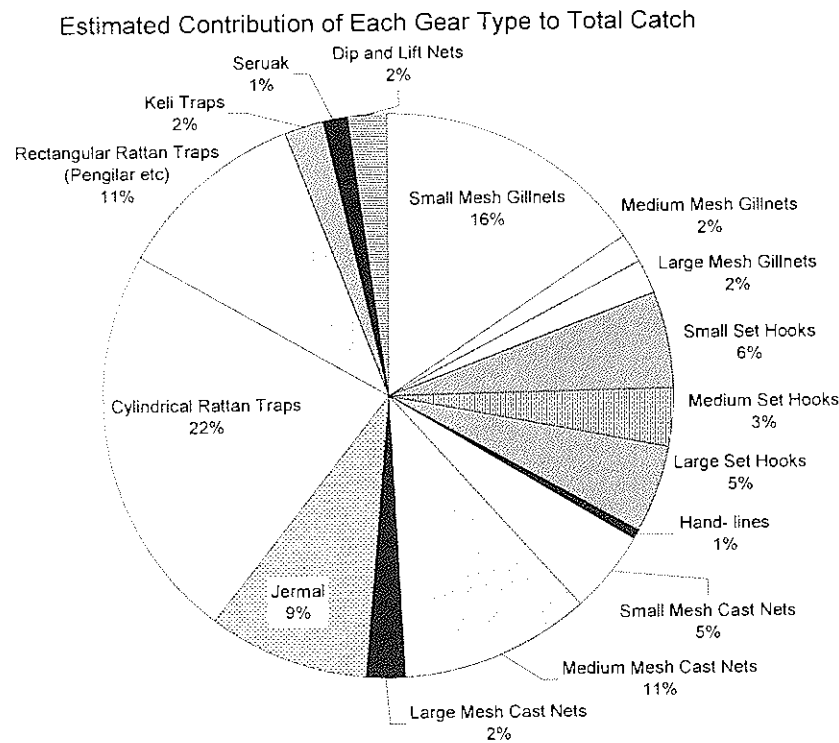


Figure 21. Catch composition by fishing gear type for the revised catch estimate.

### Bamboo Tube Traps: *Tabung*

*Tabung* are bamboo tubes up to 2 m long with a 2 to 3 cm hole cut into the top of each bamboo segment. Sometimes the tubes are tied in bundles. *Tabung* are used primarily to catch live *ulang uli*.

<sup>15</sup>Numbers of *jelawat* caught were recorded for only 23 trips, and this figure is based primarily on 22 trips sampled in December 1994.

Overall, fisherfolk reported the most use of *tabung* during March through early July (Figure 18), but in some years there is another *ulang uli* season in December and January. Villagers in the middle part of DSNP reported more use of *tabung* during December and January compared to other DSNP residents.<sup>16</sup>

Data from 126 trips<sup>17</sup> in which *tabung* were used yielded an average catch of about 3.5 fish per tube (Figure 19). Over 97% of the fish reported from *tabung* were *ulang uli*. Other species caught included *engkadik*, *engkarit*, *menyadin*, *bantak*, and *sehuang batu*, as well as 15 other species. Typical sizes of *ulang uli*, caught by all methods, were 2 to 7 cm and averaged just over 4 cm.

### Lift and Dip Nets

Small lift nets and dip nets are commonly used on an occasional or casual basis throughout the year (Figure 20).

Small dip nets (*sauk*) are about 40 to 60 cm in diameter. Lift nets (*pesat*) are square nets usually about 1 to 1.5 m (rarely 2 m) on each side. They are fixed to bamboo cross-pieces and lowered and lifted fixed to the end of a pole. Most families own both a dip net and a lift net. An estimated 1,290 dip nets and 1,410 small lift nets were in use during the survey period.

Very large oval dip nets (*ambai*) are commonly seen along the Tawang and Belitung Rivers. These have 3 to 4 inch mesh and are about 3 to 5 m long and 1.5 to 2 m across. They are used during dropping water (Figure 20). Only 33 of these were reported in the fishing gear survey and an estimate for the park would be about 90. These large dip nets are used to catch *belida*.

The catch survey did not sample small or large dip nets adequately to estimate catch rates. *Bilis* dominated catches of small lift nets which were sampled but many other small species were also caught.

Small lift nets were sampled only 149 times during the catch survey, and were perhaps sampled at times when use of these nets was common. The sampling probably did not reflect the casual, every-day, less productive use of these nets. Catch survey data indicated a catch per hour of 1.5 kg with no obvious seasonal trends.

### Total Catch Estimate

Accurate annual estimates of total catch from DSNP cannot be made given the quality and quantity of data currently available. The large number of fishing gear types and the scattered nature of the fishery, would make accurate estimates difficult, and expensive. A approximation of the total catch from DSNP in a typical year, can be made using the data reported herein.

The following estimate is based on estimates calculated for each type of fishing gear within each month. Each of these is the product of the estimated: 1) number of gear units, 2) intensity of use, 3) catch rate, and 4) number of potential fishing trips within each month.

An initial calculation resulted in an value of 15,000 tons, but this seems likely to be an over-estimate. This would amount to a fish yield of 187.5 kg per ha per year, based on

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<sup>16</sup>Of the six park sub-areas, three (the mid section, the Belitung section and the upper Tawang section) reported using *tabung* in December and January.

<sup>17</sup>Of these trips 97 included data regarding the weight of the catch and 104 included number of *ulang uli* caught.

an area of approximately 80,000 ha of lakes, rivers and flooded forest within the park. This would fall at the very upper end of the range of fish yields from similar floodplain waters (see, for example, summaries in Giesen 1987 and Lowe-McConnell 1987, Bayley 1988, and Hogarth and Kirkwood 1996). A catch of this magnitude from the relatively sterile black waters of DSNP seems unlikely. Catches from another Indonesian floodplain, along part of the Lempuing River in South Sumatra, was estimated at 130 kg per ha (MRAG 1994).

Also, based on the initial estimate, the average catch per family during November is 17.5 kg per day, a rather high value for a period of time when catches are usually low. In fact catches during that period are almost certainly lower than 5 kg per family per day.<sup>18</sup>

Although Dudley and Harris (1987) reported the difficulties associated with the use of Indonesian fishery statistics for fishery analysis purposes, the Kapuas Hulu regency figures provide another basis for comparison. Reported catches for the Kapuas Hulu have gradually increased since 1973, and during 1984 to 1995 were between 11,000 and 17,500 tons. Thus the 15,000 ton catch estimate calculated for DSNP is more or less equal to the reported catch for the whole Kapuas Hulu. In contrast, Giesen (1987) estimated DSNP catches at about 2,800 tons or about 32% of the average (1973 through 1985) catch of 8,878 tons (reported at that time) for the Kapuas Hulu.

On the other hand current DSNP catches are certainly higher than those reported by Giesen (1987). Dudley and Widjanarti (1993) and Aglionby (1995), independently calculated that about 4,000 tons of fish are captured within DSNP solely to provide food for fish raised in cages. This catch is unlikely to have been reported by the fishery statistics system, but is included in the estimate presented herein. *Toman* were not raised in cages at the time of Giesen's (1987) work.

Factors possibly leading to a catch overestimate are several. Catches weights were usually estimated visually, and supervision of data collectors was minimal. Catches may have been routinely overestimated or there may have been a tendency to sample only larger catches. Fishing gear use could also have been overestimated.

Consequently the overall catch estimate was adjusted downward based on two objectives: to reduce the overall catch estimate to within the range of 130 to 140 kg per ha, and secondly to decrease the estimated per family catch during November through February. A recalculation target for the November catch per family of less than 5 kg per day was combined with an average target no higher than 10 kg per family per day for the months of November through February.

A "revised catch estimate" was calculated using the above constraints with the original per month estimates for each type of fishing gear as a starting point.<sup>19</sup> Each of the month by gear combinations in the original table were multiplied the same fraction to lower the overall catch. Data for November, December, January and February were also multiplied by an additional factor for each month.<sup>20</sup>

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<sup>18</sup>Based on the author's field observations in 1992 while living in Nanga Pengembang and supported by record keeping by villagers there (personal communication, Carol Colfer).

<sup>19</sup>This was done using the "solver" function of the Microsoft Excel spreadsheet program.

<sup>20</sup>The adjustment factors used for these months were: Nov, 0.29; Dec, 0.37; Jan, 0.37; Feb, 0.48. The adjustment for all other months was 0.81.

The results of this recalculation are presented in Figure 21, and Figure 22. The revised catch estimate, calculated within these restrictions, is 10,400 tons. Any estimate based on these data has a fairly large variance, perhaps plus and minus 25%, which would put the actual catch in a typical year somewhere between 7,800 and 13,000 tons. This is the equivalent of between 97.5 and 162 kg per ha.

About 23% of the catch was derived from cylindrical rattan traps (*bubu*), 19% from gillnets, 15% from cast nets and 14% from hooks. Funnel nets (*jermal*) accounted for about 9 percent. The remaining amount (20%) is caught by other types of traps, liftnets and dip nets.

DSNP catches probably vary considerably from year to year. Fish populations should increase during years of high water, such as 1995 and 1996, when fishing effectiveness is lowered and extent of favorable habitat increased. These fish would then yield additional harvest during following, more typical, dry seasons. Extremely dry years would be expected to yield high catches, and such years may be followed by years with lower catches due to diminished fish populations. Extremely dry years also undoubtedly contribute to atypically high fish mortality which would also contribute to lowered catches for the next one to three years. These factors should combine to produce obvious fluctuations in catches. Such fluctuations have not been detected in fishery data currently available.

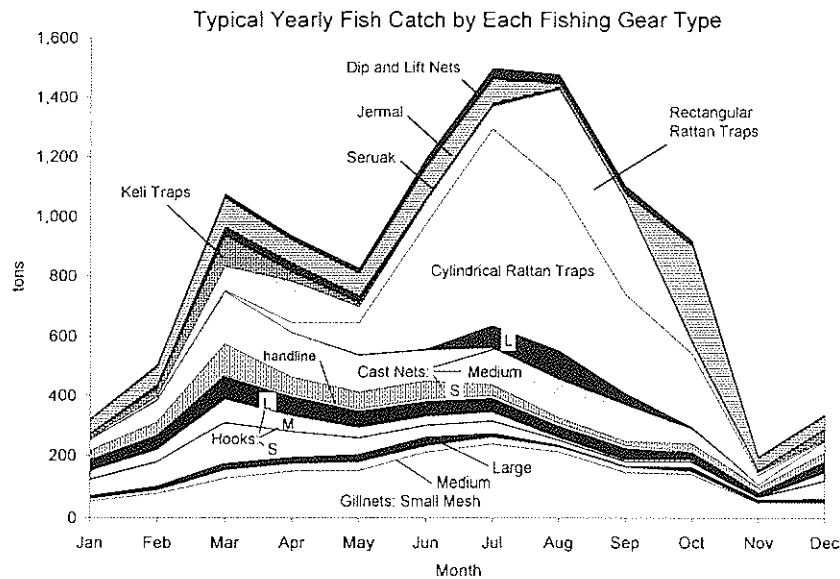


Figure 22. Revised catch estimate from DSNP by month during a typical year showing the contribution of each type of fishing gear. Based on catch survey data after adjustments to lower the overall catch and to lower catches during November through February. The revised total catch estimate is between 7,800 and 13,000 tons.

Family	Genus	Species	Common Name	literature	Lengths (cm)			Possible Indicators				
					Data from OSWR			max/	ave/		ave/	
					ave	ave	max	lit	lit	lit	max	max
Cyprinidae	Osteochilus	microcephalus	Bantak	14.2	6.6	8	17	1.20	0.46	0.56	0.39	0.47
Cyprinidae	Thynnichthys	polyteps	<u>Bauk ketup</u>	18	6.4	8.8	24	1.33	0.36	0.49	<u>0.27</u>	0.37 x
Cyprinidae	Labobarbus	ocellatus	<u>Bauk tadung</u>	22	7	8.6	25	1.14	0.32	0.39	<u>0.28</u>	0.34 x
Cyprinidae	Macrochinchthys	macrochirus	<u>Belantau</u>	100	26.0	25.6	42	0.42	<u>0.26</u>	0.26	0.62	0.61 x
Notopteridae	Chitala	lopis	<u>Belida</u>	150	49.1	50.2	112	0.75	<u>0.33</u>	0.33	0.44	0.46 x
Helostomatidae	Helostoma	temminckii	Biwawan	30	11.5	14.5	32	1.07	0.38	0.48	0.36	0.45
Cyprinidae	Cylocheilichthys	armatus	Buin	23	<u>13.1</u>	<u>15.8</u>	<u>20</u>	0.87	0.57	0.69	0.65	0.79
Cyprinidae	Cylocheilichthys	repasom	Buin	28	<u>13.1</u>	<u>15.8</u>	<u>20</u>	0.71	0.47	0.56	0.65	0.79
Channidae	Channa	50	22.1	26.8	48	0.53	<u>0.23</u>	0.30	0.49	0.56	0.56 x	
Pangasidae	Pangasius	polyuranodon	Duara	83	32.2	38.4	58	0.70	0.39	0.46	0.56	0.66
Cyprinidae	Cylocheilichthys	apogon	Emperas	21	5.1	7.3	17	0.81	<u>0.23</u>	0.35	0.30	0.43 x
Cobitidae	Botia	hymenophyssa	<u>Egopatik</u>	23	15.1	17.6	30	1.30	0.66	0.76	0.50	0.59
Cyprinidae	Thynnichthys	rhynoides	Enjukan	60	23.2	22	45	0.75	0.39	0.50	0.52	0.59
Cyprinidae	Leptobarbus	hoenii	Jelawat	20	11.5	14.7	20	1.00	0.57	0.74	0.57	0.74
Cyprinidae	Roblethichthys	microteps	Kapas	30	15.4	16.1	21	0.70	0.51	0.54	0.73	0.77
Cyprinidae	Amblyrhynchichthys	truncatus	Kedukul	28	14.4	19.6	25	0.89	0.52	0.70	0.58	0.78
Cyprinidae	Osteochilus	melanopleura	<u>Kelabau</u>	37	14.7	19.0	47	1.27	0.40	0.51	<u>0.31</u>	0.40 x
Cyprinidae	Osteochilus	schlegelii	<u>Kelabau putih kehalil</u>	40	13.6	19.2	36	0.90	<u>0.34</u>	0.48	0.38	0.53 x
Cyprinidae	Parachela	oxygastroides	<u>Kelampak</u>	20	8.6	11.2	25	1.25	0.43	0.56	<u>0.34</u>	0.45 x
Clariidae	Clarias	batrachus	Kelik	40	<u>24.7</u>	<u>29.1</u>	<u>40</u>	1.00	0.62	0.73	0.62	0.73
Clariidae	Clarias	leiacanthus	Kelik	33	<u>24.7</u>	<u>29.1</u>	<u>40</u>	1.21	0.75	0.88	0.62	0.73
Clariidae	Clarias	meladerma	Kelik	34	<u>24.7</u>	<u>29.1</u>	<u>40</u>	1.18	0.73	0.86	0.62	0.73
Cyprinidae	Luciosoma	trinema	Kenyuar	25.5	11.0	11.7	25	0.98	0.43	0.46	0.44	0.47
Channidae	Channa	pleurophthalmus	Kerandang	40	23.1	23.0	36	0.90	0.58	0.57	0.64	0.64
Eleotridae	Oxyeleotris	marmorata	Kelutuk	46	24.5	30.6	48	1.04	0.53	0.66	0.51	0.64
Cyprinidae	Labobarbus	festvus	Kupang	24	15.6	7.2	29	1.21	0.65	0.30	0.54	0.25
Siluridae	Kryptopterus	micronema	Lais bangah	32.5	41.0	50.6	68	2.09	1.26	1.56	0.60	0.74
Siluridae	Ompok	hypophthalmus	Lais butu	31	19.7	22.6	40	1.29	0.64	0.73	0.49	0.56
Siluridae	Kryptopterus	apogon	<u>Lais jukung</u>	77	24.3	28.7	61	0.79	<u>0.32</u>	0.37	0.40	0.47 x
Bagridae	Mystus	nigriceps	Landin	33.5	12.8	15.0	21	0.63	0.38	0.45	0.61	0.72
Cyprinidae	Hampala	macrolepota	Langkung	70	25.1	27.1	40	0.57	0.36	0.39	0.63	0.68
Schilbiidae	Pseudeutropus	brachypterus	Nuayang tebal	11.5	<u>6.4</u>	<u>8.2</u>	<u>16</u>	1.39	0.55	0.71	0.40	0.51
Schilbiidae	Pseudeutropus	moolenburghae	Nuayang tipis	10	<u>6.4</u>	<u>8.2</u>	<u>16</u>	1.60	0.64	0.82	0.40	0.51
Cyprinidae	Osteochilus	kahajanensis	Palau	22	<u>10.4</u>	<u>11.3</u>	<u>22</u>	1.00	0.47	0.52	0.47	0.52
Cyprinidae	Osteochilus	kappeni	Palau	17.5	<u>10.4</u>	<u>11.3</u>	<u>22</u>	1.26	0.60	0.65	0.47	0.52
Bagridae	Mystus	nemurus	<u>Patik / baung</u>	57	19.6	22.7	60	1.05	0.34	0.40	<u>0.33</u>	0.38 x
Pristolepididae	Pristolepis	fasciata	Patung	21	10.0	12.4	21	1.00	0.48	0.59	0.48	0.59
Cyprinidae	Leptobarbus	melanopterus	Piyam	24	14.0	14.7	30	1.25	0.58	0.61	0.47	0.49
Channidae	Channa	manuloides	Piyang	27	28.1	27.9	41	1.52	1.04	1.03	0.69	0.68
Bagridae	Mystus	micracanthus	Rik	15	7.0	8.7	18	1.20	0.47	0.58	0.39	0.48
Dainiidae	Dainioides (Cous)	microlepis	<u>Rongau</u>	47	18.1	22.0	31	0.66	<u>0.34</u>	0.47	0.52	0.71 x
Channidae	Channa	barienseis	Runtuk	23.5	<u>18.2</u>	<u>23.2</u>	<u>40</u>	1.70	0.82	0.99	0.48	0.58
Channidae	Channa	fasciata	Runtuk	36	19.2	23.2	40	1.11	0.53	0.65	0.48	0.58
Channidae	Paradoxodacna	piratica	Senara	? 10	7.4	9.3	22	2.20	0.74	0.93	<u>0.34</u>	0.42 ?
Channidae	Parambassis	apogonoides	Senara	? 9	7.4	9.3	22	2.44	0.83	1.04	<u>0.34</u>	0.42 ?
Channidae	Parambassis	macrolepis	Senara	? 10	7.4	9.3	22	2.20	0.74	0.93	<u>0.34</u>	0.42 ?
Channidae	Parambassis	wolfii	Senara	? 20	7.4	9.3	22	1.10	0.37	0.47	<u>0.34</u>	0.42 ?
Engraulidae	Lycothissa	crocodilus	Silauri	24	14.5	15.5	19	0.79	0.60	0.64	0.76	0.81
Engraulidae	Setipina	cf. melanochir	Silauri									
Siluridae	Wallago	teeri	Tapah	150	59.7	50.0	130	0.87	0.40	0.33	0.46	0.38
Siluridae	Betodotichthys	dinema	Tebirin	70	46.6	47.7	73	1.04	0.67	0.68	0.64	0.65
Cyprinidae	Labeo	chrysopekadion	<u>Temuai</u>	80	13.8	18.5	34	0.43	<u>0.17</u>	0.23	0.40	0.54 x
Cyprinidae	Barbodes	schwanenfeldi	<u>Tengadak (Isuain)</u>	35	7.1	8.1	23	0.86	<u>0.20</u>	0.23	0.31	0.35 x
Cyprinidae	Puntipolites	bulu	<u>Tengalan</u>	37	<u>17.1</u>	<u>22.8</u>	<u>53</u>	1.43	0.46	0.62	<u>0.32</u>	0.43 x
Mastacembelidae	Mastacembelus	erythrotaenia	Titan belaban	? 76	12.6	18.9	73	0.96	<u>0.17</u>	0.25	0.17	0.26 ?
Mastacembelidae	Macrognathus	maculatus	Titan kapar	? 28	12.6	18.9	73	2.61	0.45	0.68	<u>0.17</u>	0.26 ?
Mastacembelidae	Macrognathus	aculatus	Titan ketokoi	? 27.5	12.6	18.9	73	2.65	0.46	0.69	0.17	0.26 ?
Mastacembelidae	Mastacembelus	unicolor	Titan ketokoi	? 55	12.6	18.9	73	1.33	0.23	0.34	<u>0.17</u>	0.26 ?
Channidae	Channa	micropeltes	Toman	100	37.8	38.9	97	0.97	0.38	0.39	0.39	0.40
Cobitidae	Botia	macracanthus	<u>Ujung uli</u>	30	4.4	5.9	20	0.67	<u>0.15</u>	0.20	0.22	0.29 x
Cyprinidae	Puntipolites	waandersii	<u>Umpan</u>	50	12.3	15.4	37	0.74	<u>0.25</u>	0.31	0.33	0.42 x

## Notes

for Toman reported lengths of less than 10 cm were excluded from the calculations for Jelawat lengths less than 12 cm were excluded from the calculations

**Table 6. Fishes commonly caught that reach a maximum size greater than 15 cm. A comparison of typical total length in the catch with the maximum possible length gives a crude indicator of intensity of fishing for each species. Common names for fishes this measure indicated a possible problem are underlined. Maximum size was taken from the literature. If maximum size in our samples (max) exceeded the value from the literature then the largest size from our samples was used in calculating the indicator. If the indicator was less than 0.35 it was taken as a suggestion that the average size caught was relatively small compared to the potential maximum size.**

Another indicator using the average of typical large fish in each catch is provided for comparison (ave L/ max or ave L/ lit). Because forms did not always contain information about fish lengths, sometimes ave L is smaller than ave.

Common names were taken from the data forms and, after some consolidation,



matched with scientific names from Widjanarti (1996). Boxes enclose data from species sharing the same common name.

**NOTES:** ave=average of “average length” reported on the catch forms, ave L=average of “length of large fish” reported on forms, max=largest size reported on any form, lit=maximum length reported in Kottelat *et al.* (1993) or from Giesen (1987).

### **Fishery Management Considerations**

#### **Goals**

The overall fishery management goals of Indonesia include the provision of food and employment as well as management to ensure long term productivity of the fishery and the allocation of the fish catch among a relatively large number of people.

Management of the national park implies other goals such as: the protection of biodiversity, the protection of endangered species, general protection of flora and fauna, and the park itself. In fact it is generally agreed that, under Indonesian law, people cannot live within a wildlife park. This legal situation complicates efforts at co-management of the resource because, legally, local people should not be there. Legalities of resource ownership are beyond the scope of this paper, except to say that residents of DSNP have fished in the area for many years. However, numbers of park residents is much greater now than in the recent past.<sup>21</sup>

In theory the issue of resource allocation is reasonably straightforward. Any permitted fish harvest should be allocated to persons who traditionally fished in DSNP. In addition to people living in the park, people from outside the park, from towns along the Kapuas River and from Dayak villages to the north, have traditionally fished within the park, especially during the dry season. Also, fish leave the park during low water, and allocation of permitted fish catches to those outside the park must also be considered.

The general goals of fishery management at DSNP, might be stated thusly:

To manage the DSNP fishery: on a sustainable basis, for harvest by persons traditionally involved in the fishery, in a way that will protect and enhance the wildlife park functions of DSNP.

#### **Size considerations**

Within DSNP some fish species are caught at sub-optimal sizes because of the many types of small-mesh fishing gear being used. Several species identified by villagers as being less abundant than in years past (see page Figure 23) are also species that would typically reach larger sizes than are currently common. As an example *belantau* is listed as having a maximum length of 100 cm (Kottelat *et al.* 1993), but the largest specimen recorded during our three year catch survey was 35 cm, and most individuals examined were less than 30 cm. It is possible that the *belantau* population has been reduced by excessive fishing especially with small mesh gears.

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<sup>21</sup>Giesen (1987: 184) reported that many villages are fairly recent, but that others were established in the 1800's or earlier. He notes also that the populations of the larger villages grew rapidly during the 1980s, and Aglionby (1995) reported that the permanent population of the park had grown 40% in the last 10 years.

Various workers (e.g. Beverton and Holt 1959) have reported that the ratio of size at first maturity to maximum size is a constant within species groups. This ratio falls between 0.4 and 0.8. That is, for some species, size at first spawning is 40% the maximum size while for others the ratio is larger. For commonly caught DSNP species we can compare maximum size reported in the literature to typical sizes reported in our DSNP catch data. In lieu of other measures, the ratio of typical size to maximum possible size can be used as a general indicator over-harvest to indicate which species warrant further study. Table 6 contains 48 fish<sup>22</sup> which are both reasonably abundant in DSNP catches and also reach a maximum size of 15 cm or more. Also indicated on this table is the ratio of the typical size<sup>23</sup> in the catch to the expected maximum size. Species where this ratio is less than 0.35<sup>24</sup> are considered "possibly over-fished." The biology of these fishes should be investigated, particularly with regard to their size at first breeding. These 17 species are:

*Belantau*: Reported as rare by fishermen since the 1960's, and large individuals are no longer present.

*Belida*: Listed as a protected species by Indonesia since 1980<sup>25</sup>, and is rare in other areas of Indonesia where it was formerly abundant. The population at DSNP is healthy, but the diminishing size of *belida* in the is of concern.

*Ulang uli*, *engkadik*, and *ringau*: Ornamental species important for the aquarium trade. *Ringau* is vulnerable because it has a relatively large size at breeding compared to its marketable size, and large individuals are rare. Populations of the other two seem tolerant to extreme fishing pressure on the young. Over two million *ulang uli* are exported from the Kapuas Hulu year after year. The adults of both species are increasingly rare, and collapse of these fisheries could occur.

*Kelabau*, *kelabau putih*, *tengadak*, *tengalan*, and *umpan*: These similar species of the cyprinid family, capable reaching moderate sizes (35 to 50 cm depending on the species), are generally caught at smaller sizes in small-mesh gill nets, and other gear. Generally, large specimens are absent from the catches.

*Temunit*: Although fairly common, fishermen claim, and data support this claim, that large specimens are absent. The largest individual recorded in our catches was less than half the maximum size.

*Delak*: One of several similar species. Data concerning it may not be accurate. Members of this genus (*Channa*), including *toman*, are an important component of the hook fishery, and require further study.

*Bauk ketup* and *bauk tadung*: Common in cast nets and *jermal*. May not be "over-fished" since both abundant at times. Nevertheless, large specimens are not common in the catches.

*Kelompok*: Caught in cast nets and *jermal* but make up only a moderate to small proportion of the catch.

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<sup>22</sup>These 48 common names include 56 species names.

<sup>23</sup>Data collectors were asked to recorded the largest, smallest, and "normal" size of fish in each catch.

<sup>24</sup>This is an arbitrary value, but is based on the idea that fish might start breeding at sizes as small as *perhaps* 0.4 times the maximum length. If the average size in the catch is  $0.35 L_{\max}$  then some fish will have a chance to breed even if fishing is intense.

<sup>25</sup>Protected by Ministerial Decree: Kep. Ment. Per. No. 716/Kpts/Um/10/1980.

*Lais jungang*: An important component of the gill net fishery. Larger specimens are fairly rare.

*Patik* (= *baung*) is probably not currently in danger of being over fished. It is abundant, although large specimens may not be as abundant as in the past.

### Species of Special Interest

Other fishes reported as rare or of significantly lowered abundance, but not indicated by the size ratio above, are reported in Table 7. Only two *siluk* were reported during our survey. This species was formerly common. Trade in this ornamental fish is an extreme example of what results if adequate controls are not in place when a natural product increases in value. Twenty years ago fish traders realized that red phase *siluk*, found primarily the DSNP area, could be sold for as much as \$3,000. The resulting intensive fishery almost exterminated this species.<sup>26</sup>

<i>siluk</i> (=arowana)	Very high price and resulting intensive fishing has almost exterminated this species from the wild.
<i>bubuk</i> (=paku)	Also reported as rare by Giesen (1987).
large <i>jelawat</i> (those over 3 kg)	Large specimens are very uncommon. Widely cultivated. Not endangered but no longer an important component of the fishery.
<i>piam</i>	Still present but no longer numerous.
<i>ketutung</i>	Fisherfolk now consider these extremely rare, but were formerly abundant. They are no longer caught, and were not reported in our catches. None reported by Kottelat (1993) or Widjanarti (1996). However, Giesen reported this species as abundant in 1987.
<i>kapas</i>	Reported by fishermen as less abundant than in years past. However, this species was listed on over 200 (5%) of our forms, and the sizes caught do not indicate any obvious problems.

**Table 7. Types of fish reported as rare by DSNP fisherfolk. Based on field notes, especially discussions with fishermen in Nanga Kenelang, 5 November 1992.**

*Ulang uli*, intensively harvested in Kalimantan and Sumatra for the aquarium fish trade, may be over-harvested in the Kapuas Hulu region. Large specimens are rarely encountered by fishermen. A local regulation requires that *ulang uli* larger than 15 cm be released. The market for this species is for smaller specimens but larger specimens are vulnerable to gill nets.

*Ulang uli* are migratory, but the nature of the migration is unknown. Young fish first appear in December and January with a second peak in abundance occurring in April and May. Prasetyo and Ahmadi (1994) reported a similar catch pattern for *ulang uli* in the Batang Hari River in Sumatra. There fish less than "2 inci" were caught downstream, implying that spawning may be in downstream areas. *Ulang uli* caught in DSNP are usually 2 to 6 cm and average somewhat less than 5 cm. Information on the growth, migration and breeding of *ulang uli* is essential for better management.

<sup>26</sup>Attempts to increase the value of other harvested products must be coupled with initiatives carefully manage the resource in question. In this regard particular attention should be paid to *siluk*, *belida*, *ketutuk*, *ulang uli*.

Fisherfolk report that large *jelawat* are no longer caught in DSNP area. Although, the size ratio used above did not detect *jelawat* as a species needing attention this result is because the maximum size reported in the literature (41 cm in Kottelat *et al.* 1993, and 60 cm in Giesen 1987) is considerably smaller than the actual potential maximum size. Using a length-weight relationship (Christensen *et al.* 1986) the corresponding weight for a 60 cm fish would be about 5 kg. However, Sachlan (1957) reported *jelawat* as large as 18 kg. It seems possible, then, that *jelawat* are harvested at sub-optimal sizes.

*Toman* occur in over 80% of catches from large and medium size hooks, and comprise about 50% of the weight caught by those gears. A recent<sup>27</sup> development in DSNP communities is the raising of *toman* in cages (see Dudley and Widjanarti, 1993; Aglionby 1995). This lucrative activity provides almost one third of the total fish-related income in DSNP. Schools of juvenile *toman*, 3 to 5 cm long, are captured with cast nets in quiet backwaters. They are raised in wooden cages for 12 to 15 months until they reach 0.8 to 1.5 kg. While in the cages they are fed fish which are caught by any means possible.

Two potential fishery problems arise from *toman* cage culture. Firstly, large numbers of juvenile *toman* are taken from the wild,<sup>28</sup> and secondly a large amount of fish is caught to feed *toman*.

One opinion is that cage culture of fish is less destructive of the overall resource than fishing and thus is a reasonable money earning option for park residents. However, both cultured *toman* and their food are taken from the wild. Importantly, *toman* culture is carried out in addition to, not instead of, fishing activities. While *toman* cage culture earns needed money for people, uncontrolled growth of this practice could endanger DSNP resources. Consequently, it is necessary to limit, rather than promote, cage culture of *toman*. One approach might be to limit the number of *toman* cages per family.

*Toman* culture relies exclusively on the capture of juveniles from the wild, and may eventually endanger *toman* populations. At present adult *toman* are common, but as more young are taken from the wild, a negative seems likely. Villagers believe that the fishery for adult *toman* is facing a problem, and many villages have instituted regulations limiting capture of juvenile *toman*. Most have limited the minimum size at which the juveniles can be kept.<sup>29</sup> In some villages the fishery for juvenile *toman* had been (in 1995) closed.

The capture of large numbers of small fishes, including juveniles, for use as *toman* food, also seems problematic as this may add to the early mortality of important species (see also the sections on Natural Mortality and *Jermal* below).

*Ketutut* are increasingly important in the live fish food trade, and are held in cages until sold. They are caught in small numbers in medium and small-mesh gill nets and in traps. *Ketutut* over 0.5 kg were sold while those under 0.4 kg are held in cages and fed

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<sup>27</sup>Giesen (1987) in a thorough study of the DSNP area did not discuss *toman* culture. Apparently *toman* culture was not important at that time.

<sup>28</sup>There are approximately 1,500 *toman* cages each stocked with 750 or more fish giving a total of about 1,125,000 fish being raised. Perhaps 67% of these cages are restocked with new fish each year requiring perhaps 750,000 *toman* fingerlings per year.

<sup>29</sup>This is also partly due to the fact that *toman* smaller than about 3 cm do not survive well in captivity.

until they are bigger.<sup>30</sup> *Ketutut* apparently spawn in DSNP, and juveniles (2 to 3 cm long) are known to frequent the shoreline at night. There are some reports that the young emerge onto shore. Some villagers believe that *Ketutut* are becoming less abundant, and several villages already have regulations limiting the size of capture of *ketutut*, or forbidding the capture of young. It seems inevitable that cage culture of this species will be attempted.

### **Fish Movement**

Most fish leave DSNP during the dry season and thus are available to fishers outside the park. The flooded area at low water is often a small fraction of the high water area. Not only must fish leave DSNP, but they are forced to move significant distances and in doing so become more vulnerable to various types of fishing gear. Conversely, fish are carried into the park during rapidly rising water when the Tawang River flows into the park at rates exceeding 2,000 m<sup>3</sup> per second (Klepper 1994). Thus fish within DSNP originate from and return to the Kapuas River.

### **Natural Mortality**

Natural mortality of fish, particularly young, is linked to yearly variations in water level. As water drops young (and other small) fish are increasingly vulnerable to predation. Lowered low oxygen concentrations in dropping waters probably increases mortality as well. During years of especially low water these effects are intensified. Predatory air breathing fish, such as members of the family Channidae (*toman* and related species) have more access to food during low water and are not affected by low oxygen concentrations.

In general fish populations that experience high natural mortality are less affected by intense fishing. Fish not caught will die of natural causes in any case. This situation, typical of floodplains, implies that harvest of floodplain fisheries can be fairly intensive without causing undue harm to the fish population.

Nevertheless, the ultimate ecological role of dying fish should be considered, particularly in a wildlife park. Under natural circumstances dying fish would be eaten by predator fishes and other predators including piscivorous birds. A puzzling aspect of DSNP is the very low population of fish-eating birds, especially when compared to floodplains elsewhere. Giesen (1987, citing a report from 1903, and comments from DSNP residents) reported evidence of formerly abundant water bird populations. Egg collecting might account for disappearance of colonial water birds such as herons and egrets, while hooks and gill nets could account for the disappearance of other fish-eating birds.

### **Potentially Destructive Fishing Methods**

Certain fishing methods are often viewed as destructive. The most widely cited example from DSNP is poison used by Dayak villagers (Giesen 1987, Aglionby 1995). However, other fishing gears are sometimes viewed as harmful. Within DSNP gill nets are banned in the village of Nanga Laboyan, and funnel nets (*jermal*) are illegal in many villages.

The deleterious nature of a fishing method depends on one's perspective. Dayak villagers catching fish in the traditional way (using poison) have a very different view than do Malay villagers downstream who see their caged fish dying as a result. Villagers

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<sup>30</sup> Author's field notes 5 September 1992, Nanga Pengembung.

using *jermal* to catch *ulang uli* have a different view from those who perceive *jermal* as overly efficient nets which allow a few individuals to capture large numbers of fish. While recognizing that all fishing methods catch fish, characteristics which define “destructive” fishing methods might be:

1. Catch excessive numbers of fish prior to the minimum spawning size.
2. Cause the death of numerous fish which are not caught or used.
3. Are so efficient that fishing opportunities for other people are significantly decreased.
4. Cause the unnecessary death of organisms other than the target fish.

Many fishing methods might fall within these categories if used without regulation. Methods within DSNP most likely to cause these problems are poison, *jermal* and small-mesh gill nets. The use of both *jermal* and poison are already sensitive issues in the area and both have been the subject of various regulations.

### Poison

Dayak villagers use poison to catch fish primarily during the dry season. Often use of poison causes death of excessive numbers of fish including those raised in cages by Malay villagers living downstream. Although traditional law specifies sanctions for improper use and types of poisons, some incidents have resulted in the involvement of police and intervention by the Governor (see Aglionby 1995).

Although use of traditional of fish poisons have long been a part of Dayak life, the negative impacts of poison on fish populations and on other fisherfolk are a critical issue. While the Iban (the Dayak group of the area) have rules and procedures for communal fishing with natural poisons (see Sandin 1980), the demographic and social environment of the villagers has changed so much that poisoning should not be practiced as freely as it once was (Wadley pers. com.). Ideally the use of poison should be phased out. The first steps toward making this transition would be enforce traditional law to eliminate the use of non “natural” poisons, to restrict poisoning to small areas, and to require agreement of other villages in the area.

### *Jermal*

Formerly, *jermal* were primarily used to catch ornamental fishes, especially *ulang uli*. With the growing importance of *toman* cage culture, *jermal* have become a primary method of catching anything that can be fed to caged *toman*. Much of the controversy over *toman* culture is related to the use of *jermal* and their perceived impact on fish abundance. *Jermal* account for 10% of the annual DSNP catch. This is taken by relatively few individuals (perhaps 250), compared to more than 1,000 gill net users.

*Jermal* are, in theory, limited by a fisheries department permit requirement.<sup>31</sup> Many villages also have specific regulations related to seasons and places where *jermal* can be used. A number of villages prohibit *jermal*. The current efforts to limit *jermal* are worthwhile and should be continued. An effort should be made to decrease the role of *jermal* in providing food for *toman*. Possibly regulation could limit the size (mouth opening) of *jermal*, prohibit *jermal* which block more than 20% of a river, require *jermal* to be at least 200 m apart. Mesh size regulations for *jermal* are not realistic given their role in the *ulang uli* fishery.

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<sup>31</sup>The requirement is also a source of income for the fisheries department.

### Small-Mesh Gill Nets

*Kelabau*, *kelabau putih* (= *kebali*), *tengadak* (= *suain*), *tengalan* and *umpan* were identified as “over-fished” based on their sizes in the catch. These species are common in small-mesh gill net catches, and it is likely that excessive use of such nets are responsible for a decline in abundance of larger specimens. Gill nets with meshes of less than 2 inches account for over 58% of the gill nets recorded in the fishing gear survey, and over 45% of the gill nets encountered in the catch survey.<sup>32</sup> It is probable that large numbers of small-mesh gill nets are exerting a negative influence on DSNP fish populations by a) catching young fish prior to their spawning and b) by preventing fish from reaching an optimal size prior to harvest.

Very small-mesh nets (less than 1.75 inches ) could be easily phased out because they comprise only 3% of gill nets. Because 55% of gill nets in use had a mesh size of 1.75 inches, further limits on mesh size may be difficult to institute. Nevertheless, it seems likely that a minimum gill net mesh size of 2 inches would be helpful, and regulation requiring meshes of this size or larger might be phased in over a two or three year period to allow retirement of smaller mesh nets.

Better management of large-mesh gill nets, used to catch *belida*, is also possible. *Belida* nets, especially those set across rivers, should have meshes that catch *belida* perhaps 50 cm or larger. The best mesh size for this approach is not yet known, but may be as large as 5 or 6 inches. Fisherfolk may be supportive of such a regulation and could suggest appropriate mesh sizes.

### Suggested Fishery Management Approach

#### The Fishery and its Relation to the Park

At present there is little or no effect of DSNP on the fishery. No new regulations specifically associated with the existence of the park have been implemented. Because the park could act as a fish refuge during much of the flood season, and because some fish species are rare or said to be less abundant than in previous years, controlled and more restrictive fishing policies can benefit villagers, including those in areas outside DSNP. Overly strict regulation of fishing activity would limit the fish harvest and the livelihood of local people. Although considerable attention has been given to maintaining fish harvests by residents within the park, consideration also needs to be given to the role the park can play in protecting fishery resources. Since regulations are rarely enforced except at the local level: 1) enforcement will probably have to take place at the local level with support, when necessary, from local police, and 2) the existence of DSNP can be used to enhance protection and management of the fishery resource.

Human fishing activities have a direct effect on the integrity of the wildlife park. The large amount of fishing gear (especially hooks, traps and gill nets) has an impact on fish and other fauna (e.g. birds, turtles, crocodiles, snakes). The extent of this effect is difficult to gauge because these organisms were likely depleted over many years. Some of this impact, such as the entanglement of birds in fishing nets, is inadvertent, but some is intentional. These include activities directed at particular species (e.g., *siluk*) and continued use of poison for fishing. Excessive harvest of forest products for fishing use may also contribute to adverse effects of fishing on DSNP habitat. The harvest of rattan

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<sup>32</sup>Additional amounts of small-mesh netting was used in combination with larger meshes, but the ratio of mesh sizes in the mixed nets is not known.

for making fish traps (and for other uses) is one example of human induced changes to DSNP flora (Peters 1993, 1994, 1995a, 1995b).

More general impacts associated with human activity affect wildlife park habitats. The major activities of this type are fire (Luttrell 1994), agriculture (Colfer *et al.* 1993a, b, c, d), harvest of timber and forest products (Indriana, N. 1995, Peters 1993, 1994, 1995a, Colfer *et al.* 1993e), and hunting (Colfer *et al.* 1993f, Wadley *et al.* 1997). Of these a major concern is fire with over 20% of the park having been burnt in recent years.<sup>33</sup> For a summary of human impacts on DSNP see Giesen (1995).

### Fishery and Park Management Starting Points

Of primary importance for park protection and better fishery management is the need to limit the number of people living within the park. Resources are limited, and an increasing human population has adverse effects on wildlife and habitat. The sensitivity of this issue prevents government agencies and NGOs from discussing it seriously. The first step toward limiting the number of residents could be to provide current residents with exclusive rights to live within the park and use rights for specified park resources. Residence permits might be issued in several forms (Table 8). In exchange for residence and use rights recipients could be obligated to abide by conservation regulations developed by their community in cooperation with appropriate agencies.

For better management of the park, it is essential that existing information be supplemented with a better understanding of the biology and ecology of fish. Information needed includes that about spawning periods, potential and actual maximum size, age, growth rates, size and age at maturity, and migration patterns. In addition, discovery of significant behavioral traits (such as special feeding or spawning requirements, and migratory behavior) would be important for fishery management.

Suggested Permit	Purpos	Time
<u>Permanent stay</u> _____ to be issued long-term residents only (have DSWR more than 8	To provide a fixed long-term DSWR residents the assurance that stay within	No time
<u>Limited stay</u> _____ for persons have lived within DSWR only years (have lived in DSWR 3 years)	To give shorter term an opportunity to DSWR for a limited years	3 to 5 (not
<u>Temporary</u> _____ for other term residents (have lived reserve less than 3 years) who traditionally have reserve for fishing or other management purposes, purposes are in agreement plan	To provide a legal persons to carry out traditional activities reserve. Should <u>limite</u> to those people who traditionally had access to resource	1 to 5 Renewable year but renewable year

**Table 8. Suggested types of residence permits for DSNP. The concept of residence permits, and a target park human population, may have to come from outside the DSNP community, but the actual details of its implementation should come from the villagers themselves.**

<sup>33</sup>Prior to the very dry 1997 dry season.



Design Principles for Collective Management of a Common Property Resource (adapted from Ostrom 1990)	Current DSNP Situation	Needed Actions
1. Clear boundaries and membership: People who participate in the harvest and management of resources are clearly identified. Boundaries of the resource are also clearly defined.	At present villagers within DSNP do not have recognized exclusive rights to fish, but do have local rules which usually require outsiders to have permission to fish within a village area. For each village a specific "work area" is recognized.	Work toward establishment of exclusive rights of DSNP villagers to fish within the context of a minimum set of conservation rules.
	However, there are ties between many villages and their "parent villages" outside the park along the Kapuas. It is possible that people from these Kapuas towns might also claim park resources. Others traditionally fish within the park.	Clarify other possible claims on park fishery resources and attempt to strengthen claims of villages within the park.
	In addition, there have been some statements from higher officials that the park's fishery is open to everyone.	Work to assure that officials at various levels recognize the claims of DSNP villagers on the fishery resource (within the conservation framework).
	Although villagers tend to recognize a need for overall fishery resource management, their current resource control mechanism extends only to each village's "work area."	See actions under Number 8
	In addition, fish migrate out of the park and are subject to fishing by "outsiders" during the dry season. However, villagers seem to accept this fact.	Examine the relative effects of fishing within and outside the park. If necessary implement rules at a level which includes areas outside the park. (see item 8)
	Note: In some ways the fishing area can be viewed as the collectively managed resource. Nevertheless, rules related to management of the fish resource itself are necessary.	

<p>2. Congruent rules: Operational rules about how the resource is used are related to local conditions. In general those who use more of the resource should expend more time money or effort.</p>	<p>Rules developed in each village are specific to that village's needs. However, because fish migrate, rules for the whole area are needed, but do not exist. Village level rules differ among villages.</p>	<p>Work toward improved understanding of the need for fishery management over the entire research and surrounding area. Also see Numbers 3 and 8.</p>
	<p>Villagers' (and managers') understanding of fish populations is limited. Consequently current understanding may not be sufficient for making appropriate rules.</p>	<p>Examine and improve villagers' information about biology and ecology of fish populations so that information can be incorporated into local rules. Use their information and new information to assist them in formulating fishery rules.</p>
	<p>Rules are generally equally applied to all people. There may be tendencies for those with more money to have more gear, but fishing sites seem to be allocated fairly (e.g., by lottery, rotation).</p>	<p>Encourage the idea that any new limitations (for example fishing gear limitations) should affect villagers in a equitable way.</p>
<p>3. Collective choice arrangements: People who are actually involved in using the resource have an opportunity to modify the rules governing resource use.</p>	<p>Villagers currently are involved with making village level rules regarding fish catching and fishing site allocation. There also seem to be inter-village mechanisms regarding the rules related to each village's work area.</p>	<p>Encourage the continuation and improvement of this system. Encourage the recognition of it as the fishery management system (within the conservation framework).</p>
	<p>Above the village level there are no such arrangements, although they are essential for good management of the fishery.</p>	<p>Assist in the establishment of arrangements to encourage park wide (and perhaps wider) rules regarding fish catching. See actions under number 8.</p>
<p>4. Monitoring: Users of the resource are responsible for monitoring the use of the resource, either directly or indirectly.</p>	<p>People in these villages generally know what is being done by their neighbors. Monitoring is done by the fishers themselves, at least at the village level.</p>	<p>Work to improve monitoring abilities to include inter-village cooperation.</p>
<p>5. Graduated sanctions: There is a series of gradually increasing punishments for violation of the rules. These depend on the seriousness</p>	<p>Most villages have fines or other measures to punish violators within the village work area. However, there are no mechanisms for park</p>	<p>Establish a park wide system of sanctions for park wide rules. These can probably be monitored at the village level since most fishing</p>

and the context of the offence.	wide rule making or sanctions.	occurs within each village work area.
6. Conflict resolution mechanisms: Some sort of arrangement is necessary to discuss and resolve conflicts and disagreements that will arise.	<p>This approach may be available at the village level.</p> <p>Nevertheless, disagreements exist resulting from different rules in different villages (e.g., use of <i>jermal</i>, poison, gillnets), and there does not seem to be an effective mechanism, within the resource management context, to resolve these disagreements.</p> <p>Such disputes sometimes are brought to local police or government officials.</p>	<p>Establish, or improve existing, conflict resolution mechanisms, especially those for solving inter-village conflicts if they should arise.</p>
7. Recognized rights to organize: External authorities do not interfere with the resource users right to devise their own rules.	<p>Normally external authorities do not interfere with village level regulations. However, this may be merely due to a lack of interest on the part of the external authorities.</p> <p>Sometimes, however, external authorities make rules or suggestions for rules which indicate that they do not formally recognize the village level regulations.</p>	<p>Assure that village and park level regulations, and rights to modify them, are officially acknowledged (within the framework of conservation rules).</p>
8. Nested units: For more complex resource systems a system for developing management rules at several levels might be necessary.	<p>There is no specific organization made up of resource users above the village level.</p>	<p>It is essential to help villagers establish fishery management units above the village level.</p> <p>These should be established at two (or three) levels: 1) groups of adjacent villages, 2) the whole DSNP, and perhaps 3) the DSNP plus surrounding villages where fishing is important.</p>

Note: Five sub-districts (*Kecamatan*) form the next higher legal entity above the village level. However, use of these as resource management units may divide rather than unite the DSNP villages. Nevertheless their cooperation is needed.

Work to assure that higher level mechanisms operate to unite park villages in their management of the fishery (for example across *Kecamatan* boundaries).

Suggested Needs for Collective Management within a Conservation Area	Current DSNP Situation	Needed Actions
1. Clearly defined rules and requirements for conservation (approved by conservation authorities) within which fishery (and other resource) rules can be formulated by resource users.	Although many conservation regulations exist, virtually none are enforced except perhaps in the case of large scale violations.	There is a need to formally incorporate conservation rules into the fishery regulations of the park fishery management program.
	Residents are generally aware of the status of the area as a wildlife park. They are also reasonably aware of the overall goals of conservation.	There is a need to continue awareness programs related to conservation goals, and to incorporate conservation enforcement into the fishery management package.
	Nevertheless, villagers have only been given a general idea as to what is expected of them in terms of conservation.	Conservation rules need to be formulated and will, necessarily include some restrictions on fishing methods. Fishery management rules created by resource users need to recognize these.
2. The number of people living in a conservation area should be limited and, over time, should be reduced.	The DSNP population has grown by over 40 percent in the past 10 years.	There is a serious need to stabilize the population of the park. A system of (a fixed number) of residence permits is suggested.
3. Benefits which might accompany conservation activity (e.g., better fishing, eco-tourism) should go to those who had prior resource rights.	This is the de-facto situation at present. However, there is currently no formal arrangement for these rights.	There is a need to establish a system to determine, and prioritize, any prior rights to park resources.

		Even though rights to certain resources may need to be limited by rules of the conservation framework, those with previous rights should have priority in receiving any benefits which might come from the protected area.
4. Arrangements for special rights within the park, need to incorporate a clear statement of who has such rights, what those rights are, and by what process they might be modified.	There is no formal recognition of such rights, although most parties seem to agree to this idea in principle.	Individuals and groups having special rights should be identified and their special rights within the park formalized and recognized.

**Table 9. Actions needed at DSNP in relation to management of the fishery as a locally managed common property resource.**

#### **A Suggested Framework for Cooperative Management of Fisheries within DSNP**

Although few effective means of governmental fishery regulation and enforcement exist at DSNP, this need is fulfilled, to a limited extent, by a system of village-level rules regarding fishing access, sites, and types of gear. These rules tend to be based on the perceived amount of fish available and on the relation between available fishing locations and village population. In some cases specific gear types are not allowed or certain types of fish cannot be captured. Local regulations form core of management ideas around which more comprehensive regulations can be structured. Comments about village-level fishery regulations can be found in Anon (1993) and Sinaga (1994a, b). Nevertheless, an effective management strategy can only evolve if rules are coordinated among all villages.

#### **Basis of Cooperative Management**

The existence of village level management leads to an overall strategy for fishery management. By building on existing management, managers could incorporate both fishery and conservation needs. Ostrom (1990) believes that if certain "design principles" are met the likelihood of successful long-term local management of a common property resource will be enhanced. Table 8 shows Ostrom's eight design principles with the authors perception of the status of each principle at DSNP and probable actions needed to bring the DSNP situation into line with the principles. In the case of DSNP such design principles would be best applied within a conservation framework, and suggestions for such a framework appear at the bottom of Table 8.

Primary among actions needed to increase the likelihood of success of local management of the fishery resource is the need to formally recognize rights of local people to use and manage their resources.

There is a need to define the extent of the fishery resource for which management rights are recognized. Because fish leave the park during the dry season there is a reasonable concern that management only within the park is inadequate. However, fishing outside the park seems less important, and the Kapuas river channel is not suitable

for many types of fishing. It may be sufficient to define the resource as the fishery within DSNP boundaries.

The ability of the people to make reasonable rules about their fishery needs to be strengthened. Although local people make rules at the village level there is no park-wide mechanism for making fishing rules and such a mechanism should be implemented.

Enforcement of regulations is necessary. Ideally most enforcement will be via peer pressure and cooperation. Nevertheless, sanctions of some sort must apply to those who violate agreed regulations. Presently village level sanctions exist with local police being called in if necessary. Evidence indicates that this approach needs to be strengthened by giving local regulations a firm legal status.

Better information about biology and ecology of fishes would be helpful for management, yet this is not available for many DSNP species. Local knowledge is one source of information. This can be supplemented with scientific studies. Of particular concern is knowledge from both sources related to breeding, migration, and growth of important fish species.

#### **Within a Conservation Framework**

For successful management of DSNP the locally managed fishery must be incorporated into the overall conservation framework. Local rules for fishery management should also comply with a set of conservation rules designed to protect DSNP and its biota. One essential is that the conservation rules be clarified, formalized, and disseminated so that people know what they are. Very probably local people need to discuss these rules, their timetable for implementation, and possible exceptions.<sup>34</sup>

A second link between successful management of DSNP and fishery management is the need to stabilize and decrease the human population of the park. This issue can be linked to the idea of prior resource rights if a reasonable formula can be established to determine which people have prior rights to the DSNP fishery. In addition to the permit system suggested above, which can be implemented over many years, more consideration should be given to improving economic opportunities public facilities in villages outside DSNP so people have more incentive to move or remain there.

A third step toward cooperative management of DSNP and the fishery is to provide an assurance to local people that benefits which might result from better management of DSNP will go to people who had prior resource use rights. For example, programs for eco-tourism should be arranged so that local people, rather than outsiders, are employed. Nevertheless, this approach should avoid representing the primary role of DSNP as a source of income, but income which may derive from the park in the course of good conservation management should, as a first priority, go to people who have prior resource use rights.

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<sup>34</sup>For example, the important fish species *belida* is protected under Indonesian law and accordingly should not be harvested. Nevertheless it is harvested within DSNP, and it would be sensible to allow its harvest to continue. However, this "permission" could be linked to rules suggested to the local people/managers which would provide improved management for *belida*.

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APPENDIX A. COMMON AND SCIENTIFIC NAMES OF FISHES MENTIONED IN THE TEXT, TABLES OR FIGURES. (ADAPTED FROM WIDJANARTI 1996). IN ORDER BY COMMON NAME. ALSO SEE TABLE 6.

Common Names					
Used in Text	Alternate Names		Family	Genus	Species
Bantak			Cyprinidae	Osteochilus	microcephalus
Bauk ketup	Bauk pipih		Cyprinidae	Thynnichthys	polylepis
Bauk tadung			Cyprinidae	Labiobarbus	ocellatus
Baug	Baug kuning		Bagridae	Mystus	planiceps
Betantau	Timah-timah		Cyprinidae	Macrochirichthys	macrochirus
Belida	Belida labuan		Notopteridae	Chitala	lopis
				synonyms: (Notopterus	borneensis)
				(Notopterus	chitala)
Biawan	Bawan	Tambakan	Helostomatidae	Helostoma	temminckii
Bilis			Clupeidae	Clupeichthys	bleekeri
Bubuk			Cyprinidae	Neobarynotus	microlepis
Buin	Engkaras	Kempras	Cyprinidae	Cyclocheilichthys	armatus
Buin	Buing		Cyprinidae	Cyclocheilichthys	repason
Delak	Gabus	Telak	Channidae	Channa	striata
Duara	Juara	Sada'an	Pangasiidae	Pangasius	polyuranodon
Emperas	Engkaras	Mata merah	Cyprinidae	Cyclocheilichthys	apogon
Engkadik	Langli	Pansek	Cobitidae	Botia	hymenophysa
Engkarit	Karit		Cyprinidae	Osteochilus	partilineatus
Engkarit	Karit		Cyprinidae	Puntius	eugrammus
Engkarit			Cyprinidae	Puntius	lineatus
Entukan	Lumo		Cyprinidae	Thynnichthys	thynnoides
Jelawat			Cyprinidae	Leptobarbus	hoevenii
Kapas	Lumbut		Cyprinidae	Rotheichthys	microlepis
Kelabau	Kelabau padi		Cyprinidae	Osteochilus	melanopleura
Kelabau putih=kebali	Kebali batu	Kebali	Cyprinidae	Osteochilus	schlegelii
Kelompok	Entebuloh		Cyprinidae	Parachela	oxygastroides
Kelik	Lele		Clariidae	Clarias	batrachus
Kelik	Kelih		Clariidae	Clarias	leiacanthus
Kelik	Duri		Clariidae	Clarias	meladerma
Kerandang			Channidae	Channa	pleurophthalmus
Ketutuk	Bekutuk	Betutut	Eleotrididae	Oxyeleotris	marmorata
Ketutung	Batang buro		Cyprinidae	Balantiocheilus	melanopterus
Lais bangah	Lais jungang		Siluridae	Kryptopterus	micronema
Lais butu	Lais pendek mulut	Limpok	Siluridae	Ompok	hypophthalmus
Lais empang			Siluridae	Kryptopterus/Ompok	not known
Lais jungang	Lai' jungang		Siluridae	Kryptopterus	apogon
Langkung	Adung	Dungan	Cyprinidae	Hampala	macrolepidota
Menyadin			Cyprinidae	Osteochilus	intermedius
Menyadin	Riu'		Cyprinidae	Osteochilus	triporos
Nuayang tebal	Nuajang	Riu' pate'	Schilbiidae	Pseudeutropius	brachyopterus
Nuayang tipis	Nuajang	Riu' pate'	Schilbiidae	Pseudeutropius	moolenburghae
Patik / baung	Baug	Baug putih	Bagridae	Mystus	nemurus
Rik ( or Ri' )	Baug		Bagridae	Mystus	micracanthus
Ringau	Ringan		Datnioididae	Datnoides (Coius)	microlepis
Rita' (or Ritak)			Cyprinidae	Rasbora	pauciperforata
Runtut			Channidae	Channa	bankanensis
Runtut	Gabus cina		Channidae	Channa	lucius
Seluang *	Enseluai bujur	Seluang bujur	Cyprinidae	Rasbora	agryrotaenia
Seluang batu	Enseluai batu	Tulum	Cyprinidae	Paracrossochilus	vittatus
Seluang buluh			Cyprinidae	Rasbora	borneensis
Seluang engkrunyuk	Pantau bana	Seluang minyak	Cyprinidae	Rasbora	trilineata
Seluang hantu	Seluang batu		Cyprinidae	Epalzeorhynchus	kalopterus
Siluk	Arowana	Kayangan	Osteoglossidae	Scleropages	formosus
Tapah			Siluridae	Wallago	leeni
Tebirin			Siluridae	Betodontichthys	dinema
Temunit	Ikan arang	Kak'	Cyprinidae	Labeo	chrysopehekadion
Tengadak (=suain)			Cyprinidae	Barbodes	schwanefeldii
Tengalan			Cyprinidae	Puntioplites	bulu
Toman	Anak loman	Gabus tobang	Channidae	Channa	micropaltes
Ujang uli	Entebiring	Ikan macan	Cobitidae	Botia	macracanthus
Umpan			Cyprinidae	Puntioplites	waandersii

\* Note: A number of other Cyprinid species share the common name Seluang.

## THE CROCODILES OF DANAU SENTARUM, WEST KALIMANTAN

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*Wetlands International**P.O. Box 7002, 6700 CA, Wageningen**The Netherlands**Email: frazier@wetlands.agro.nl***Introduction**

*Danau* (=lake) Sentarum National Park (00°51'N 112°06'E), a Wetland of International Importance (under the Ramsar Convention), is located in the province of Kalimantan Barat (West Kalimantan), over 700 km upstream from the lower South China Sea (Giesen and Aglionby, this volume).

The wetlands of Danau Sentarum (including the lake Danau Sentarum proper) are a complex of seasonal freshwater lakes, connecting rivers and swamp forest located in the catchment of Indonesia's longest river, the Kapuas. Danau Sentarum and environs experience the fullest extremes of seasonal fluctuations in water level. These wetlands form a distinct and important hydrological unit absorbing floodwaters from *Sungai* (=river) Kapuas during the wet season and contributing up to 50% of the river's downstream discharge in the dry season (Klepper, 1994).

Giesen (1987), in his initial study of Danau Sentarum, presented a cursory review of the few previous exploratory or scientific accounts that included the area (then known as the Kapuas Lakes). Some of these older accounts make mention of crocodiles in and around D. Sentarum. However, Beccari (1904) commented that he "never had the good fortune" to see *Tomistoma schlegelii* (one of two crocodilian species known to inhabit the D. Sentarum region), while collecting biological specimens there in 1867. The other crocodile known to occur at D. Sentarum is *Crocodylus porosus*, to which Beccari lost several of his travel companions elsewhere in Borneo.

While additional older references likely exist, an exhaustive literature search for historical information on the distribution of crocodiles in Borneo was not undertaken for this article. However there have been several recent investigations touching upon Bornean crocodile distribution. (These include Cox and Gombek 1985, in Sarawak; Cox *et al.* 1993, pan-Kalimantan; Frazier and Maturbongs 1990, in East and Central Kalimantan; Muin and Romono 1994, in E. Kalimantan; Ross *et al.* 1998, pan-Kalimantan; Stuebing *et al.* 1998, in Sarawak; and Whitaker 1984, in Sabah). For Danau Sentarum specifically, several researchers (e.g. Giesen 1987 and A. Sebastian *in litt.* 1994) have casually (but relatively infrequently) observed either or both species of aforementioned crocodile. Frazier (1994) conducted the only structured crocodile survey of D. Sentarum. Additionally, teams in 1995 (Ross *et al.* 1998) conducted a couple of brief night surveys there but did not sight any wild crocodiles.

Determination of crocodile status at Danau Sentarum is complicated by the system's unique hydrology, and by the fact that the taxonomy of palustrine crocodiles in the Indopacific region including Borneo (and specifically including the Danau Sentarum region) is unclear (Ross 1990; Cox *et al.* 1993; Ross *et al.* 1996).

### Methodology

Conventional methods to determine the occurrence and species of crocodiles, and their relative status within an area, are a combination of field survey (looking for wild specimens and spoor), examination of captive specimens, animal parts and artifacts, and interview of informants (e.g. hunters, fisherfolk and other local residents, traders, etc). Going further to estimate crocodile population numbers requires that replication be an integral part of an extended survey regime. For example, a single pass along a river during one night (or day) in a season may well reveal the existence of a crocodilian(s) and even their species. It will not provide a population estimate, although the level of observations may infer a paucity or abundance of individuals. No replicate crocodile studies have been performed at Danau Sentarum.

Frazier (1994) employed nocturnal spotlighting from boats and on foot as his survey method. Spotlighting crocodiles is a simple and relatively inexpensive way to verify crocodile presence and oftentimes, species. Therefore in a preliminary assessment of an area, it is a practical initial approach. Spotlighting involves the smooth, systematic and comprehensive scanning of exposed land-water interfaces (e.g. banks, bars and fallen trees) as well the open water to the fore of the survey craft. A single beam of light is used taking care not to illuminate the boat (or spotter's hands and face). A search beam reflects crocodilian eye-shine with a characteristic brilliance, in a range of hues from yellow to amber to red. It is this eye-shine that many crocodile hunters around the world still exploit in pursuit of their prey. It doesn't take long for most observers to gain the ability to separate other types of reflected eye-shine—there are many (e.g. invertebrates, frogs, birds)—from those of the crocodile. Given dark conditions and slow, fluid and quiet movement, it is often possible to approach crocodiles (especially young ones), close enough to allow for species identification and size estimation. Specimens seem mesmerized (or perhaps blinded) by the search beam and (if not too large) can often be hand-captured by the experienced. Captured crocodiles are then inspected (species, vigor, color and markings, sex, etc) measured, marked and released.

Such parameters as time, compass bearings and/or landmarks, weather, water level (tidal phase), lunar phase, habitat and human activity are routinely recorded, with a view to replicate studies. In 1994, survey distances were subsequently calculated by measuring courses against landmarks on 1:50,000 scale base maps that had been prepared by the ODA/PHPA GIS unit of a joint UK-Indonesia government project (UK-ITFMP) then operating (Frazier 1994), with D. Sentarum as a major study area (Giesen and Aglionby, this volume).

It is important to note the limitations of spotlighting, and to have a clear understanding of the value of any such observations gained by it. Spotlighting is ineffective in heavily vegetated swamps and thicket or forest. Resident crocodiles more often than not hide in or behind vegetation or debris. The search beam is rendered impotent under such conditions. Spotlighting reaches its most effective along an exposed land-water interface, that is to say primarily along *bare* river banks (or lake shore). With the coming of the dry season, rivers recede to expose their banks, and crocodiles which do not move to larger rivers or other wetlands farther away, concentrate in the diminishing waters (or at least this has always been the prevailing view).

A prime consideration in evaluating spotlight observations is the level of human activity in an area, especially hunting. Crocodiles under hunting pressure are likely to be wary and may submerge in response to the noise of an outboard motor or the cast of a

search beam. It is likely that older crocodiles are more wary than younger ones. The author has seen exceptions to this seemingly logical conclusion, but wariness is an unknown and *immeasurable* quantity. There is always the chance that individual crocodiles are already submerged or have their eyes oriented away at the precise moment the search beam is cast. Given such unfathomable variables, spotlight observations cannot be used as a definite measure of population numbers, but they may be able to provide the aforementioned information on species identity as well as some information on size class (i.e., age class).

Low yet navigable water levels are conventionally considered a boon to crocodile surveys since remaining crocodiles theoretically concentrate near and in persistent water. In the main Danau Sentarum study (Frazier 1994) however, water levels were often so low as to preclude navigation. Those river courses still able to accommodate boat traffic were invariably choked with people fishing, and their diverse assemblage of vessels and implements.

Three distinct types of habitat were cited by local residents as *dry season* haunts of the crocodile in the Danau Sentarum area (Frazier 1994). These were *hulu sungai* (upper reaches of rivers), *lubuk* (the sometime dry-season remnants of the wider and deeper pools of a contiguous river course) and *kerinan* (isolated dry season pools in forest or dry lake bed). One source, however, stated that *C. porosus* also retreat to Sungai Kapuas in the dry season. Typically all three habitats (with the exclusion of some *lubuk*) could only be reached on foot under those conditions during the 1994 survey. The same water-borne spotlighting principles were applied to the foot searches, but maintaining a low level of noise, and use of a single beam of light (for more than one person) proved difficult. Whitaker, however, found on-foot searches along upstream forested segments in the Bintuni Bay region of Irian Jaya to be an effective method of surveying *C. novaeguineae* (Frazier, 1990).

Anecdotal information is sometimes the only “data” that can be collected. In areas where crocodile encounters are infrequent (owing to reduced numbers) it is typically older men who make the best informants. Interviews should occur under relaxed conditions so that a measure of rapport can be established. Often mystical powers or actions are attributed to crocodiles, and attentive listening maintains the harmony of the interview. Obviously information obtained in interviews is of unknown and varying quality, and often colored by the perceptions and prejudices of the informant. The questions posed should never provide an answer for the informant. It is often advantageous to ask an informant to serve as a guide, thereby gaining an investment of time in support of his or her story.

### Species

There are reportedly four crocodile species described from Kalimantan/Borneo (Cox *et al.* 1993; Ross *et al.* 1998). Three of these species are still known to be extant in the wild. The status of the extant species according to The 2000 IUCN Red List of Threatened Animals (Hilton-Taylor 2000), the IUCN/SSC Crocodile Specialist Group (CSG), (Ross 1998) and CITES (CITES 2000), are summarized in Table 1. A fourth species of Bornean crocodile, *C. raninus*, was recently resurrected by Ross (1990) on the basis of an examination of museum material and literature review. Subsequently the type locality for *C. raninus* was restricted to Pontianak, West Kalimantan (Ross 1992; Ross *et al.* 1998), which is situated near the mouth of Sungai Kapuas, the river catchment of Danau Sentarum. However no observations have been confirmed as *C. raninus* since the

museum specimens were collected over 100 years ago. A search of the "CITES Species Checklist" (<http://www.unep-wcmc.org/CITES/common/dbase/fauna/index.shtml>) on the Crocodylidae, does include an entry for *C. raninus* (access date: October 29, 2000), but it is not otherwise listed under the CITES appendices (same source).

**Table 1. Status of Borneo's known extant crocodiles.**

<i>Species</i>	IUCN Red List 2000	CSG 1998	CITES 2000
<i>Crocodylus porosus</i> Estuarine crocodile	LRlc	H	I/II*
<i>Crocodylus siamensis</i> Siamese crocodile	CR A1ac	H+	I
<i>Tomistoma schlegelii</i> False gharial/gavial	<b>EN C1</b>	H+	I

[Descriptions of the various codes used herein refer only to the data presented in Table 1.

For complete descriptions of the RL, CSG and CITES categories, see the original sources].

RED LIST

CR=critically endangered; A1ac= An observed, estimated, inferred or suspected population reduction of at least 80% over the last 10 years or three generations, whichever is the longer, based on (and specifying) direct observation and a decline in area of occupancy, extent of occurrence and/or quality of habitat.

E=endangered; C1= Population estimated to number less than 2500 mature individuals and an estimated continuing decline of at least 20% within five years or two generations, whichever is longer.

LRlc=[globally] Low risk, least concern.

CSG

H=high need for wild population recovery.

H+=highest need for wild population recovery.

CITES

I=Appendix I, II\*=Appendix II under the annual quota criterion (for Indonesia, 6000 skins in 2000)

Two of the three known *extant* Bornean crocodiles occur in and around Danau Sentarum (in apparently very low densities). While a plethora of local names exist for the crocodylians of Borneo (Ross *et al.* 1996), the species confirmed at D. Sentarum are locally referred to as *buaya* for *Tomistoma schlegelii* and *rabin* for *Crocodylus porosus* [*buaya* is the generic *bahasa* Indonesia name for "crocodile"] (Frazier 1994). Giesen (1987) and Frazier (1994) observed both wild and captive *Tomistoma* at Danau Sentarum. In 1996, several additional captive *Tomistoma* and *C. porosus* were observed in villages in or near D. Sentarum (Ross *et al.* 1998). Giesen (1987) observed an estimated 2-m total length (TL) *C. porosus* in the field. Several credible accounts and photographs of captives of both species exist from Danau Sentarum. A deteriorating photograph of a very large, perhaps 4-5 m TL probable *C. porosus* (accidentally captured and drowned in a fishing net in Sungai Kenelang in 1989) was observed in 1994 (with copies since obtained) by the author. Local informants recounted numerous anecdotes of wild encounters with one or the other crocodile species to the author at D. Sentarum (Frazier 1994). In 1994, a 4 meter-long *Tomistoma* was accidentally drowned in a *jermal* fishing net near Bukit

Tekenang; its skeleton was collected and deposited at the Zoological Museum in Bogor (W. Giesen *in litt.* 2000).

Immediately after the 1994 survey, the author was provided with undeveloped film said to contain crocodile images from the Danau Sentarum region (taken in August 1994). Immediately upon return from the field, the film was processed. It yielded four photographs of a captive yearling *Crocodylus* sp., which resembled *C. porosus* except that it otherwise possessed twin pairs of enlarged bilaterally symmetrical post-occipital scutes. Post-occipital (PO) scutes are (enlarged) dorsally positioned scales occurring immediately behind the skull platform, or on the back of the “neck” of the crocodile. (The absence of, or vestigial, enlarged PO scales is one quick field method used to differentiate *C. porosus* from other *Crocodylus* sp.). The photographed specimen was said to have been caught in Sungai Tengkidap (J. Aglionby pers. comm. 1994), a river on the southern bounds of the lake complex. Enlarged post-occipital squamation is relatively rare in the estuarine crocodile. Ross *et al.* (1996) found mean occurrence of enlarged PO scales to be less than 1 scale in 32 West Kalimantan and 23 East Kalimantan specimens of wild-caught captive crocodiles. Ross and Mayer (1983) mention that Deraniyagala (Deraniyagala 1939) reported *C. porosus* specimens with up to 4 enlarged PO scutes, but the former authors only rarely observed up to 2 distinct scutes in their study. A photograph of a *C. porosus* captured subsequently in a *bubu* (fish trap) at Danau Sentarum (J. Aglionby *in litt.* 1994), revealed typical PO *C. porosus* squamation (i.e. no enlarged scutes). In 1995, a captive *C. porosus* from Leboyan, (D. Sentarum) with 3 larger PO scutes was photographed (Photograph 4 in Ross *et al.* 1996), but these were distinctly asymmetrical in size and shape, and therefore did not resemble the regular pattern displayed by the Sungai Tengkidap specimen. Likewise, this author cannot recall ever observing *C. porosus* with 4 post-occipital scutes that were arrayed as large distinct bilaterally symmetrical twin sets (as manifested in the S. Tengkidap *Crocodylus* sp.).

Owing to its PO scale pattern, it was initially thought that the photographed specimen could possibly represent *C. siamensis*, which has recently been confirmed as present in the wild in East Kalimantan (Ross *et al.* 1998). However this preliminary conjecture was easily rejected upon comparison of photographs of the S. Tengkidap specimen with those of captive yearling *C. siamensis* from Thailand and East Kalimantan. *C. siamensis* has a strikingly rough appearance and a comparatively broad and blunt snout, and notwithstanding the PO squamation, the Sungai Tengkidap specimen more closely resembles the “smoother” and “sharper snouted” *C. porosus*.

Neill (1971) recounted how in 1935, Schmidt suggested that a freshwater *Crocodylus* sp. should be found on Borneo, and when it was, it was identified as *C. siamensis*. Neill's map showing Bornean distribution (p. 398) puts known *C. siamensis* records in West Kalimantan and these are on or about the lower Sungai Kapuas. Interesting though is the placement of a question mark for the species' distribution in the vicinity of the Kapuas Lakes, i.e. Danau Sentarum (as well as in Central/South Kalimantan).

In numerous interviews, local residents did not even hint at the presence of (or perhaps did not recognize) more than two crocodile species during the main Danau Sentarum survey (Frazier 1994). In both East and Central Kalimantan the author found widespread consensus among residents that there were *at least 3* crocodile species present (Frazier and Maturbongs, 1990). Anecdotal support for a third resident species of crocodylian from other parts of West Kalimantan (and Central Kalimantan) was not



corroborated by (high-water-impacted) survey efforts in 1995 and 1996 (Ross *et al.* 1998).

In terms of PO squamation, the aforementioned Sungai Tengkidap photographic specimen was probably “not typical of *C. porosus* or *C. siamensis* but may be referable to *C. raninus*” (Ross *et al.* 1996), however certain more definitive diagnostic features were not visible in the photographs. The dorsal PO squamation of the S. Tengkidap photographic specimen also resembles that in photographs (in Ross *et al.* 1998 as Figures 1-4) of two captive specimens taken at a crocodile farm in South Kalimantan in 1995 (pers. obs.). These latter two farm specimens were attributed to the “raninus group” of crocodiles by Ross *et al.* (1996) on the basis of their “ventral squamation,” the character of which is a central diagnostic morphological feature for this group (Ross 1990). The raninus group or “large scale group” of crocodiles has 22-26 rows of transverse ventral scales (Ross *et al.* 1996). Unfortunately the unidentified *Crocodylus* sp. from S. Tengkidap was only photographed from the dorsal perspective, and its PO squamation while intriguing and perhaps suggestive, is itself not diagnostic. An effort was mounted to find, re-photograph and retrieve this unidentified crocodile after the exposed film was developed and sparked interest. W. Giesen traveled to the area three months later (W. Giesen *in litt.* 1994). There he learned that there had originally been two crocodiles that had been caught in rapid succession. One of these had escaped two days later. Then, shortly after the remaining crocodile was photographed, a *dukun* (soothsayer) ordered that the specimen be released. It seems that the child of the captor of the crocodile had fallen ill, and the *dukun* concluded that the crocodile had caused this illness, perhaps in retaliation for being held captive.

### Survey Results

With the exception of two brief night surveys (at Danau Pengembung and D. Semati), conducted in 1995 by Ross *et al.* (1996) under unseasonably high water levels (and yielding negative observations), only one structured crocodile survey regime has taken place at Danau Sentarum. This was a dry-season survey conducted by Frazier (1994). The following details relate to that survey regime.

Three water-borne night surveys over an estimated (one-way) distance of 134 km of river and three night-searches on-foot along tributaries to water holes, covering an estimated 25 km (one-way) were undertaken during this preliminary investigation of crocodiles at Danau Sentarum. In addition, other similar travel in and near the reserve in excess of 300 km provided supplementary opportunities for observation. Crocodilian eye-shine was sought whenever travelling at night, and daylight afforded the opportunity to look for crocodile tracks and slides, or individuals floating or basking. Table 2 lists surveys and major field travel during the 1994 preliminary investigation along with summarized crocodile observations (from Frazier 1994).

**Table 2. List of surveys and field travel to survey destinations, with observations.**

No.	Starting Date	Survey Course (or Travel Route and Destination)	crocodile observ.	km
1	06.08.94	Daytime travel from the mouth of Sungai Tawang to Bukit Tekenang ( <i>en route</i> to base camp)	nil	49.6

2a	07.08.94	Danau Genting to mouth of Sungai Pengembung (return only; on foot)	2 tracks	9.3
2b	08.08.94	Pengembung to Bukit Tekenang (Sungai Tawang)	nil	6.4
3a	08.08.94	Lubuk Penyerang Burung and Hulu Sungai Pemerak to Nanga Pemerak (return only; on foot)	nil	(8?)
3b	08.08.94	Nanga Pemerak to Bukit Tekenang (Sungai Tawang)	nil	13.1
4a	09.08.94	Daytime travel Bukit Tekenang (Sungai Tawang) to Sekolat (Sungai Belitung)	nil	26.2
4b	09.08.94	Sekolat to Danau Sekawi (Sungai Belitung)	nil	13.5
4c	09.08.94	Danau Sekawi (Sungai Belitung) to Bukit Tekenang (Sungai Tawang)	nil	39.7
5	10.08.94	Daytime travel from Bukit Tekenang to Semanggit (Sungai Embaluh Leboyan)	nil	29.3
6a	10.08.94	Kerinan Suakuri (off Sungai Embaluh Leboyan in the vicinity of Bukit Semujan; on foot )	1? (track)	(8?)
6b	11.08.94	Kerinan Suakuri (off Sungai Leboyan in the vicinity of Bukit Semujan; on foot) daytime return visit		(8?)
7	11.08.94	Temperau (Sungai Embaluh Leboyan) to Bukit Tekenang (Sungai Tawang)	6 [all 6 within]	51.9 7.6]
8a	12.08.94	Daytime travel from Bukit Tekenang to Pulau Majang (Sungai Tawang, Sungai Kenelang and on foot)	nil	36.3 (+6?)
8b	13.08.94	Daytime travel from Pulau Majang to Temukup (on foot, Sungai Kenelang, Sungai Tawang and Sungai Sumpak)	nil	70.1
9	13.08.94	Temukup to Sumpak (Sungai Sumpak)	nil	42.0

During the entire survey regime, only 6 crocodiles were spotted, all on a 7.6 km span of the same river (Sungai Embaluh Leboyan, Survey 7), resulting in an observed density of 0.8 crocodiles/km over that segment (which fell completely outside of the then current reserve boundaries). The density observed for the entire Survey 7 was a near negligible 0.1 crocodiles/km. Two of the six crocodiles were identified as *Tomistoma schlegelii* and one of these false gharials was captured, examined and measured, marked and released. The remaining four crocodiles were recorded as EO (eyes only) observations. It was clear however that they were all sub-adult and probably yearling class, as were the two animals that were identified to species.

Just outside of Nanga Pengembung, along the shrunken course of Sungai Pengembung (*en route* to Survey 2a), the party was searching for and found what appeared to be two distinct sets of juvenile-adult crocodile tracks (disclosed earlier during an interview in the village). However on two occasions, hikes to *lubuk* ended without observations. An unidentified track in mud surrounded by a peat deposit was noted at Kerinan Suakuri (Surveys 6a and b). Other intriguing information about crocodile inhabitation of *kerinan*, including crocodile nesting, could not be verified in the allocated time especially due to the unavailability of willing guides.

#### **Anecdotal Information**

Anecdotal information abounds on crocodiles at Danau Sentarum. Interviews should ideally help to elicit information useful in narrowing and focusing search area. In the 1994 study (Frazier 1994), one interview led to observations of two individual sets of crocodile tracks (Survey 2a). The informant had said that an adult *Tomistoma* had recently (June 1994) been seen in this area during daylight hours. Other interviews didn't prove so fruitful but nonetheless provide some possible clues for future study of crocodiles at Danau Sentarum. A selection of anecdotes and observations follows.

On Aug 7, 1994, Pak (=sir) Sahalan (of Nanga Kenelang), a former crocodile hunter provided information on *Tomistoma schlegelii* (known in the D. Sentarum area as *buaya*, which simply means *crocodile* throughout most of Indonesia). He related that the dry season sees a retreat of *buaya* into more secluded areas because with the lowering of water comes an increase in fishing. *Buaya* were said to seek the deeper, wider pools (*lubuk*) of the shallow river courses and small isolated ponds (*kerinan*). The informant said that small crocodiles (formerly) remained in the remnant river courses, and (1-5) adults would seek shelter in *lubuks*. [Later Pak Sahalan served as guide to a couple of alleged *lubuks* (Survey 3a) where he had captured adult *buaya* years before, but these "wide places" appeared incapable of accommodating even one juvenile crocodile].

Pak Sahalan also related that the *Tomistoma* nesting season was September/October and that the species typically lays a clutch of 29-35 eggs in a nest of litter constructed at the base of a tree. (Informants from D. Sentarum told Ross *et al.* (1996) that the nesting season was July/August and that clutch size was 25-40. Three wild *Tomistoma* nests discovered in East Kalimantan in 1996 by Ross *et al.* (1998) had clutch sizes ranging from 23-37, and were found both in forest and on a floating mat of vegetation. Informants put the nesting season at July-October, or usually the dry season). Another informant, Pak Abdul Muin (of Pulau Majang), said both *rabin* and *buaya* made nests in July; lay eggs in August; and that their eggs hatch in September or October. When asked where crocodiles nested in the area, the informant described a place he called "Kerinan Mensait." He said

he had observed a high density of nesting *rabin* (*C. porosus*) at this location (some years before). He described the area's vegetation as being dominated by clumps of *Pandanus* sp. While his characterization of nesting phases was too compressed, his description of mounded nests, nesting material and surrounding vegetation seemed to indicate familiarity with crocodile nests. The informant enumerated three reasons that people were not currently exploiting this area of (prolific) crocodile nesting: 1) the area was hard to find, 2) skin prices were too low, and 3) hunters needed to be brave to enter a *rabin* nesting area. The author's several attempts (at various villages) to hire guides to the area were unsuccessful (Frazier 1994).

The informant Pak Sahalan contended that both species of known D. Sentarum crocodile will regurgitate partially-digested prey to attract game, laying in wait with its mouth open ready to seize inquisitive pigs or other animals investigating the smell. The informant stated that the preferred bait for hooking crocodiles was monkey flesh. In 1994, a drowned adult *Tomistoma* (mentioned in the Introduction) was found to contain several "furballs" which closely resembled the fur of *Macaca fascicularis*, W. Giesen *in litt.* 2000). Frazier (1994) didn't see any signs or hear of any current crocodile hooking when he was in the D. Sentarum area.

When asked about local residents' attitudes toward crocodiles, the general consensus among another group of informants was *fear*, although they did not express any overt malice toward the animals. They explained that people do not actively seek out crocodiles but that the animals sometimes drown in fishing nets. This was supported by E. Widjanarti (pers. comm. 1994), a researcher who had seen the skin of the (above-mentioned) adult *Tomistoma* that had drowned in a *jermal* fishing net. This event had been reported in a local newsletter published by the conservation project (Edition 14, June 1994 of *Suara Bakakak*) at Danau Sentarum.

### Crocodile Habitat

The paucity of wild crocodile observations from the few surveys at Danau Sentarum means that descriptions of crocodilian habitat must rely primarily on anecdotal information. The relative importance of these habitats cannot be estimated given this dearth of data. Many basic habitat descriptions have necessarily been included in the foregoing to illustrate survey methods and characterize species occurrence. The following summarizes the available information on the (dynamic) crocodile habitats of Danau Sentarum.

By some standards, crocodiles are possibly more difficult to observe in the *dry* season than in the wet season at Danau Sentarum. This is in contrast to the conventional view wherein the dry season *is* the time to observe crocodiles (presumably this applies to crocodile haunts elsewhere which are less disturbed than those at Danau Sentarum). The distinctive hydrological regime at D. Sentarum is one of polar extremes. In the typical dry season, water drains into the Kapuas River to such an extent that vast areas of dry, sparsely vegetated (but formerly submerged) land remain. During the wet season this floodplain receives backflow from Sungai Kapuas, filling up to form a vast flooded complex. In May of 1867, Beccari (1904) was travelling on Danau Seriang (presumably just west of Danau Sentarum proper) and wrote this description: "The surface of the lake, clear and free from arboreal vegetation, extends only a few miles, but nowhere could we see a trace of dry land."

Local informants universally contended that the dry season sees the departure of crocodiles from larger river courses of Danau Sentarum. Surveys on these larger rivers

indeed yielded no crocodile observations (pers. obs.). Crocodiles are said to move to *hulu sungai* (upper river courses), *lubuk* (pools in intermittent or shallow rivers) and *kerinan* (isolated persistent water holes) habitats (and in one account, to the Kapuas River). Giesen *et al.* (1994) also suggested that crocodiles might also make a seasonal retreat to Sungai Tawang (however no sightings were made along this heavily disturbed river during the 1994 study). Crocodiles would presumably migrate to the aforementioned more secluded areas in response to the radical intensification in fishing and peripheral activities that are encouraged and facilitated by falling water levels. However, this could not be confirmed in the 1994 study (Frazier 1994). Only 6 wild crocodiles were observed during the entire, albeit brief, 1994 survey regime. These surveys included a variety of habitats, but not many replicates of the *hulu sungai*, *lubuk* and *kerinan* types. All of the observed crocodiles were sighted in a single sector on Sungai Embaluh Leboyan (a relatively narrow floodplain river bounded alternatively by riverine forest and *Pandanus* sp.). This site was formerly outside of the eastern reserve boundary. Ross *et al.* (1996) reported that Danau Semati (upriver from the S. Embaluh Leboyan site just mentioned), is a small *Pandanus* sp. and grass fringed lake, with some *Hanguana malyana*, said to be a *Tomistoma* stronghold (but this was not confirmed during a brief night survey). In the same vicinity are also D. Merbong (bordered by swamp forest) and D. Lintang (fringed by *Pandanus* sp.).

Additional specific as yet unsurveyed (or scarcely surveyed) locales said to be crocodile habitat include: 1) Kerinan Mensait (west-northwest of Temukup). This is purportedly an area of *C. porosus* nesting, characterized by *Pandanus* sp. vegetation; 2) The lakes Danau Batu(k), (hulu Sungai Kulan); Hulu Uangtapa; and Danau Semanuk, (hulu Danau Belida) were known refuges of either or both *buaya* (*Tomistoma*) and *rabin* (*C. porosus*) in the past; and 3) the permanent lakes southeast of Danau Luar and, as mentioned by Ross *et al.* 1996, the lakes north of Sungai Embaluh Leboyan (Giesen *et al.* 1994).

The author knows of no scientific research including the particulars of crocodile nesting at Danau Sentarum. However, recent records of *Tomistoma* nests from East Kalimantan (in Ross *et al.* 1998) and Sarawak (in Steubing *et al.* 1998) may provide clues for additional study on the availability of suitable nesting habitat at Danau Sentarum. In East Kalimantan (N=4 nests) three types of nesting habitat were noted: 1) mixed freshwater swamp, on a floating mat of vegetation, 2) secondary forest, and 3) peat swamp, at base of tree (all inspected in August 1996). In Sarawak, a nest was also discovered at the base of a tree in disturbed peat swamp forest (observed in July 1994).

### Management Issues

During the course of the 1994 survey it became readily apparent that crocodiles at Danau Sentarum face a host of adverse factors, both natural and anthropogenic (Frazier 1994). Danau Sentarum undergoes seasonal fluctuations in water-level, spectacular in amplitude; from large open lakes and flooded forest in the wet season to a mosaic of bone-dry and bare lake-bed moonscapes dissected by tepid, stagnant and near-desiccated streams in the dry. While nothing can ameliorate the natural (crocodiles have adapted to these conditions), the man-induced threats can certainly exacerbate the precarious position that crocodiles occupy at Danau Sentarum in the dry season. Adverse factors have been treated individually below, in the current order of the magnitude of negative impact as perceived by the author.

### ***Jermals* and other fishing nets and barriers**

Danau Sentarum is a bountiful fishery that has been heavily exploited for over a century (Giesen 1987; Dudley this volume). Frequently enough, crocodiles inadvertently fall victim to a range of nets, traps and other fishing apparatus. Often these are small to medium-size specimens which are sometimes pulled from the implements still alive, e.g. a small *C. porosus* was caught alive inside a *bubu* (fish trap) shortly after the current survey regime (J. Aglionby *in litt.*, with photo of specimen, 1994). This is also mentioned as a widespread phenomenon throughout Kalimantan in Ross *et al.* (1998). Other times crocodiles drown or are perhaps killed in order to extract them. A. Sebastian (*in litt.* 1994) came upon a dead juvenile crocodile (probably *Tomistoma*) along Sungai Embaluh Leboyan that appeared to have had part of its snout hacked off (perhaps whilst extricating it from a fishing net). Other captive, presumably-netted crocodiles were recently observed or reported to have been held at Nanga Kenalang (a 2 m TL *C. porosus*, W. Giesen pers. comm., 1994), Nanga Pengembung (3 small *Tomistoma*, E. Widjanarti pers. comm. 1994) and Sekolat (a juvenile *Tomistoma*, pers. obs.). The effect of this scale of incidental removal in healthy crocodile populations would normally be negligible, as the majority of crocodiles don't survive long enough to breed anyway.

It is the *jermal* however and other large gill nets and barriers which pose the greatest danger to crocodiles. A *jermal* is a very long V-shaped apparatus composed of a (fine-meshed) net secured to a series of long fixed poles. It is often used in concert with *empang* (a fish barrier; a bamboo/stick fence placed across a channel typically with a central slot where a net is connected), together presenting an extremely effective (destructive) method of capturing fish, which sometimes inadvertently snares crocodiles.

*Jermals* (with or without *empang*) are often dominating structures in relation to the channels where they are placed. *Jermals* not only net very large catches of fish, but also occasionally ensnare (sometimes large) crocodiles. As reported elsewhere in this article, a large *Tomistoma* drowned in a *jermal* near Genting in June 1994. The large *C. porosus* accidentally netted in 1989 might well have been caught in a *jermal* or perhaps a *pukat* (a type of gill net). Informants at Nanga Pengembung reported that large crocodiles sometimes drown in fishing nets although the frequency of occurrence was described as "not every year."

As with other reptiles, typically only a very small percentage of a total crocodile population will survive to adulthood. This breeding cohort occupies that narrow position at the top of the population pyramid. Perhaps as many as 90-95% of the viable embryos deposited as eggs in nests will not survive to reach breeding-age, falling victim to a host of predators and natural or anthropogenic disasters. In populations as disturbed as those at Danau Sentarum, the loss of each breeding-size crocodile (e.g. to a *jermal*) has an even greater disproportionate effect on the viability of those populations.

Giesen (1987) found "net density" to be "very great in some areas" and described *pukat* densities as "extremely high" in Danau Sekawi. During the 1994 study the author found that the same situation prevailed. While Sungai Kenalang was chock full of small gill nets and floated hooks and trot lines, 9 active *jermal* were encountered between Danau Sekawi and Sekolat along Sungai Belitung. Eight of these were located upstream from the confluence of Sungai Bekuan which is roughly equivalent to 1 *jermal* erected every 1.2 km (over approximately 9.5 km). *Jermals* were also observed on Sungai Embaluh Leboyan especially below Nanga Leboyan and above Semanggit. Likewise a *jermal* was also seen in the vicinity of Lubuk Pengael on Sungai Sumpak. Sungai

Tawang was very heavily fished, as exemplified by an assortment of anchoring poles, trot lines, and nets and traps with *empang* running its entire length.

### **Forest burning**

Giesen (1987) reported that suspected intentional burning was consuming "large areas of low-lying inundated forest" in the Danau Sentarum area, and cited literature mentioning area fires in the latter half of the previous century. More recently, Luttrell (1994) investigated contemporary forest burning at D. Sentarum (April-June 1994) and compiled a preliminary list of major burn events over the last 30 years based on informant interviews. Both authors mentioned the opening up of habitat for fishing, as one of the reasons behind the burning. Luttrell listed 20 locations as key fire sites. Like her, this author found deliberate forest burning to be extremely prevalent, encountering smoke and fire on every outing. Two on-foot surveys also abutted previous burn sites. A detailed study on burning at Danau Sentarum is provided by Dennis *et al.* (this volume). A return to Kalimantan Barat in 1996 by the author (Ross *et al.* 1998) did not include Danau Sentarum, but it was clear that burning has become all too common on a massive scale. While this phenomenon was not examined *per se* in 1994, the author feels that this practice must be considered detrimental to crocodiles in the absence of information to the contrary.

Kottelat (1993) emphasized the singular importance of the forest as an exogenous nutrient source for the lakes of Danau Sentarum. This can be inferred from the almost total absence of submerged vegetation in the lakes. Extrapolating from other similar Southeast Asia locales, he also suggested that forest habitat was important for fish reproduction. Furthermore, in this study of fish, Kottelat pointed out that forest loss removes "shelters and sources of habitat complexity," causes a loss of food sources, increases water temperature thereby lowering dissolved oxygen capacity, and increases siltation destroying spawning grounds and larval habitats for some species. This has an obvious potential implication for the piscine component of crocodile diet.

But perhaps of more immediate concern is the potential direct impact that forest burning has on crocodile populations. With the opening up of more forest the likelihood of frequent human incursion increases. This might simply force crocodiles to seek other more secluded areas or it might result in an increase in the level of accidental net mortality through increased fishing opportunity. Finally, by virtue of its scale and extent, burning of forest habitats probably has already destroyed some crocodile nesting areas. This obviously can have a drastic impact on crocodile populations.

### **Fish poisoning**

Giesen (1987) discussed fish poisons and the history of their use in West Kalimantan and the Danau Sentarum area. In Giesen's account, Schadee (1913) is cited as reporting that "most monitor lizards, turtles and crocodiles are killed as well during the [poisoning] operations." This author in fact observed monitor lizards eating dead fish (from among many) perhaps killed by poison along Sungai Tawang (Frazier 1994).

Two major fish kills occurred just before and during the author's brief visit and this testifies to another real threat to the crocodiles of Danau Sentarum. It is highly likely that both kills were the result of deliberate poisoning. Whatever the genesis and formula, it appears that fish poisoning is occurring regularly in the dry season in *hulu sungai* (upriver) locations. There are two immediate potential adverse effects for the crocodile: 1) the aforementioned secondary poisoning from consumption of contaminated prey and

2) site abandonment due to collapse of prey fish populations and/or irritation caused by the toxic agent. Such forced migration itself would put crocodiles at risk from other threats. One major poisoning event merits additional detail here.

In the first hours of 8 August 1994, the author's survey party returned to base camp to find Tekenang village alive with commotion (Frazier 1994). Local residents discovered that their entire stock of fish, was dead and dying inside *keramba* (fish cages) moored along the edge of Sungai Tawang. Later that afternoon, during further survey travel the party noted a great number of dead fish at Sumpak, but little mortality was observed at Nanga Pemerak upon passing (15:45) and upon return (17:15). However the author observed numerous large fish breaking the river's surface in gentle rolling arcs. Later the survey team returned to Nanga Pemerak from a foot survey sometime after 23:00. Here the party was met with a surreal scene where the river paralleling the village was completely carpeted with a seething mass of dying and dead fish.

News of this fish kill travelled fast throughout the Danau Sentarum area. A group of informants placed the blame for this event squarely on people living in *hulu sungai* locations. Many residents felt that this fish kill stemmed from use of a commercial piscicide or other industrial agent (rather than traditional *tuba akar*, "root poison") owing to its devastating efficacy.

### Hunting

Hunting crocodiles for hides had apparently abated at Danau Sentarum (as at 1994) owing to depressed world skin prices. (Ross *et al.* 1998 and Steubing *et al.* 1998 commented more recently on the relatively low prices for the lower quality hides of *Tomistoma*). No evidence whatsoever concerning current deliberate crocodile hunting was uncovered by Frazier (1994). However inadvertently captured/drowned crocodiles are sometimes skinned for hide sale. Small to medium-size crocodiles captured live from nets and traps are sometimes kept as pets or curiosities (pers. obs.; J. Aglionby pers. comm. 1994; W. Giesen pers. comm. 1994) or are sold to traders (J. Aglionby *in litt.* 1994; Giesen, 1987).

Should skin trading become profitable once again, hunting of crocodiles in the already heavily disturbed environs of Danau Sentarum will represent a significant impact to local and perhaps regional crocodile populations.

### Conclusion

A paucity of scientific data exists on all aspects of crocodiles at Danau Sentarum. This dearth of knowledge extends not only to ecological and population aspects, but also to the taxonomic status of its crocodiles. It is clear however, that dry season phenomena of natural and anthropogenic origin operate in a perverse synergy to adversely affect the crocodiles that are there. The local population of seasonal fisherfolk explodes as the waters of Danau Sentarum recede, and fish density increases. The use of indiscriminate fish capturing methods, especially *jermals* and poisoning, directly and at least indirectly in the case of poisoning, have an adverse impact on crocodiles. Forest burning without doubt exerts negative pressure on crocodiles, by opening secluded habitats to human exploitation and by probably destroying nesting habitat. Danau Sentarum would on its surface, appear eminently suitable crocodile habitat given its plentiful sources of food and its semi-remote character. However the manifold large-scale anthropogenic impacts described above are likely significantly depressing this natural potential. Danau Sentarum National Park, irrespective of its park status is in fact a multiple use area. One of these



uses is obviously conservation. For all land uses to coexist harmoniously, they should be sustainable. However, *jermal* fishing, use of industrial piscicides or surrogate chemicals, and forest burning are not sustainable and will ultimately adversely affect all land uses, in one time scale or another.

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## A STUDY OF HUNTING AND TRADE OF FRESHWATER TURTLES AND TORTOISES (ORDER CHELONIA) AT DANAU SENTARUM

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A study of hunting and trade in the species of non-marine turtles and tortoises (Order Chelonia) indigenous to Danau Sentarum National Park (DSNP) was undertaken during the summer months of 1995. Research revealed that the trade targets three species of softshelled turtles (*Amyda* (formerly *Trionyx*) *cartilagenea*, *Dogania subplana* and *Pelochelys bibroni*) and the Malaysian giant tortoise *Orlitia borneensis*. Due to the unusual amount of rain during the 1995 dry season there was little observation of and systematic research into specialized hunting techniques. Research on population dynamics was also impeded. Information and data were, therefore, collected by interview and the results are presented in this paper.

Of the two culturally distinct human populations within DSNP, only the Dayak Ibans actively hunts softshells. None of the 11 species of freshwater turtles and tortoises present in DSNP are unique to the area, or indeed Borneo. The trade in the Malaysian giant tortoise is local, but the softshells caught in DSNP are part of the international trade throughout Southeast Asia. An estimated maximum of 50 tons of softshells cross the Kalimantan/Sarawak border at Lubuk Antu/Badau each year. A large proportion of these turtles come from DSNP and immediate areas. The trade was estimated to be worth up to USD 75,000 to the human inhabitants of DSNP.

### Introduction

During the early 1990s the Overseas Development Agency (ODA) sponsored research in a wide variety of disciplines throughout Danau Sentarum National Park (DSNP; then a Wildlife Reserve). The objective of the research was to formulate a management plan to be implemented by the PKA (Indonesian Directorate General of Forest Protection and Nature Conservation, Ministry of Forestry—then PHPA). In the course of the preliminary research, it was found that a small number of Dayak Ibans took part in hunting and trade of freshwater turtles and tortoises. Further ODA-sponsored research was therefore undertaken during the summer of 1995 by the author to determine the species diversity of freshwater turtles and tortoises in the region and the extent, hunting methods and financial implications of the trade.

DSNP (see Giesen, 2000 for map) is a seasonal lake-cum-swamp forest system that empties into the Kapuas River during the dry summer months (Giesen, 1987; Giesen, 2000). The park is home to two distinct ethnic groups, the lake dwelling and partly seasonal Islamic Malays, and the Christian forest dwelling Dayak Ibans. One and a half thousand Ibans still live in traditional longhouses or towns (e.g. Lanjak), hunting and practicing shifting cultivation. Resident Malays live in stilted villages on the edge of the lakes, the seasonal Malays inhabit floating villages that are rectified each year (J. Aglionby pers.comm., 1995).

There has always been a trade in freshwater turtles and tortoises throughout Asia for meat, traditional Chinese medicine (TCM) ingredients and religious, but the trade appears to have escalated in the last 10-15 years.

As local populations of freshwater turtles and tortoises in the main consumer countries such as Taiwan, Hong Kong and China shrank to the point where the effort put into collecting became greater than the market price fetched (Chen *et al.*, 1999; Lau *et al.*, 1999; Lau and Shi, 1999), Chinese communities looked to other areas to meet the demand. Around this time countries adjacent to China (Vietnam, Cambodia, and Laos) “opened” after many years of isolation and the international trade became more prolific. At the end of the 1980s, Chinese currency became convertible (J. Skepper pers. comm., 2000) and other Southeast Asian countries such as Malaysia, Thailand, and Indonesia became involved in supplying Chinese communities in Asia. Even countries such as Bangladesh and India are involved in supplying Chinese restaurants and traditional Asian medicine (Das, 1990).

Of all the freshwater turtles and tortoises that are consumed, softshells (Family Trionychidae) are considered the best, due to the low bone-to-body ratio and the larger proportions of cartilage and gelatinous skin. They are served as a delicacy in Chinese restaurants, some of which sell exclusively turtle dishes. Several authors have stated that at least half of the international trade in non-marine freshwater turtles and tortoises is in softshells, mostly the Asiatic softshelled turtle *A. cartilaginea* (Das, 1990; Jenkins, 1995; CNRMES, 1994; ATTW, 2000).

Turtle eggs and meat still serve as an important source of protein for some ethnic groups, especially in some areas of Bangladesh (Das, 1990) and Laos (P.P. van Dijk, pers. com., 1995). Areas with large Muslim communities experience lower exploitation rates, as Islam forbids the consumption of turtles and tortoises because of their amphibious and scavenging nature. This restriction does not apply to eggs, which are highly esteemed by some Muslims (personal observation; Das, 1990; Jenkins, 1995). In DSNP, the Islamic Malay fishermen that accidentally catch a turtle will trade these with Iban middlemen or hunters if more convenient; trade is not seen as opposing the teachings of Islam.

Turtles are considered a “hot” food, curing and strengthening the body in cold months. Eggs are believed to have aphrodisiac properties, while turtle blood is said to increase human blood protein and energy levels. It is common to find turtle blood prescribed to athletes in Southeast Asia. The majority of trade in Southeast Asia appears to supply Chinese settlements (personal observation; Jenkins, 1995). Apart from a small amount of domestic trade, most softshells from DSNP are destined for Chinese settlements in Kuching or further a field in Hong Kong and Singapore.

Turtle shell products are derived from the carapace of softshells and the plastron of hard-shells. They are sold unprocessed or turned into pills, powders and jellies to remedy such inconveniences and illnesses as a weak voice, nocturnal sweats, difficult childbirth and a swollen pancreas (Jenkins, 1995; Motluk, 1995).

At present, the trade in freshwater turtles and tortoises remains unregulated by government officials. Bangladesh comes the closest: permits are issued, “certificates of health” are required for export, and it is illegal to export turtles weighing under one kilogram; a system that would be useful for monitoring the trade in any country. However none of the species for which permits can be issued are indigenous to Bangladesh, thereby making all trade in indigenous species illegal. This does not deter

the traders as turtles of Bangladeshi origin turn up in Eastern Asia; Hong Kong, South Korea, Japan, China, and Malaysia (Das, 1990).

### Interview Survey Methodology

The summer of 1995 (July to September), when the research was undertaken, was unusual in that it rained almost every night. At a time of year when the dwarf swamp forest should have seen their annual months of sun (Giesen, 1987), the lakes remained full and the forests remained flooded. Systematic and quantitative field surveys were therefore not feasible and as a result, no specimens were seen in the wild.

The subsequent method of interviewing hunters, middlemen, traders, and Malay fishermen proved lucrative. Upon arrival at an Iban village and after announcing that the author was interested in freshwater turtles and tortoises, the entire village's collection of "pets" would appear from the back of the longhouses on the end of pieces of string. Photographs and annotated diagrams of all specimens encountered (Testudinidae and Emydidae) were drawn. Identification was verified at the field center using a dichotomous key (de Rooij, 1915). Table 1 shows species that are indigenous to DSNP. Information specifically on hunting, trade, and the species involved (softshells and Malaysian giant tortoises) was gathered by interviewing Iban hunters, middlemen, traders and Malay fishermen.

Due to different cultural interpretations of time, it was difficult to establish trends in relative abundance, both present and over a period of time. Interviewees had difficulty in deciding whether a species was relatively "abundant, few or rare" in a given area. Their answers were lumped together with the number of specimens encountered to give a very crude, estimated value of present abundance a species relative to the other species found (Table 1). Investigation into the trade was extended through the Badau/Lubuk Antu border to Kuching, Sarawak. An overall review of hunting practices and trade is presented in this paper.

### Results

Species of freshwater turtles and tortoises recorded in the survey are given in Table 1.

### Hunting Methods

The two main species collected by hunters were the Asiatic or River softshelled turtle, *A. cartilagenea* (locally called *labi-labi sungai*) and Malaysian giant turtle *O. borneensis* (*biuku*). The other two species of softshell, *D. subplana* (*labi-labi hitam*) and *P. bibroni* (*labi-labi kuning*) were not caught very often; when they were the hunter would often not realize he had a different type of turtle. These two species were traded as if they were *A. cartilagenea*. Although Malays did not actively hunt/fish for turtles, Ibans hunt freshwater turtles and tortoises both for subsistence and for profit.

Both Malays and Ibans catch turtles whilst fishing. Local fishermen routinely set hooks and lines to catch fish; the larger of these hooks will also catch turtles. For Malays, fishing this way is their main source of income, and produces the majority of their turtle catch. The productivity of this method in terms of turtles is not very high, with one family catching 2-3 a month and is seen as opportunistic turtle catching. This method of catching turtles occurs all year round in the larger rivers that flow all year round, and seasonally in the lakes.

**Table 1: Species of Freshwater turtles and tortoises found in DSNP.**

Species	Common English name	Local name	IUCN RDBk <sup>a</sup>	Relative abundance <sup>b</sup>	Habitat preference <sup>c</sup>
<b>Testudinidae</b>					
<i>Manouria emys</i> <sup>d</sup>	Asian brown tortoise	Baning	VU A1acd, B1+2acd CITES App. II	Few	Moist hill forest on the edge of the park, e.g. Empaik
<b>Bataguridae</b>					
<i>Siebenrockiella crassicollis</i>	Black marsh turtle	Kura-kura jaung	(VU A1cd+2cd)	Abundant	Dwarf and tall swamp forest, wet cultivated land, even permanent dry lands (outside park)
<i>Cuora amboinensis</i>	Asian box turtle	Kura-kura tambit	LR:nt (VU A1d+2d)	Abundant	Dwarf and tall swamp forest, wet cultivated lands, even permanent dry lands (outside park)
<i>Cyclemys dentata</i>	Asian leaf/stream turtle	Kura-kura air	(LR:nt)	Few – abundant	Hill streams, sometimes shallower tall swamp forest, wet cultivated land
<i>Heosemys spinosa</i>	Spiny turtle	Kura-kura umung	VU A1bd (EN A1bcd)	Rare	Dwarf and tall swamp forest
<i>Malayemys subtrijuga</i>	Ricefield/ Snail-eating turtle		(VUbA1a+2d)	Rare <sup>e</sup>	Tall swamp forest, wet cultivated land
<i>Orlitia borneensis</i>	Malaysian Giant turtle	Biuku	LR:nt (EN A1cd+2CD)	Abundant	Rivers of all sizes, all swamp forests and lakes
<i>Pyxidea mouhottii</i>	Keeled box turtle		(EN A1d+2d)	Rare <sup>e</sup>	Hill forests, tall swamp forest at the

					base of hills
<b>Trionychidae</b>					
<b>Amyda cartilaginea</b>	Asian softshelled turtle	Labi-labi sungai	VU A1cd+2cd	Abundant	Completely aquatic; rivers and lakes
<i>Dogania subplana</i>	Malayan softshelled turtle	Labi-labi hitam	(LR:1c)	Few	Completely aquatic; rivers and lakes
<i>Pelochelys bibroni</i>	Asian giant softshelled turtle	Labi-labi kuning	VU A1cd (VU A1cd+2cd)	Rare	Completely aquatic; rivers and lakes

<sup>a</sup>IUCN RDBk - World Conservation Center Red Data Book 1999. Listings in brackets indicate proposed changes by the Asian Turtle Trade Working Group 2000

<sup>b</sup>Little information on demography or even relative abundance could be collected. Interviewees could not provide much information on population size except to say whether, in their opinion, a species was relatively "abundant," "few" or "rare" in a given area. This information, together with data on species encountered, gave a crude, estimated relative abundance.

<sup>c</sup>Giesen 1987; Giesen 2000

<sup>d</sup>No encounters occurred; deduced from detailed descriptions and identification of pictures.

<sup>e</sup>Rare only in DSNP due to the area being on the fringe of optimum habitat type.

Fish traps are used by a small number of people, mainly Malays. If the traps are large enough, turtles can be caught in both baited and unbaited traps. This is common practice in Laos (P.P. van Dijk, pers. comm., 1995).

In the dry season, aquatic life is reduced to small residual pools of water (*kerinan*) and permanent streams as the lakes and swamp forest dry out. Groups of three to six Ibans set off on a hunting expedition, touring these residual pools of water. One trip can last for a few weeks, depending on how long it takes to collect their limit of turtles. The men wade through the water and mud, probing with a spear-like tool (*ciruk*) and feeling with their feet. Likely burrow locations are investigated, the men even crawling in if the holes allow. Sometimes a single cavernous "burrow" can be highly profitable, producing up to 25 turtles. This is the main method of specialized hunting in DSNP.

Iban living in longhouses further away from the lakes on the permanent streams build barriers across the path of the water. Pits are dug at the side of the barrier, and channels direct turtles from the barrier to the pits. The channels contain "valves" ensuring a turtle can get into but not out of the pits. This method is apparently not very successful, one longhouse on the edge of the park said they catch one turtle every one or two weeks.

The author was told by locals further down the Kapuas River of Iban hunters using natural and commercial poisons or explosives to flush turtles out of their burrows. No evidence of this was found nor did the author hear of any such activities occurring in DSNP.

Once caught, the turtles are put in a bag or their flippers are tied up. Great care is taken as softshells in particular are aggressive and have a nasty bite. Turtles are then piled into boats or trucks, and transported in this fashion to their next destination.



### **Turtle trade inside DSNP**

The Malaysian giant tortoise and the Asian brown tortoise *Manouria emys* are the only species present in DSNP that are listed as protected. The Asian brown tortoise is listed as CITES Appendix II, and the Malaysian giant tortoise is protected under Indonesian national law (Government Regulation No. 7; Samedi and Iskandar, 1999). The question of whether a species was legally allowed to be traded never arose during the survey. It was noted that collecting Asianbrown tortoises was frowned upon as they held the ghosts of either the deceased or some kind of god.

All the trade with Sarawak in that area went through the Badau/Lubuk Antu border. Locals were allowed to cross over at their leisure, anyone from outside the area had to go round. People and trade goods that go through the border post at Badau/Lubuk Antu appear unchecked; no duty is paid on trade goods going through the border.

The trade does not appear to be sensitive to either species or sex. No hunter interviewed was aware of the differences between the sexes.

Very few Malaysian giant tortoises reach Badau or Lubuk Antu, as there is little demand for their meat. If caught and not released, they are sold locally. Trade appears to be in softshells only, and tend to be the Asian softshelled turtle.

### **Softshelled Turtlese**

Hunters often store live turtles and tortoises in cages suspended in water, or in a specially dug pit, until they have enough for a trip to a local market town. The main middleman in Lanjak collects enough turtles in a pit to fill a truck. From Lanjak he then drives to the border town of Badau and across the border to Lubuk Antu to sell his load.

Fishermen from Meliau and the Empanang River often catch the occasional softshell with a line and hook trading it locally, often within their longhouse.

In villages such as Empaik, turtles are collaited and one person goes to Badau or Lubuk Antu to sell on behalf of the village. Other hunters travel up the Empanang River to Badau, from as far away as the Kapuas River, hunting and buying turtles from the villages along the way. On this route, the hunters go through Nanga Kantuk. Roughly one ton of turtle (approximately 50 individuals) pass through here each year (personal observation) making it an important village for turtle trade. However, neither the trade nor hunting of turtles is the main occupation of any of the local residents.

Middlemen resident in Lanjak collect two to three hundred kilograms of softshells before traveling to Lubuk Antu or Sibul, which is further into Sarawak. Occasionally they will go as far as Miri (Sarawak). All the traders pass through the Badau-Lubuk Antu border. The main dealer in Lanjak will go once a week in the dry season and about once a month in the rainy season.

Smaller traders go to the Badau/Lubuk Antu border two or three times every two months all year round. On the Indonesian side of the border, in Sawit, there is a little shop that deals in softshells. They buy from locals who only have a few softshells to sell, keep them in a water filled pit at the back of the shop, and sell to the occasional person or to traders going across the border. They deal in about 100 kilograms, or 4-5 turtles a month.

The author met one dealer who traveled through DSNP from Pait, south of the park, up to Lubuk Antu. On the way, he bought and fished for softshells. He would make up to 10 trips a year, each time carrying 30 to 35 turtles, amounting to eight tons a year.

The two main traders in Lubuk Antu, one Chinese and the other Iban, send their softshells to Miri or Sibul. Here they are either consumed by the local Chinese

population or exported to China, Hong Kong, and Singapore. Turtles from DSNP very rarely make it to Kuching, which has its own local trade.

Out of the three softshelled species present, the Asiatic softshelled turtle *A. cartilaginea* is considered a delicacy, especially at around 4 to 7 kilograms. However, as there is no difference in the price that the hunters and middlemen make at this weight, they tend to be kept until they grow into the next weight bracket.

#### Trade outside DSNP: further down the Kapuas River

Iban from Danau Gandal hunt softshells in the area southwest of the Park and take them either up the Empanang River to Nanga Kantuk, or down the Kapuas River to Semitau. From Semitau they are taken down-river to supply Chinese populations.

The trade from DSNP and surrounding areas to further down the Kapuas, even to Pontianak, is limited due to a good local trade down-river. The position of DSNP, practically adjacent to the Sarawak border, makes it easier for people in this area to trade with Sarawak than with other parts of Kalimantan. Also, the prices are relatively higher in Sarawak than in West Kalimantan.

#### Volume and value of the trade

Export of softshells to Sarawak produces the majority of DSNP's revenue from freshwater turtles and tortoises. Table 2 shows the volume of trade that was identified during the course of this study. These annual figures were calculated by multiplying the number of trips per season by the number of kilograms per trip. The length of the dry season (10 weeks) was taken as an average of the length of the dry seasons in 1992-94 inclusive; 1995 was not included due to the unusual amount of rain. Hunters and middlemen would quote how much a load of turtle meat was in kilograms. If they quoted how many turtles were taken per load, this was multiplied by the average size of the softshell. Hunters quoted around 20 kilograms for an average softshell, and the largest the author observed was 32 kilograms.

**Table 2: The volume of turtles being traded in DSNP (per annum) (based on two different assessment methods).**

Volume of softshells crossing the border from known sources in Kalimantan (based on interviews with the hunters and middlemen)		Volume of softshells arriving in Lubuk Antu from DSNP (based on interviews with the two main traders in Lubuk Antu)	
Source	Volume	Traders <sup>b</sup>	Volume
Lanjak	20,750 kg	Trader #1	47 tons <sup>a</sup>
Empanang	1,000 kg	Trader #2	3 tons
Empaik	3,000 kg		
Paik (one trader)	8,250 kg		
Sawit	1,200 kg		
Total	34,200 kg	Total	50,000 kg

<sup>a</sup> A further 3 tons were collected locally in Lubuk Antu.

<sup>b</sup> Numbered for the sake of confidentiality

The research allows an overview of the trade, but not a systematic, accurate analysis. Thirty four thousand kilograms of turtle meat is the total deduced from interviews with the middlemen and hunters that were encountered throughout the period of research. Given that there are others the author did not encounter, this measure was taken as a

minimum. The hunters and middlemen from Kalimantan sold to two traders in Lubuk Antu. This figure of 50 tons is therefore a maximum of the amount of turtle meat coming from Kalimantan. There were other traders in Lubuk Antu, but it appeared that they did not trade with Indonesian turtles

The trade in the Malaysian giant tortoise is local and very limited. They are not caught very often and the demand for their meat is negligible. Consequently, there are no reliable figures for the volume of these tortoises hunted or traded per year. The few middlemen (*Lanjak*) that did trade in these tortoises bought them for 950 Rp/kg and sold them for 1200 Rp/kg ( $\pm 100$  Rp).

The price of a softshell depended very much on its weight class. There appeared to be two different types of weight class system in this area: i) less than 19 kilograms, ii) between 19 and 29 kilograms and iii) more than 30 kilograms. A turtle of 20 kilograms tended to cost around 3370 Rp/kg (1.49 USD/kg) across the board of hunters and middlemen. Prices for weights either side of this varied enormously from person to person. The average softshell sold weighed between 10 and 20 kilograms.

The smaller turtles fetch higher prices, and tend to be more sought-after in Chinese restaurants; small softshells look better on the plate than a piece of a larger softshell and there is a greater proportion of cartilage and gelatinous skin per portion (ATTWG 2000:148-155).

**Table 3: Middlemen's selling prices for each weight class in three turtle selling areas in Borneo and three in Sumatra (all figures in USD).**

Weight class	Lanjak, <sup>a</sup> Kalimantan	Lubuk Antu, Sarawak <sup>b</sup>	Sibu, <sup>b</sup> Sarawak	Kan dis <sup>c</sup>	Medan <sup>c</sup>	Tembilahan <sup>c</sup>
0–3 kg	1.99	2.44	0.38	1.6– 2.02	5.61	2.25
3–10 kg	1.99	2.44	0.38	1.6– 2.02	5.62	Less
10–20 kg	1.99	2.44	0.38	0.9	Less	Less
20–29 kg	1.55	1.88	3.01	0.9	Less	Less
>29 kg	1.11	1.50	2.26	0.9	Less	less

<sup>a</sup> Data from middlemen in Lanjak

<sup>b</sup> Data from traders in Lubuk Antu

<sup>c</sup> Data from Shepherd 1999:112-119

Once in Sarawak, the price of softshells rose to an average of 2.41 USD per kilogram (see Table 3 for details).

The total financial benefit to the inhabitants of DSNP is summarized in Table 4. The cost to the hunter/middleman for hunting, keeping and transport of the softshells has not been deducted from the calculated profits as it was hard to isolate these costs.

**Table 4: Value of the trade to hunters and middlemen.**

	Weight (tons)	Hunters (USD)	Middlemen (USD)
Price per kilogram		0.92	2.41
Minimum/yr	34.2 tons	51,018	31,476
Maximum/yr	50.0 tons	74,557	82,473

The fact that the trade is 4.48 per cent of the gross income for DSNP (J. Aglionby pers. comm., 1995), and that less than a quarter of the total population of DSNP is involved in this trade, indicates that it is an important income to a sector of the local population.

### Discussion and Conclusion

Results of the study indicate that DSNP is home to a total of 11 species of turtles and tortoises (c.f. Table 1), none of which are endemic to the area, or indeed to Borneo. All the indigenous species are exploited throughout Asia to various degrees. However, it is only the softshelled turtles that are exploited for commercial gain. Species of hardshell, although traded extensively throughout Asia, are hardly even taken home in DSNP. This national park could become a safe haven for these unexploited species of freshwater turtles and tortoises, even though DSNP is peripheral habitat for the more terrestrial species.

The impression that the author gained whilst interviewing indigenous people was that species other than the softshells (especially the Asiatic softshelled turtle *A. cartilaginea*) are spared exploitation due to the lack of commercial interest rather than as a result of legislation. This is especially so in the case of the Malaysian giant tortoise, a protected species apparently sought after in Chinese communities (Jenkins, 1995; ATTWG, 2000). Paradoxically, Jenkins (1995) states that there has been a dramatic increase in the export of the Malaysian giant tortoise from Kalimantan since the late 1980s, resulting in high prices. This demand does not appear to have filtered through to DSNP. Perhaps trade will develop in DSNP if the supply of softshells, the currently preferred species, becomes depleted.

A figure of fifty tons per annum has been calculated as the maximum amount of turtles passing through this unmonitored Badau/Lubuk Antu border point. Van de Bunt (1990) reported 66 tons of Asiatic softshell turtle was officially exported from Sumatra in 1988. In his case study, Shepherd (2000) found that 25 tons of turtles (50% softshells) were being exported from two provinces in Sumatra per week; an estimated 1300 tons per annum. As there were very few official government records describing exports, Shepherd had to interview the shipping agents. It is more than probable that the size of the trade is underestimated, however it has certainly grown in the last 10 years.

A major problem with monitoring any kind of movement in wildlife is the average official's lack of specialist knowledge. While a herpetologist can tell the difference between one species of softshell and another, an official may not have this ability, and may not even try. A field guide with good photos, and possibly annotated diagrams, giving the legislative status for the various species would be very useful in obtaining more reliable data from border check points.

At the same time as establishing a good, reliable method of monitoring the trade (not only of freshwater turtles and tortoises), research into the reproductive ecology and habitat needs of indigenous species is essential. Very little is known about the population ecology and biology of freshwater turtles or the carrying capacity of habitats like DSNP. Therefore making judgments as to how the turtles are affected by the regular removal of a substantial part of their population is very difficult. Freshwater turtles and tortoises are very cryptic, and the habitat they live in (swamp forests and rivers) does not facilitate research. From investigations into husbandry techniques of softshells in captivity and from what little is known from the wild, we can piece together a probable life history.

Freshwater turtles lay eggs in muddy banks, therefore in DSNP they probably lay in the dry season when the water level in the swamps has dropped, revealing suitable banks. Like most softshells, the Asiatic softshell is a prolific egg layer. As many as 20 to 30 eggs can be laid in one clutch by an experienced female (Ernst and Barbour, 1989). Tracks leading to and from the nest are left behind by the gravid female on certain substrates. Nests, therefore, are relatively easy to identify. Rates of egg mortality are susceptible to stochastic events, e.g. flooding or drying out of nests. Infant mortality is high; raptors and large reptiles such as monitor lizards target hatchlings on their way to the water. The annual flooding of the lakes will affect both the egg and infant mortality; if the lakes flood too early, the nests are lost, if the lakes flood to late, the hatchlings are at greater risk while trying to get into the water. Once in the water, large fish and aquatic reptiles find young turtles an easy meal. Even though these animals reach sexual maturity at the relatively early age of 4 years (Highfield, 1996) and produce a large number of eggs, this species has a low recruitment rate.

Habitat destruction is a major long-term threat to all biodiversity of DSNP. Commercial logging and clear felling have a definite effect on water. As well as the increase in the risk of floods, waterways being damaged from floating the logs down the river, the increase in silt suspended in the water will change the acidity and mineral balance of the water. From captive studies, Highfield (1996) states that water quality is important for the healthy skin of softshells kept in captivity. It is unclear how freshwater turtles and tortoises are affected by the change in water quality caused by logging, but it almost certainly affects their prey species.

European zoos are planning to build on current knowledge of endangered Asian freshwater turtles and tortoises (particularly *Batagur baska*, *Callagur borneoensis* and *O. borneensis*) by setting up coordinated management and breeding groups (Zwartepoorte, 2000). Hopefully the captive world will be able to contribute valuable information for conservation of these species in their natural habitats.

Commercial farming has been looked at as an alternative source for trade in various species through out the animal kingdom. Softshells, predominanatlly the Chinese softshell *Pelodiscus sinensis* species that is native to the Far East, are being farmed commercially in other parts of Asia (Thailand, Vietnam, Cambodia, China, peninsular Malaysia) exclusively for export. It is a species that breeds well and grows fast in the more tropical climates of Southeast Asia. Compared to species such as the Asian softshelled turtle, which are slow growing and whose eggs and hatchlings have a high mortality rate in captivity, the Chinese softshell is a much more commercially viable species. Currently an estimated five to ten thousand tons are being produced a year (ATTWG, 2000). This equals, if not exceeds, the number of wildcaught softshells in the trade a year. Whether this farming of softshells is beneficial or not is a subject of much debate (ATTWG, 2000). Problems have already arisen with turtles escaping and establishing feral populations, which may potentially compete with indigenous species.

As the population estimates given earlier in this paper (c.f. Table 1) are crude and relative, and as optimum population densities, which will be different for all species, are not known, it is impossible to state definitively how exploitation rates are affecting the population. The general impression obtained over the research period was that the number and size of turtles being caught has reduced over the years indicating that fewer turtles are reaching the older age classes. The combination of a cryptic lifestyle, fast

swimming and good defense makes softshells difficult to catch and therefore potential survivors.

To conclude, the international situation for softshelled turtles appears to be far from optimistic. Although most species in DSNP are not at immediate risk, either locally or internationally, the Asian softshelled turtle appears to have a tough future ahead. population of turtles. Assuming that all fifty tons of turtle came from DSNP, the exploitation rate works out as 0.5-1 kg/hectare/year. Not all of DSNP is softshell habitat, so this seemingly low rate is an underestimate. There is no dispute that hunting for trade is the most immediate concern for softshelled turtles in DSNP, if not all of Asia. In order that these creatures do not reach such low populations that they become locally extinct, it is imperative that laws that are already in place are enforced on the ground, and new legislation addressing the extent of the softshell trade are addressed.

### Recommendations

The points below are recommendations for DSNP, with particular reference to the trade in freshwater turtles and tortoises, principally the Asian softshelled turtle *A. cartilaginea*:

- A review of national legislation taking note of the latest IUCN Red Data Book listings and IUCN Appendices (re-evaluated in Dijk *et al.*, 2000).
- Enforcement of probably adequate existing national legislation.
- Develop a protocol about what to do with confiscated turtles and tortoises. IUCN/SSC Tortoise and Freshwater Turtle Specialist Group aim to develop realistic solutions and guidelines to deal with these kinds of situations (ATTWG, 2000). For present guidelines see IUCN website <http://www.iucn.org>.
- Further research into the trade, following it through Sarawak to see exactly where turtles from DSNP end up.
- Further research into the population ecology and biology of relevant species indigenous to DSNP.
- Investigate the possibility of farming indigenous species of softshells for trade as an alternative to hunting, including an Environmental Impact Assessment.

In response to increasing concern over the number of species in the trade, a workshop on the conservation and trade of freshwater turtles and tortoises in Asia was held in Cambodia in December 1999 (van Dijk *et al.*, 2000). Experts from each of the Asian countries involved were asked to produce a report. The end result was a more in-depth view of the trade over the whole of Asia and suggestions that are applicable to most countries involved (Van Dijk *et al.*, 2000).

Like most endangered species, both flora and fauna, the destiny of these species lies in the hands of the people who inhabit and alter the landscapes in which they live.

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## BIRDS OF THE DANAU SENTARUM NATIONAL PARK

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The Danau Sentarum National Park (DSNP) is a wetland conservation area of high priority (Scott, 1989; Giesen and Aglionby, 2000, this volume; Jeanes and Meijaard, 2000b, this volume). Under pressure of the present rapid development of Borneo's natural resources, its lake system and associated swamp forest habitats constitute an increasingly scarce ecosystem. DSNP is especially important for a number of birds dependent on the swamp forest habitats provided by this unique reserve. However, threats come from habitat destruction, excessive egg collecting, hunting for meat, collecting for the pet trade and other disturbances (Giesen, 1987; van Balen, 1996; Dennis *et al.*, 1997).

This paper evaluates the importance of the area and its immediate surroundings for the conservation of birds, in particular those that are dependent on the DSNP wetlands and associated forest habitats, and the hills in the peripheries of the area.

**METHODS****Data collection****Review of reports**

The following reports have been scrutinized: Giesen (1987): 1986; Hood (1993): 1-24 Dec. 1992; 23 Feb.-8 Mar. 1993; Sebastian (1993): 8-18 Aug. 1993; van Balen (1996): 28 Jul.-2 Aug. 1993; 30 Mar.-9 Apr. 1994; Dennis (1994): 26 Nov.-3 Dec. 1994; Dennis *et al.* 1997: 30 Jan.-11 Feb. 1996; R. Jensen (unpublished data): Nov. 1993-Jul. 1994 (RJ). Additional records are from Enthoven (1903), Dunselman (1937), L. Jembu (KSDA, Sintang): reported in Giesen (1987); R. Wadley (1992-93); H. Noveriawan (HN): 1992-1993; R. (Rona) Dennis (RoD): 1995-96; R (Roddy) Dennis: 1996; E. Meijaard (EM): 1996; B. Suriansyah (BS): 1993-1994; A. Jumhur (AJ): Project I-UKTFMP field staff, 1996).

**Mist-netting**

In January-February 1996 Dennis *et al.* (1997) set up mist-nets during three days at two sites.

### **Tape recording**

A Marantz CP430 cassette deck and Audiotechnic unidirectional microphone were used in the field to record bird voices for identification and documentation purposes. Videotape recordings were made of various birds by BS in June-August 1993.

### **Census techniques**

In 1994 counts were carried out in a number of habitats, from the low, stunted swamp forests in the central parts of DSNP to the tall dipterocarp hill forests in the peripheries. For each habitat type, four sample counts were made along transects that were walked or boated along slowly, during each of which 45-49 encounters of birds were tallied (cf Thiollay, 1995); in the early morning these counts would last 30-40 minutes, later in the morning and afternoon up to 1.5-2 hours. Waterbirds, raptors, swifts (an exception has been made for Silver-rumped Swift *Rhaphidura leucopygialis* and tree-swifts) were excepted from the sampling.

### **Interviews**

During most surveys semi-structured interviews were conducted with local hunters and fishermen in the DSNP. Valuable information on occurrence and abundance was obtained on a variety of species, but records of rare or "displaced" species were treated by us with caution.

### **Data analysis**

#### **Bird Species Diversity**

The Shannon-Weaver formula (MacArthur and MacArthur, 1961) is used for calculating the values for the Bird Species Diversity index (H):

$$H = -\sum p_i / \ln p_i$$

in which  $p_i$  is the number of individuals of species  $i$  divided by total number of individuals.

The diversity index is determined by species number and evenness (or equitability,  $J$ ; see Pielou 1966). As shifting relative densities of species within a community could influence the dynamics (stability, productivity) of an ecosystem, evenness in particular is an important measure of community structure.

$$J = D / D_{\max} \text{ (with } D_{\max} = -\log_e 1/n; n = \text{number of species in the sample).}$$

#### **Similarity Index**

The similarity index (S) of Jaccard (1901) was used to show to change in species composition of the different communities going from the low, disturbed swamp forest through tall swamp forest and complex dipterocarp hill forest.

$$S = c / a + b + c$$

in which a and b are the numbers of species unique to communities 1 and 2 respectively, and c species common to both.

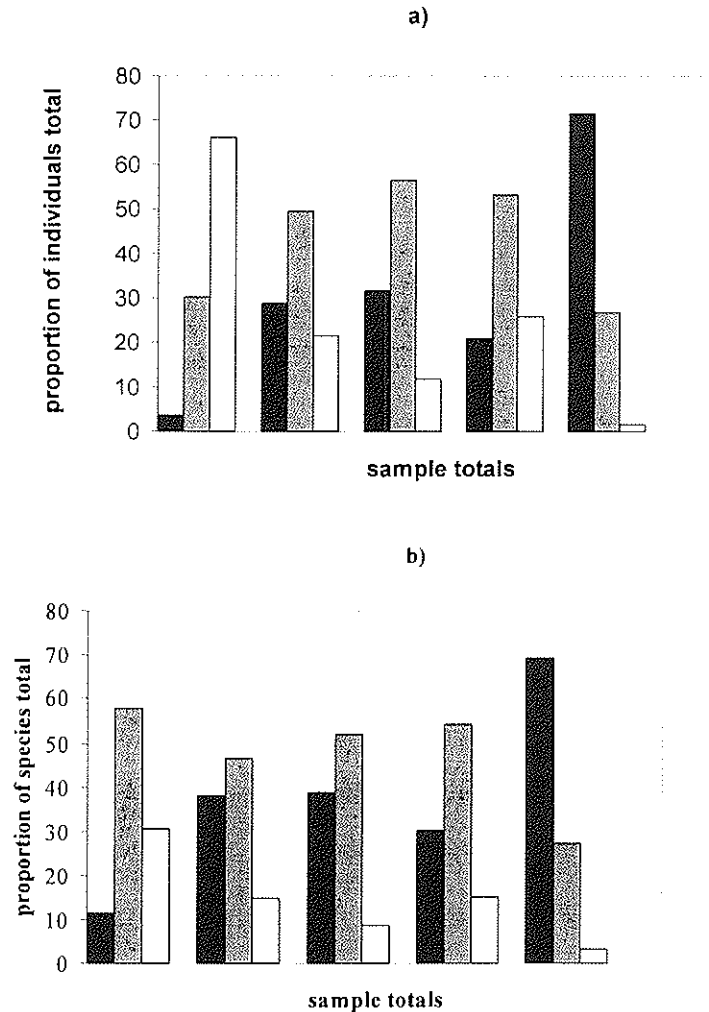
## **RESULTS**

### **Birds and habitat**

The DSNP consists of extensive seasonally inundated stunted forest, surrounded by taller swamp forest and dry land forest on levees and hills. This offers a scale of different

vegetation types, which have been extensively surveyed during a number of wildlife surveys. Detailed descriptions of their structure, floristic composition, and relevance for wildlife can be found in Giesen (1987, 1996, 2000, this volume) and Jeanes and Meijaard (2000b, this volume).

**Figure 1. Proportions of individuals (a) and species (b) in the samples belonging to species of the following three habitat classes in DSNP: forest interior (black bars), secondary growth/forest edge (dark grey bars) and open woodland/cultivated areas (pale grey). From left to right: Tekenang, Pamera, Empaik, Gernis and Menyukung. In the Tekenang area the large number of individuals (a) for a small number of open woodland species (b) is obvious; the proportions of these in the other areas are more balanced, accounting for higher evenness values.**



### Dwarf Swamp Forest (sample locality: Tekenang)

This habitat is dominated by 5-8 m tall trees, flooded up to ten months a year, and at times is almost entirely submerged. Bird species found were mostly those typical of secondary habitat, and Figure 1a-b shows clearly how these are abundant in number of individuals, but low in species number.

Sebastian (1993) pointed out the common characteristics between mangrove forest and *Melaleuca* forest in Malaysia, and the similarly simple structured dwarf swamp forest of DSNP. The list of species exclusively or extensively dependent on mangroves in Borneo contains 21 species (Wells 1985), which includes five species, doubtfully assigned to the Bornean mangrove avifauna. These may elsewhere be confined to mangrove, but in Borneo they are found in other habitats as well (Purple Heron *Ardea purpurea*, Ashy Tailorbird *Orthotomus ruficeps*, Rufous-tailed Tailorbird *O. sericeus*, Pied Fantail *Rhipidura javanica*, and Olive-backed Sunbird *Nectarinia jugularis*). To Wells' list the Greater Goldenback *Chrysocolaptes lucidus* can also be added considering its apparent preference for mangroves in Kalimantan (cf Eve and Guigue 1989). Of Borneo's 17 mangrove species, the following nine were found in DSNP:

Oriental Darter *Anhinga melanogaster*  
 Great-billed Heron *Ardea sumatrana*  
 Striated Heron *Butorides striatus*  
 Black-crowned Night-heron *Nycticorax nycticorax*  
 Lesser Adjutant *Leptoptilos javanicus*  
 Brahminy Kite *Haliastur indus*  
 Brown-capped woodpecker *Dendropos moluccensis*  
 Greater Goldenback *Chrysocolaptes lucidus*  
 Mangrove Whistler *Pachycephala grisola*

### Stunted Swamp Forest (sample locality: Gernis)

This habitat is dominated by small to medium sized, 8-15 m tall trees, flooded 5-8 months annually with 3-4 m water depth. Despite its rather low canopy, this forest is relatively rich in bird species, partly because of the inclusion of riparian forest.

### Tall swamp forest (Sample localities: Empaik, Pemera)

This habitat is dominated by 25-30 m straight-stemmed trees, and inundated for 3-6 months annually with 3 m water depth. This forest was the richest of the swamp forest types, not only because of a more complex structure but also its proximity to the adjacent dry forest on hills.

The following terrestrial species associated with swamp forest and riverine habitat were found throughout the swamp forests (with the exception of the bulbul, which has become extremely rare in recent years):

Lesser Fish-eagle *Ichthyophaga humilis*  
 Greyhaded Fish-eagle *Ichthyophaga ichthyaetus*  
 Blue-eared Kingfisher *Alcedo meninting*  
 Straw-headed Bulbul *Pycnonotus zeylanicus*  
 Stork-billed Kingfisher *Pelargopsis capensis*  
 White-chested Babbler *Trichastoma rostratum*  
 Malaysian Blue flycatcher *Cyornis turcosus*

**Hill dipterocarp forest (Sample localities: Semujan, Menyukung)**

This habitat is dominated by dipterocarp trees, a tall to very tall forest with emergents up to 35-45 m, on hills of 370 m (Semujan) and 630 m (Menyukung). This is rich forest, with potentially a near-complete representation of the lowland Bornean avifauna. Hunting practices and disturbance of forests has reduced the numbers of certain bird groups (notably pheasants).

**Bird species diversity**

Rigorous scrutinizing of the existing ornithological reports rendered the total number of confirmed species to 237 (see Appendix 1). An additional 45 species were recorded, but their overall scarcity on Borneo, or otherwise unexpected presence in DSNP, urges confirmation and/or proper documentation.

**Table1. Similarity Indices for bird communities in five census sites in DSNP. A gradual shift in species composition is found from the dwarf swamp forest Tekenang through the swamp forest cluster (Gernis, Pemera, and Empaik) to Menyukank.**

	T	E	P	G	M
Tekenang	x	.24	.38	.38	.11
Empaik		x	.44	.47	.22
Pemera			x	.54	.23
Gernis				x	.19
Menyukung					x

**Table 2. Bird Species Diversity Values for five census localities in DSNP. BSD: Bird Species Diversity index (Shannon-Weaver formula; MacArthur and MacArthur 1961); Species Richness (number of species for four 50-individual samples); Evenness (or Equitability; Pielou 1966).**

	BSD	Species Richness	Evenness	sample size
Tekenang	2.82	27	.86	195
Empaik	3.36	46	.88	186
Pemera	3.58	46	.93	190
Gernis	3.45	46	.90	186
Menyukung	3.73	61	.91	186

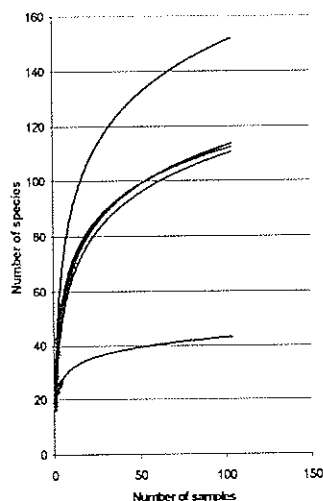
Figure 2 shows the cumulative species numbers for the five sampling localities (each sampled by four times ca 50 individuals, and extrapolated to 100 samples). The Tekenang curve has nearly reached its maximum, i.e., more sampling would yield only few species. For Menyukung more surveys would have been needed to cover its complete species spectrum. The three swamp forest curves (Empaik, Gernis and Pemera) are intermediate. The curves show that Menyukung would potentially contain at least 160 spp, each of the three swamp forest at least 120, and Tekenang c. 45 spp.

The five sample areas are readily classified into three groups with similar diversity values, species richness, and evenness (see Tables 1 and 2). The Tekenang area is much impoverished in terms of species diversity, and a large proportion of its avifauna consists of secondary growth species (Figure 1a and 1b). The three more complex swamp forest localities (Gernis, Pemera, Empaik) are much richer with an increasing proportion of primary forest species. The hill forest (Menyukung) scores highest in terms of diversity, and the majority of its birds are primary forest inhabitants.

#### Seasonality in habitat use

Field observations suggest that the peat swamp and hill forests constitute important refuges for a variety of wildlife during the seasonal flooding (9-10 months/year) of the lake basin (Jeanes and Meijaard, 2000b, this volume). Other changes in species composition are under influence of the phenology of flowering and fruiting trees, which is linked to flooding (Giesen, 2000, this volume). In August very few pigeons and barbets were seen by Sebastian (1993), few to none in November-December (Dennis 1993; Dennis *et al.* 1997; RJ). These birds were found to be far more numerous in both individuals and species in April, especially Cinnamon-headed Green Pigeon *T. fulvicollis* (van Balen 1997), and this coincided the fruiting of figs (W. Giesen pers. comm.).

**Figure 2. Cumulative curves for five census localities in DSNP, extrapolated to 100 samples (from top to bottom: Menyukung, Pemera, Gernis, Empaik and Tekenang).**



Scarce information in DSNP (Dennis *et al.* 1997; SvB, pers. obs.) suggests that there is increased breeding activity of raptors and insectivorous birds during April (high water levels), and less activity in August (low water levels), November and December.

The DSNP offers wintering habitat for a relatively small number of birds. Twenty confirmed species of northern migrant have been recorded, constituting less than 10% of the total and numbers of the species are low. The number of recorded species of migratory waders is very low compared to other comparable areas, such as the Middle Mahakam Area. This may be partly caused by the distance to coastal areas and flooding of potential feeding grounds during the birds' wintering season. Furthermore, the lake bottom consist of a very hard and cracking clay soil (W. Giesen, pers. comm.), which may be a less suitable substrate for the invertebrate prey the waders feed on.

### Systematic Notes

The following is a systematic account of the birds in DSNP. See Appendix I for complete lists of the species and families mentioned. The following categories of birds receive special attention as their presence in DSNP is of major conservation importance.

### Globally threatened bird species

This category follows the BirdLife International Red List of birds (Collar *et al.* 1994). Nine threatened and 22 near-threatened species (including eight which presence has yet to be confirmed) have been found in the area.

### Water birds

Water birds (according to Sonobe and Usui 1993) of the following orders: Pelecaniformes, Ciconiiformes, Anseriformes, Gruiformes and Charadriiformes. Herons are especially well represented, but waders, rails and ducks are much scarcer.

### Endemic species

Only five (including two species yet to be confirmed) of the 36 to 44<sup>1</sup> Bornean endemics have been recorded from DSNP.

PHALACROCORACIDAE (Darters/Cormorants) Borneo: 3 [+ 1] spp. Recorded in DSNP: 1. The globally near-threatened Oriental darter *Anhinga melanogaster* is a scarce bird in the area, but reportedly more common and found breeding in the area in the past (Dennis *et al.* 1997).

ARDEIDAE (Herons) Borneo: 17 [+ 3] spp. Recorded in DSNP: 12 [+2].

Unconfirmed record of Rufous Night-heron *Nycticorax caledonicus* (BS) would be the first documented for Kalimantan; Chinese Pond-heron *Ardeola bacchus* is a very rare visitor to Borneo and its records (LJ; AJ) should be confirmed. There is a record of the globally endangered Chinese Egret *Egretta eulophotes* (Dennis *et al.* 1997)<sup>2</sup>. Several active nests of the near-threatened Great-billed Heron *Ardea sumatrana* have been observed (RJ). At Pejerin there is a breeding colony of Purple Heron *Ardea purpurea* (Dennis *et al.* 1997), but this under extreme pressure because of the collection of eggs and young birds.

CICONIIDAE (Storks) Borneo: 2 spp. Recorded in DSNP: 2

There are a fair number of sightings of the globally endangered Storm's Stork *Ciconia stormi* in the area (Hood 1993; Sebastian 1993; Dennis 1993; van Balen 1996).

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<sup>1</sup>This depends on taxonomic views.

<sup>2</sup>Two recently caught birds tethered on raft at Meliau, 2 Feb 1996.

One capture specimen was released by park staff at Tekenang in August 1994. Nesting has been reported by locals from several places in the area, but nest site description (at 1 m in floating grass/reed vegetation) does not fit the description for documented nesting in literature. Surprisingly the vulnerable Lesser Adjutant *Leptoptilos javanicus* was unknown from DSNP until breeding was reported in 1995 (8+ nests) and 1996 from the Nung forest, where they had not been breeding for the last thirty years (Dennis *et al.* 1997).

PANDIONIDAE (Osprey) Borneo: 1 sp. Recorded in DSNP: 1

ACCIPITRIDAE (Hawks/Eagles) Borneo: 22 [+4] spp. Recorded in DRWR: 11 [+6].

There are unconfirmed records of Bat Hawk *Macheiramphus alcinus* (BS), Besra *Accipiter virgatus*, Grey-faced Buzzard *Butastur indicus* (Dennis 1994<sup>3</sup>; H. Noveriawan unpublished data 1992-93). The buzzard is known from northern Borneo only, whereas the Bat Hawk and Besra are generally rare in Kalimantan and no records are known from West Kalimantan; documentation of the records is needed. The globally near-threatened Lesser Fish-eagle *Ichthyophaga humilis* is a riverine forest specialist and found in very small numbers in DSNP; Grey-headed Fish-eagle *I. ichthyaetus* is more widespread in the more open swamp forests. The globally near-threatened Jerdon's Baza *Aviceda jerdoni* was seen on several occasions (Dennis 1994; van Balen 1996). There are a number of records of the vulnerable Wallace's Hawk-eagle *Spizaetus nanus* (Dennis 1994; van Balen 1996; RJ); observations of the hill species Blyth's Hawk-eagle *Spizaetus alboniger* (Giesen, 1987; Hood, 1993; Dennis 1994) need confirmation. In the villages numerous captive Brahminy Kites *Haliastur indus* were seen; the very high proportion of juveniles suggests a high turnover through death or sale (Sebastian 1993; Dennis 1994; van Balen 1996).

FALCONIDAE (Falcons) Borneo: 4 [+2] spp. Recorded in DSNP: 1 [+1].

The record of a Peregrine Falcon *Falco peregrinus* (BS) needs confirmation, and would be the first for the province.

ANATIDAE (Ducks) Borneo: 6 [+6] spp. Recorded in DSNP: 1.

PHASIANIDAE (Pheasants) Borneo: 12 [+1] spp. Recorded in DSNP: 4 [+3].

Most records of the species have been obtained through interviews with local hunters (Hood 1993; Dennis 1997) and the presence in the reserve of Black Partridge *Melanoperdix nigra*, Crestless Fireback *Lophura erythrophthalma* and Bulwer's Pheasant *L. bulweri* has to be confirmed in due time. An old, unconfirmed record of *Polyplectron schleiermacheri* has been omitted as the bird appeared to be unknown with local hunters; however, in 1998-99 the species' presence was confirmed from Sungai Badak, near the Sarawak border, immediately NNW of DSNP (R. Sözer, pers. comm.). The vulnerable Crested Fireback *Lophura ignita* is widespread in the dryland forest in the peripheries of the area; although not seen by us in the wild, captive birds, feathers etc shown to us of birds killed were evidence.

RALLIDAE (Rails) Borneo: 11 [+2] spp. Recorded in DSNP: 2 [+2].

The records of Red-legged Crake *Rallina fasciata* and Watercock *Gallinula cinerea* (BS) need confirmation due to possible confusion with other rails.

CHARADRIIDAE (Plovers) Borneo: 8 [+4] spp. Recorded in DSNP: 1.

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<sup>3</sup>One in tree near Lake Bekuwan on 29 Nov 1994; not perfect views but considered this species.



Plovers are scarce in the interior and accordingly only few reach DSNP. An early arrival of eight Little Ringed Plover *Charadrius dubius* was observed on 10 August 1993 (Sebastian 1993), and the only recent one for West Kalimantan.

SCOLOPACIDAE (Sandpipers) Borneo: 25 [+10] spp. Recorded in DSNP: 2.

Common Sandpiper *Actitis hypoleucos* and Wood Sandpiper *Tringa glareola* are widespread migrants from the northern hemisphere occurring in small numbers.

LARIDAE (Gulls/Terns) Borneo: 13 [+3] spp. Recorded in DSNP: 1.

Little Terns *Sterna albifrons* are reportedly breeding on the DSNP lake shores, as was already observed in September 1934 by Dunselman (1937).

COLUMBIDAE (Pigeons/doves) Borneo: 19 [+1] spp.: Recorded in DSNP: 8 [+4].

The following species need confirmation: the predominantly montane Mountain Imperial Pigeon *Ducula badia*, (BS), the feral Zebra Dove *Geopelia striata* (BS), Jambu Fruit Dove *Ptilinopus jambu* (BS) and globally near-threatened Large Green Pigeon *Treron capellei* (Giesen 1987; BS).

PSITTACIDAE (Parrots) Borneo: 4 spp. Recorded in DSNP: 3.

CUCULIDAE (Cuckoos) Borneo: 24 spp. Recorded in DSNP: 17 [+2].

Records of the globally near-threatened Short-toed Coucal *Centropus rectunguis* (BS) and Bornean Ground-cuckoo<sup>4</sup> *Carpococcyx radiceus* (BS) need confirmation. A Chest-winged Cuckoo *Clamator coromandus* was seen on 5 February 1996 (Dennis *et al.* 1997).

TYTONIDAE (Barn-owls) Borneo: 1 sp. Recorded in DSNP: 1.

STRIGIDAE Borneo: 8 [+3] spp. Recorded in DSNP: 6.

A large number of owls have been recorded in the area, comprising all lowland owls known from Kalimantan.

PODARGIDAE (Frogmouths) Borneo: 6 spp. Recorded in DSNP: [3].

Three species of frogmouth are listed for DSNP, but no records have been adequately documented. A call resembling that of the montane (!) Bornean Frogmouth *Batrachostomus mixtus* (D. Yong in litt. 1995) was recorded by SvB in July 1993.

CAPRIMULGIDAE (Nightjars). Borneo: 5 spp. Recorded in DSNP: 2 [+1]

The globally near-threatened Bonaparte's Nightjar *Caprimulgus concretus* was tape-recorded in April 1994 (van Balen 1996). Two specimens of the Grey Nightjar *Caprimulgus indicus* were seen hawking over the river on Tawang on 1 December 1994 (Dennis 1994).

APODIDAE (Swiftlets) Borneo: 9 [+3] spp. Recorded in DSNP: 5 [+3].

The records of Silver-backed Needletail *Hirundapus cochinchinensis* (Dennis 1994; would be the first record for Borneo)<sup>5</sup>, White-throated Needletail *H. caudacutus* (R. Jensen, unpubl. data; would be the first for Kalimantan) and Edible-nest Swiftlet *Aerodramus fuciphagus* (van Balen 1996) need confirmation and more detailed documentation.

HEMIPROCINIDAE (Tree-swifts) Borneo: 2 spp. Recorded in DSNP: 2.

TROGONIDAE (Trogon) Borneo: 6 spp. Recorded in DSNP: 3

ALCEDINIDAE (Kingfishers) Borneo: 11 spp. Recorded in DSNP: 6.

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<sup>4</sup>This species has recently been split into Sumatran *Carpococcyx viridis* and Bornean Ground-cuckoo *C. radiceus* (Collar and Long 1996)

<sup>5</sup>Four flying high over the Entipau River on 1 Dec 1993: smaller than *H. giganteus*, pale back, white vent and no white throat.

MEROPIDAE (Bee-eaters) Borneo: 3 spp. Recorded in DSNP: 2.

CORACIIDAE (Rollers) Borneo: 1 sp. Recorded in DSNP: 1.

BUCEROTIDAE (Hornbills) Borneo: 8 sp. Recorded in DSNP: 8.

For hornbills the DSNP seems to be suitable as all species known for Borneo have been recorded. The vulnerable Wrinkled Hornbill *Rhyticeros corrugatus* was seen in small numbers (RW; Dennis *et al.* 1997); globally near-threatened Black Hornbill *Anthracoceros malayanus* was recorded from taller swamp forest whereas Helmeted Hornbill *Rhinoplax vigil* is only known from the hill forests.

CAPITONIDAE (Barbets) Borneo: 9 spp. Recorded in DSNP: 6.

The globally near-threatened Red-crowned Barbet *Megalaima rafflesii* is found in the reserve.

INDICATORIDAE Borneo: 1 sp. Recorded in DSNP: 1

The globally near-threatened Malaysian Honeyguide *Indicator archipelagicus* was mistnetted on 10 Feb 1996 (Dennis *et al.* 1997). Also reported by BS.

PICIDAE (Woodpeckers) Borneo: 17 [+1] spp. Recorded in DSNP: 15.

A video recording made by B. Syariansah showed a rather distant Greater Goldenback *Chrysocolaptes lucidus*. This and the Common Goldenback *Dinopium javanense* are very locally distributed to rare on Borneo, with the former only known from the far NE of the island (Smythies 1981) and Mahakam mangroves (Holmes 1997). There is a record of the coastal Brown-capped Woodpecker *Dendrocopus moluccensis* in October 2000 (EM).

EURYLAIMIDAE (Broadbills) Borneo: 8 spp. Recorded in DSNP: 5.

PITTIDAE (Pittas) Borneo: 8 [+1] spp. Recorded in DSNP: 2.

HIRUNDINIDAE (Swallows) Borneo: 4 [+1] spp. Recorded in DSNP: 3 [+2].

The occurrence on Borneo of Red-rumped *Hirundo daurica* is yet to be confirmed, but the similar (and likely to be confused) Striated Swallow *Hirundo striolata* is known from northern Borneo. Birds belonging to either species are reported from Kalimantan (Holmes 1997); because their identification in the field is problematic, their records in DSNP (Dennis 1994<sup>6</sup>; EM<sup>7</sup>) need confirmation. The record of Asian House Martin *Delichon dasypus* (HN, BS) needs confirmation, considering the rareness of this species on Borneo.

CAMPEPHAGIDAE (Cuckoo-shrikes) Borneo: 14 spp. Recorded in DSNP: 5 [+2].

The records of Bar-bellied Cuckoo-shrike *Coracina striata* and the hill dwelling Bar-winged Hemipus *Hemipus picatus* (BS) should be confirmed because their overall scarcity on Borneo and the lack of suitable habitat in DSNP.

PYCNONOTIDAE (Bulbuls) Borneo: 23 spp. Recorded in DSNP: 15 [+4].

Black-crested Bulbul *Pycnonotus melanicterus*, Grey-cheeked Bulbul *Criniger bres* and Ochraceous Bulbul *C. ochraceus* are hill birds or scarce on Borneo and their records (BS; RW) need confirmation. On Borneo the globally near-threatened Hook-billed Bulbul *Setornis criniger* is a scarce swamp forest bird on Borneo, and its record (RW) needs proper documentation. The vulnerable Straw-headed Bulbul *Pycnonotus zeylanicus* was already rare in 1986 (Giesen 1987); the only records thereafter are from along the Batang Ketam river, where calls were heard in August 1993 (Sebastian 1993), and a bird flying across the river in November 1994 (Dennis 1994).

<sup>6</sup>Four very pale birds seen above Tekenang hill on 26 November 1994

<sup>7</sup>Seen in the north of DSNP in 1996.

IRENIDAE (Leafbirds) Borneo: 6 spp. Recorded in DSNP: 5.

LANIIDAE (Shrikes) Borneo: 4 spp. Recorded in DSNP: 3.

The Bornean endemic, and globally near-threatened Bornean Bristlehead *Pityriasis gymnocephala* has been recorded in small numbers in the peatswamp forest (RnD, EM).

TURDIDAE (Thrushes) Borneo: 12 [+10] spp. Recorded in DSNP: 5 [+1].

There is an unconfirmed record of chats *Saxicola* sp. (HN), two species of which have been recorded from northern Borneo (Common Stone-chat *S. torquata* and Pied Bush-chat *S. caprata*).

ORTHONICHIDAE (Rail Babblers) Borneo: 1 sp. Recorded in DSNP: [1].

The record of the Rail Babbler *Eupetes macrocerus* (van Balen 1996) needs confirmation.

TIMALIIDAE Borneo: 34 [+1] spp. Recorded in DSNP: 15 [+2].

The records of Abbott's Babbler *Trichastoma abbotti* and the Bornean endemic Black-throated Wren-babbler *Napothera atrigularis* (van Balen 1996) need confirmation. The globally near-threatened White-chested Babbler *Trichastoma rostratum* is a widespread inhabitant of riverine forest; the globally near-threatened Ferruginous Babbler *Trichastoma bicolor* was only found in the higher and dry parts of the area. A scimitar-babbler very similar to chestnut-backed, but with a white crown patch and collar was video-taped on 11 August 1993 by BS, but the recording was unfortunately erased by accident.

SYLVIIDAE (Old World Babblers) Borneo: 15 [+3] spp. Recorded in DSNP: 5 [+1].

The record of Black-Browed Reed-Warbler *Acrocephalus bistrigiceps* (Dennis *et al.* 1997) would be the first for Borneo but needs confirmation.

MUSCICAPIDAE (Old World Flycatchers) Borneo: 26 [+3] spp. Recorded in DSNP: 5 [+4]. The records of Rufous-tailed Rhinomyias *Rhinomyias ruficauda* (Dennis *et al.* 1997), Blue-and-white Flycatcher *Cyanoptila cyanomelana*, Hill Blue Flycatcher *Cyornis banyumas* (HN, BS) and Bornean Blue Flycatcher *C. superbus* (Hood 1993) need confirmation and proper documentation, considering the aberrant habitat they were found in and/or their rareness on Borneo.

MONARCHIDAE (Monarchs/Fantails) Borneo: 7 spp. Recorded in DSNP: 6.

PACHYCEPHALIDAE (Whistlers) Borneo: 2 spp. Recorded in DSNP: 1.

PARIDAE (Tits) Borneo: 1 sp. Recorded in DSNP: [1]

The records of the Great Tit *Parus major* (HN, BS) needs confirmation as this mystery bird is only locally known from the mangroves and man-made habitats in C and S Kalimantan (Holmes and Burton 1987), north of Kuching and in Sabah (Smythies 1981)

SITTIDAE (Nuthatches) Borneo: 1 sp. Recorded in DSNP: 1.

DICAEIDAE (Flowerpeckers) Borneo: 11 spp. Recorded in DSNP: 8 [+1].

The record of Brown-backed Flowerpecker *Dicaeum everetti* (HN, BS) needs confirmation. There are several records of the elsewhere widespread Bornean endemic Yellow-rumped Flowerpecker *Prionochilus xanthopygius* (e.g., Dennis *et al.* 1997), suggesting sympatry with the in DSNP far more commonly occurring Crimson-breasted Flowerpecker *P. percussus*.

NECTARINIIDAE (Sunbirds) Borneo: 17 spp. Recorded in DSNP: 13 [+3].

The records of Copper-throated Sunbird *Nectarinia calcostetha* and Red-throated Sunbird *Anthreptes rhodolaema* (Dennis 1994), both isolated records from atypical

habitat, and those of Yellow-eared Spiderhunter *Arachnothera chrysogenys* need confirmation.

ESTRILDIDAE (Finches) Borneo: 6 spp. Recorded in DSNP: 3.

The endemic Dusky Munia *Lonchura fuscans* occurs in small numbers on the foothills of Menyukan and Semujan.

PLOCEIDAE (Weavers) Borneo: 1 sp. Recorded in DSNP: 1.

STURNIDAE (Starlings) Borneo: 3 [+4] spp. Recorded in DSNP: 2.

ORIOIDAE (Orioles) Borneo: 4 [+1] spp. Recorded in DSNP: 1.

DICRURIDAE (Drongos) Borneo: 5 spp. Recorded in DSNP: 1 [+2]

The Bronzed Drongo *Dicrurus aeneus* (WG, BS) and Crow-billed Drongo *D. annectans* (BS) need confirmation.

CORVIDAE (Crows) Borneo: 7 [+1] spp. Recorded in DSNP: 4.

Large-billed Crow *Corvus macrorhynchos* is a mystery bird on Borneo, with only four specimens collected in the past (Smythies 1981); a more rowing flight, larger bill, more open habitat and calls differing from Slender-billed Crow have been found in a fair number birds throughout DSNP (Sebastian 1993; Dennis *et al.* 1997; SvB pers. obs.); about its presence appears to be little doubt. Of the globally near-threatened Black Magpie *Platysmurus leucopterus* three were seen near the Tekenang field station (Dennis 1994).

## DISCUSSION

The minimal sample sizes fell short of covering even a near-complete spectrum of DSNP species: together they contained only 130 species. The cumulative curves confirm that the sample counts conducted are far from adequate to calculate species diversity, and only give a preliminary judgement. However, the counts suggest a trend of increasing higher diversity and expected total species number with habitat complexity. The three swamp forest plots appear extremely similar, and differences in diversity are only determined by slight differences in evenness. Despite its taller forest habitat, Empaik has lower diversity and evenness values, but has a similar extrapolated total number of species. The higher species richness of its swamp/dry hill forest ecotone apparently compensates for a lower evenness value. The cumulative curves in Figure 2ab do not tell us much about the biodiversity of entire DSNP, but the number thus far found, 237 [to 282] is likely to be close the actual number of bird species present in DSNP.

Bird families especially well represented are the herons, and a number of families which members may increase in numbers only seasonally (see van Balen 1996), dependent on fruiting resources (pigeons, hornbills), nectar resources (sunbirds), seasonal presence and breeding seasons of host species (cuckoos). The abundance and relative intactness completeness of the woodpecker guild, which are believed to be indicators of good forest (cf Lambert 1992), is rather surprising considering the disturbances that take place in the area. The (temporary) abundance of decaying wood after slashing and logging (see van Balen 1996) can only be one explanation.

Excessive trapping has almost certainly already extirpated the Straw-headed Bulbul in DSNP, as it has in most areas in the Greater Sundas (van Balen 1997). The Brahminy Kites and Purple Herons are other species under possibly excessive hunting pressure. Old reports (Enthoven 1903), topographic names referring to former bird colonies (Danau Peranak Burung; Danau Sarang Burung, Danau Pulau Burung), and the widespread water quality and prolific fish populations suggest that the flood plains might be of major importance to waterbirds such as herons and storks (Dennis *et al.* 1997). Especially the

sudden “arrival” of a breeding colony of the globally threatened Lesser Adjutant, and apparently regular (though yet to be documented) breeding of Storm’s Stork, make the area one of the last refuges of these species.

Another important category of birds in DSNP are the extreme lowland specialists (Wells 1985), many of which are globally (near)threatened, and 33 species (67% of Borneo’s total; excludes 7 unconfirmed species) occur in the DSNP. These species generally do not occur at altitudes above the hill-foot boundary and are especially vulnerable to the proceeding destruction of lowland forest in Borneo.

It is not always clear what the impact is of the seasonal inundation and human disturbance. Jeanes and Meijaard (2000b, this volume) suggest that the high incidence of human activity during the dry season (= peak fishing season) has an impact on the presence of wildlife in the lake basin. Also disturbances through swidden cultivation, burning and logging (Giesen, 1987; Giesen and Aglionby, 2000, this volume), have clearly impact on bird diversity. Especially birds of the lower forest levels appear to have very low representation (pittas, most flycatchers, ground-babblers), which can be explained by the regular flooding events, but remains enigmatic as this is also the case in the dry forest. It may indicate disturbance as a decrease in species richness of these bird groups has been found in disturbed (e.g., selectively logged) forests elsewhere (cf. Lambert, 1992). A good to excellent representation is found in monarchs, sunbirds and flowerpeckers, most of which are higher canopy species, and apparently less sensitive to both logging and inundation.

The DSNP swamps and lakes are a unique ecosystem, and with 237+ bird species it is richer than any other comparable (and intensively surveyed) wetland conservation area in Kalimantan: the Middle Mahakam Area with 207 spp. (Gönner in press), but which is very much disturbed (Giesen, 2000, this volume); Tanjung Puting with 218 spp. (Nash and Nash 1988; Negara and Barito river basins with 140+ spp, which, however, lost most of their conservation value (van Balen and Prentice 1997); Gunung Palung NP with 203 spp (Laman *et al.* 1996).

## CONCLUSIONS AND RECOMMENDATIONS

### Research

1. The DSNP area is important for a number of globally threatened, notably Storm’s Stork, Lesser Adjutant, Wallace’s Hawk-eagle, Crested Fireback and Wrinkled Hornbill, Straw-headed Bulbul (if still surviving), and offers unique opportunities for in-depth studies of their ecology and biology.

2. The number of yet to be confirmed species indicates the urgency to do more surveys, in which mist-netting and trapping in the hill and swamp forests, as well as scrub and reed marshes would be productive, especially for the more secretive species.

3. Storks, herons and darters appeared to have been far more common in the past, and are now occurring scattered in small numbers across the area. Aerial surveys are needed to locate breeding colonies of waterbirds and census numbers of these, especially on the least accessible, and thus relatively secure, lakes and marshes.

4. The detailed study of the impact of the seasonal inundation on tree phenology and breeding activity in DSNP will give insight into the ecological processes that take place and determine the shifts in distribution of birds.

### Management

1. The high potential of the swamp and hill forests in the peripheries of DSNP have great ornithological importance and should be included into DSNP as far as they have not been.
2. Law enforcement should be improved to allow the recovery of the populations of both globally and locally threatened birds, the majority of which is protected by Indonesian law (cf Abdullah *et al.* 1978). Special sanctuary zones should be established.
3. Awareness programmes should be designed to encourage to the local people to protect the waterbirds and other birds presently under high hunting pressure.

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APPENDIX 1. LIST OF BIRD SPECIES IN DSNP AND THEIR NUMBERS IN SIX CENSUS LOCALITIES. RECORDS (X, S, V) HAVE BEEN PUBLISHED IN VAN BALEN (1996) AND DENNIS *ET AL.* (1997) UNLESS INDICATED OTHERWISE.

**Nomenclature:** 1) =*Egretta alba*; 2) =*Dupetor flavicollis*; 3) =*Tringa hypoleucos*; 4) The genera *Rhopodytes*, *Rhinortha* and *Rhamphococcyx* are often combined in *Phaenicophaeus*; 5) *Aerodramus* is often lumped with *Collocalia*; 6) *Berenicornis* and *Rhyticeros* are often combined in *Aceros*; 7) =*Buceros vigil*; 8) *Criniger* = *Alophoixus*; 9) =*Iole charlottae*; 10) =*Tricholestes criniger*; 11) =*Ixos malaccensis*; 12) =*Malaccocincla malaccense*; 13) =*Malaccocincla abbotti*

**Status:** m: migrant from the palearctic; m/r: migrant and resident populations on Borneo; v: vagrant; f: feral.

**Habitats:** I: forest interior; II: forest-edge species; III: woodlands/cultivated areas; W: wetlands; \* extreme lowland specialist.

**Localities:** T: Tekenang; P: Pamera; E: Empaik; G: Gernis; S: Semujan; M: Menyknng.

**Documentation:** s: sighting; v: only voice record; t: tape recording; vt: videotape recording; m: mist-netted and ringed; text: see "Systematic List"; unpublished records by em: E. Meijaard (in litt.); rj: R Jensen (unpublished data); wg: Giesen (1987); ih: Hood (1993); rd: Dennis *et al.* (1997); rw: R. Wadley (unpublished data); rdd: R. (Roddy) Dennis.

## Appendix I

		Status	Habitat	T	P	E	G	S	M	Doc
Oriental Darter	<i>Anhinga melanogaster</i>		W	.	.	.	.	.	.	s
Great-billed Heron	<i>Ardea sumatrana</i>		W	.	.	.	.	.	.	s
Purple Heron	<i>Ardea purpurea</i>		W	.	.	.	.	.	.	s
Great Egret	<i>Casmerodius albus(1)</i>	m	W	x	.	.	.	.	.	s
Intermediate Egret	<i>Egretta intermedia</i>	m	W	.	.	.	.	.	.	s
Little Egret	<i>Egretta garzetta</i>	m	W	.	.	.	.	.	.	s
Chinese Egret	<i>Egretta eulophotes</i>	m	W	.	.	.	.	.	.	text
Cattle Egret	<i>Bubuculus ibis</i>	m	W	.	.	.	.	.	.	s
? Chinese Pond-heron	<i>Ardeola bacchus</i>	m	W	.	.	.	.	.	.	text
Striated Heron	<i>Butorides striatus</i>	m/r	W	x	.	.	.	.	.	s
Black-crowned Night-heron	<i>Nycticorax nycticorax</i>		W	rd	.	.	.	.	.	s
? Rufous Night-heron	<i>Nycticorax caledonicus</i>	v	W	.	.	.	.	.	.	text
Yellow Bittern	<i>Ixobrychus sinensis</i>	m	W	.	.	.	.	.	.	s
Cinnamon Bittern	<i>Ixobrychus cinnamomeus</i>	m/r	W	.	.	.	.	.	.	s
Black Bittern	<i>Ixobrychus flavicollis(2)</i>	m	W	.	.	x	.	.	.	s
Storm's Stork	<i>Ciconia stormi</i>	*	W	.	.	.	.	.	.	s
Lesser Adjutant	<i>Leptoptilos javanicus</i>		W	.	.	.	.	.	.	s
Osprey	<i>Pandion haliaetus</i>		W	.	.	.	.	.	.	s
Jerdon's Baza	<i>Aviceda jerdoni</i>	I	.	x	.	.	.	.	.	s
Oriental Honey-buzzard	<i>Pernis ptilorhynchus</i>	I	rd	.	.	.	.	.	.	s
? Bat Hawk	<i>Macheiramphus alcinus</i>	I	.	.	.	.	.	.	.	text
Brahminy Kite	<i>Haliaeetus indus</i>	III	x	x	x	.	.	.	x	s
White-bellied Sea-eagle	<i>Haliaeetus leucogaster</i>	*	W	.	.	.	.	.	.	s
Lesser Fish-eagle	<i>Ichthyophaga humilis</i>		W	.	x	x	.	.	.	s,t
Grey-headed Fish-eagle	<i>Ichthyophaga ichthyaetus</i>	*	W	.	.	.	.	x	.	s
Crested Serpent-eagle	<i>Spilornis cheela</i>	II	x	x	.	.	.	x	.	s,t
? Buzzard	<i>Buteo spp.</i>	m	III	.	.	.	.	.	.	text
? Grey-faced Buzzard	<i>Butastur indicus</i>	m	III	.	.	.	.	.	.	text
Crested Goshawk	<i>Accipiter trivirgatus</i>		I	x	x	.	.	x	.	s,t
? Japanese Sparrow-hawk	<i>Accipiter gularis</i>	m	II	.	.	.	.	.	.	?x text
? Besra	<i>Accipiter virgatus</i>		II	.	.	.	.	.	.	text
Black Eagle	<i>Ictinaetus malayensis</i>		II	.	.	.	.	.	.	s
Changeable Hawk-eagle	<i>Spizaetus cirrhatus</i>	III	.	.	.	.	.	rd	x	s
? Blyth's Hawk-eagle	<i>Spizaetus alboniger</i>	I	.	.	.	.	.	.	.	text
Wallace's Hawk-eagle	<i>Spizaetus nanus</i>	I	x	.	.	.	.	.	.	s
Black-thighed Falconet	<i>Microhierax fringillarius</i>		II	.	x	x	.	.	x	s
? Peregrine Falcon	<i>Falco peregrinus</i>	m	III	.	.	.	.	.	.	text
Wandering Whistling Duck	<i>Dendrocygna arcuata</i>		W	.	.	.	.	.	.	s
? Black Partridge	<i>Melanoperdix nigra</i>	*	I	.	.	.	.	.	.	text
Blue-breasted Quail	<i>Coturnix chinensis</i>		III	.	.	.	.	.	.	s
Crested Partridge	<i>Rollulus rouloul</i>		II	.	.	.	.	.	.	s
? Crestless Fireback	<i>Lophura erythrophthalma</i>	*	I	.	.	.	.	.	.	text
Crested Fireback	<i>Lophura ignita</i>	*	I	.	.	.	.	x	.	text
? Bulwer's Pheasant	<i>Lophura bulweri</i>	I	.	.	.	.	.	.	.	text
Great Argus	<i>Argusianus argus</i>	I	.	.	.	.	.	x	4	v
Slaty-breasted Rail	<i>Gallirallus striatus</i>		W	.	.	.	.	.	.	s
? Red-Legged Crane	<i>Rallina fasciata</i>		W	.	.	.	.	.	.	text
White-breasted Waterhen	<i>Amaurornis phoenicurus</i>		W	ts	.	.	.	.	.	s
? Watercock	<i>Gallierex cinerea</i>	m	W	.	.	.	.	.	.	text
Little Ringed Plover	<i>Charadrius dubius</i>	m	W	.	.	.	.	.	.	s
Wood Sandpiper	<i>Tringa glareola</i>	m	W	.	.	.	.	.	.	s
Common Sandpiper	<i>Actitis hypoleucos(3)</i>	m	W	.	.	.	.	x	.	s
Little Tern	<i>Sterna albifrons</i>		W	.	.	.	.	.	.	t,v





		Status	Habitat	T	P	E	G	S	M	Doc
? Bar-bellied Cuckoo-shrike	<i>Coracina striata</i>	*	II	.	.	.	.	.	.	text
Lesser Cuckoo-shrike	<i>Coracina fimbriata</i>	I	.	1	.	.	.	x	.	s,t
Fiery Minivet	<i>Pericrocotus igneus</i>	*	II	.	3	.	4	.	.	s
Scarlet Minivet	<i>Pericrocotus flammeus</i>	I	.	.	.	.	.	x	2	s
? Bar-winged Hemipus	<i>Hemipus picatus</i>	I	.	.	.	.	.	.	.	text
Black-winged Hemipus	<i>Hemipus hirundinaceus</i>	II	x	5	.	2	x	2	.	s,v
Large Wood-shrike	<i>Tephrodornis gularis</i>	I	.	.	.	.	.	.	2	s,v
Straw-headed Bulbul	<i>Pycnonotus zeylanicus</i>	II	.	.	.	.	.	.	.	text
Black-and-white Bulbul	<i>Pycnonotus melanoleucos</i>	I	.	.	.	.	.	rd	.	rj
Black-headed Bulbul	<i>Pycnonotus atriceps</i>	II	x	6	x	.	.	x	x	s,v
? Black-crested Bulbul	<i>Pycnonotus melanicterus</i>	I	.	.	.	.	.	.	.	text
Grey-bellied Bulbul	<i>Pycnonotus cyaniventris</i>	I	.	.	.	.	.	x	x	s
Puff-backed Bulbul	<i>Pycnonotus eutilotus</i>	I	.	.	x	.	.	.	x	t
Yellow-vented Bulbul	<i>Pycnonotus goiavier</i>	III	.	.	.	.	.	.	rd	s
Olive-winged Bulbul	<i>Pycnonotus plumosus</i>	III	rd	.	.	.	.	x	rd	m
Cream-vented Bulbul	<i>Pycnonotus simplex</i>	II	6	4	5	24	rd	5	.	s,v
Red-eyed Bulbul	<i>Pycnonotus brunneus</i>	I	rd	2	1	21	.	x	2	s,l,m
Spectacled Bulbul	<i>Pycnonotus erythrophthalmos</i>	II	.	.	.	.	.	x	x	s,t
Finsch's Bulbul	<i>Criniger finschii</i> (8)	I	.	.	.	.	.	x	x	s
? Ochraceous Bulbul	<i>Criniger ochraceus</i> (8)	I	.	.	.	.	.	.	.	text
? Grey-cheeked Bulbul	<i>Criniger bres</i> (8)	I	.	.	.	.	.	.	.	text
Yellow-bellied Bulbul	<i>Criniger phaeocephalus</i> (8)	I	.	.	.	.	.	.	2	s,t
? Hook-billed Bulbul	<i>Setornis criniger</i>	*	I	.	.	.	.	.	3	text
Buff-vented Bulbul	<i>Hypsipetes charlottae</i> (9)	I	.	.	.	.	.	.	x	s,t
Hairy-backed Bulbul	<i>Hypsipetes criniger</i> (10)	I	.	.	.	.	.	x	x	s,t
Common Streaked Bulbul	<i>Hypsipetes malaccensis</i> (11)	I	.	.	.	.	.	x	2	t
Common Iora	<i>Aegithina tiphia</i>	III	20	7	x	7	x	.	.	s,v
Green Iora	<i>Aegithina viridissima</i>	I	x	3	2	5	x	4	.	s,t
Greater Green Leafbird	<i>Chloropsis sonnerati</i>	I	.	2	2	1	.	3	.	s,v
Lesser Green Leafbird	<i>Chloropsis cyanopogon</i>	II	.	.	?x	?x	.	?x	.	rd
Asian Fairy Bluebird	<i>Irena puella</i>	I	.	.	.	.	.	x	1	s,t
Tiger Shrike	<i>Lanius tigrinus</i>	m	II	.	.	.	.	.	.	rj
Brown Shrike	<i>Lanius cristatus</i>	m	III	rd	.	.	.	.	.	rj
Bornean Bristlehead	<i>Pityriasis gymnocephala</i>	*	I	.	.	.	.	.	.	text
Oriental Magpie-robin	<i>Copsychus saularis</i>	III	20	3	2	3	x	x	.	s,t,m
White-rumped Shama	<i>Copsychus malabaricus</i>	I	.	4	1	x	x	6	.	s,t,m
Rufous-tailed Shama	<i>Copsychus pyrropygus</i>	I	.	.	.	.	.	.	.	rj
Chestnut-naped Forktail	<i>Enicurus ruficapillus</i>	I	.	.	.	.	.	.	1	s
White-crowned Forktail	<i>Enicurus leschenaulti</i>	II	.	.	.	.	.	.	.	ih
Chats	<i>Saxicola spp.</i>	v	III	.	.	.	.	.	.	text
Rail Babbler	<i>Eupetes macrocerus</i>	I	.	.	.	.	.	.	?x	text
Short-tailed Babbler	<i>Trichastoma malaccense</i> (12)	I	.	.	1	.	.	.	8	s,t
White-chested Babbler	<i>Trichastoma rostratum</i>	*	II	7	10	21	13	x	.	s,t
Ferruginous Babbler	<i>Trichastoma bicolor</i>	*	I	.	.	.	.	x	.	s,v
? Abbott's Babbler	<i>Trichastoma abbotti</i> (13)	II	.	.	.	.	.	.	?x	text
Moustached Babbler	<i>Malacopteron magnirostre</i>	I	.	.	.	.	.	x	.	v,t
Sooty-capped Babbler	<i>Malacopteron affine</i>	II	5	1	2	2	x	5	.	s,t
Scaly-crowned Babbler	<i>Malacopteron cinereum</i>	I	.	.	4	.	.	.	8	s,t
Rufous-crowned Babbler	<i>Malacopteron magnum</i>	I	.	.	.	.	.	x	.	s,v
Chestnut-backed Scimitar-babbler	<i>Pomatorhinus montanus</i>	I	.	.	.	.	.	x	4	s,t
Striped wren-babbler	<i>Kenopia striata</i>	I	.	.	.	.	.	.	x	s
? Black-throated Wren-babbler	<i>Napothera atrigularis</i>	I	.	.	.	.	.	.	?x	text
Chestnut-rumped Babbler	<i>Stachyris maculata</i>	I	.	.	3	.	.	x	.	s,t
Black-throated Babbler	<i>Stachyris nigricollis</i>	*	I	.	.	.	.	x	1	s,t,m

		Status	Habitat	T	P	E	G	S	M	Doc
Chestnut-winged Babbler	<i>Stachyris erythroptera</i>		I	x	8	20	11	x	10	s,t
Striped Tit-babbler	<i>Macronous gularis</i>		III	38	12	7	21	x	2	t,m
Fluffy-backed Tit-babbler	<i>Macronous pilosus</i>		II	.	2	.	.	x	x	s,t
Brown Fulvetta	<i>Alcippe brunneicauda</i>		I	.	.	.	.	x	21	s,v
? Black-Browed Reed-Warbler	<i>Acrocephalus bistrigiceps</i>	m	III	.	.	.	.	.	.	text
Yellow-bellied Prinia	<i>Prinia flaviventris</i>		III	.	.	x	.	x	x	s,v
Dark-necked Tailorbird	<i>Orthotomus atrogularis</i>		III	x	.	.	.	x	.	s,t
Rufous-tailed Tailorbird	<i>Orthotomus sericeus</i>		III	x	.	x	4	x	x	m
Ashy Tailorbird	<i>Orthotomus ruficeps</i>		II	12	4	10	8	x	x	s,t
Arctic Leaf-warbler	<i>Phylloscopus borealis</i>	m	II	4	3	1	3	x	2	s,t
Grey-chested Rhinomyias	<i>Rhinomyias umbratilis</i>		I	.	.	.	.	x	1	s,v
? Rufous-tailed Rhinomyias	<i>Rhinomyias ruficauda</i>		I	.	.	.	.	.	.	text
Asian Brown Flycatcher	<i>Muscicapa dauurica</i>	m	II	x	.	.	.	rd	.	s
Mugimaki Flycatcher	<i>Ficedula mugimaki</i>	m	II	.	.	.	.	.	.	cm,rd
? Blue-and-white Flycatcher	<i>Cyanoptila cyanomelana</i>	m	II	.	.	.	.	.	.	text
Pale Blue Flycatcher	<i>Cyornis unicolor</i>		I	.	.	.	.	.	.	hn,bs
? Hill Blue Flycatcher	<i>Cyornis banyumas</i>		II	.	.	.	.	.	.	text
? Bornean Blue Flycatcher	<i>Cyornis superbus</i>		I	.	.	.	.	.	.	text
Malaysian Blue Flycatcher	<i>Cyornis turcosus</i>	* II	x	.	6	4	.	x	.	s,v
Rufous-winged Philentoma	<i>Philentoma pyrropterum</i>		I	.	.	.	.	x	rd	t,m
Maroon-breasted Flycatcher	<i>Philentoma velatum</i>		I	.	.	.	.	x	.	s
Black-naped Monarch	<i>Hypothymis azurea</i>		I	3	5	7	6	x	7	s,t
Asian Paradise-flycatcher	<i>Terpsiphone paradisi</i>		I	.	3	.	3	x	1	s,t
Pied Fantail	<i>Rhipidura javanica</i>		III	.	.	x	x	x	.	s,v
Spotted Fantail	<i>Rhipidura perlata</i>		I	.	.	.	.	x	5	s,t
Mangrove Whistler	<i>Pachycephala grisola</i>		II	.	5	7	6	.	.	v,t
? Great Tit	<i>Parus major</i>		II	.	.	.	.	.	.	text
Velvet-fronted Nuthatch	<i>Sitta frontalis</i>		I	.	4	2	2	x	.	s
Yellow-breasted Flowerpecker	<i>Prionochilus maculatus</i>		I	.	.	.	.	x	.	s,t
Crimsoo-breasted Flowerpecker	<i>Prionochilus percussus</i>		II	1	.	.	1	x	2	m,v
Yellow-rumped Flowerpecker	<i>Prionochilus xanthopygius</i>		I	.	.	.	.	.	rd	s, text
Scarlet-breasted Flowerpecker	<i>Prionichilus thoracicus</i>		II	.	.	.	.	.	3	s
? Brown-backed Flowerpecker	<i>Dicaeum everetti</i>		I	.	.	.	.	.	.	text
Yellow-vented Flowerpecker	<i>Dicaeum chrysorrheum</i>		II	.	.	.	.	.	.	bs,rw
Orange-bellied Flowerpecker	<i>Dicaeum trigonostigma</i>		II	8	17	20	13	x	2	s,t,m
Plain Flowerpecker	<i>Dicaeum concolor</i>		II	.	.	.	.	x	1	s,t
Scarlet-backed Flowerpecker	<i>Dicaeum cruentatum</i>		III	8	3	3	3	x	rd	s,t
Plain Sunbird	<i>Anthreptes simplex</i>		I	.	.	.	.	x	2	s
Plain-throated Sunbird	<i>Anthreptes malacensis</i>		III	15	6	x	3	x	rd	s,v,l
? Red-throated Sunbird	<i>Anthreptes rhodolaema</i>		I	.	.	.	.	.	.	text
Ruby-checked Sunbird	<i>Anthreptes singalensis</i>		II	x	.	1	?1	.	rd	s
Purple-naped Sunbird	<i>Hypogramma hypogrammicum</i>		I	.	.	.	.	.	2	s,v
Purple-throated Sunbird	<i>Nectarinia sperata</i>	* II	rd	5	7	3	.	rd	.	s,t,m
? Copper-throated Sunbird	<i>Nectarinia calcostetha</i>		II	.	.	.	.	.	.	text
Olive-backed Sunbird	<i>Nectarinia jugularis</i>		III	12	6	x	3	.	.	s,t
Crimson Sunbird	<i>Aethopyga siparaja</i>	* II	2	3	2	x	.	.	.	s,t
Scarlet Sunbird	<i>Aethopyga temminckii</i>		I	.	.	.	.	x	1	s,t
Little Spiderhunter	<i>Arachnothera longirostra</i>		I	.	2	3	.	x	x	t,m
Thick-billed Spiderhunter	<i>Arachnothera crassirostris</i>		I	x	.	.	.	.	.	s
Long-billed Spiderhunter	<i>Arachnothera robusta</i>		I	.	.	1	.	x	3	s
Spectacled Spiderhunter	<i>Arachnothera flavigaster</i>		I	.	?1	.	.	?x	?x	rd
? Yellow-eared Spiderhunter	<i>Arachnothera chryso-genys</i>		I	.	.	.	.	?x	.	text
Grey-breasted Spiderhunter	<i>Arachnothera affinis</i>		II	.	.	.	.	.	x	s,v
Dusky Munia	<i>Lonchura fuscans</i>		III	ts	.	.	.	x	1	s



## PROBOSCIS MONKEYS IN DANAU SENTARUM NATIONAL PARK

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This paper describes the ecology of a population of proboscis monkeys at Danau Sentarum National Park (DSNP) in West Kalimantan, Indonesia. It draws primarily from the findings of a project to determine the conservation status of this population conducted in 1993 and 1994 (Sebastian, 1994). Nominated as Indonesia's second Ramsar site in 1994, and gazetted a National Park in 1999, this unique and vast inland floodplain represents one of the most significant wetlands on Borneo. There are two main isolated inland wetlands on Borneo: the Kapuas lakes (Danau Sentarum) in West Kalimantan and the Mahakam lakes in East Kalimantan (MacKinnon *et. al.*, 1996). Both have populations of proboscis monkeys. DSNP is of particular interest because it supports only one of the six colubine monkeys (four of which are endemic) on Borneo.

### **Introduction – Ecology of Proboscis Monkeys**

The proboscis monkey *Nasalis larvatus* belongs in a monotypic genus. Its closest relative is the pig-tailed langur *Simias concolor*, endemic to the Mentawai Islands off the west coast of Sumatra and classified by some authors as *Nasalis concolor* (Bennett and Gombek, 1993; Napier and Napier 1967). The proboscis monkey is a large colubine; adult males grow to 25 kg with females weighing between 7-11 kg (Schulz, 1942). They have bright, rufous-colored fur, fading to creamy, silvery white under parts and insides of limbs. Adult males have pure white rumps and tails (those of females are often gray) and the male develops a long pendulous nose, giving the species its name. Ankel-Simons (2000) explains that the nose of the male assists in enhancing vocalizations by acting as an organ of resonance. Proboscis monkeys also have partial webbing on the hind feet, a physical characteristic shared with no other primate, and may be an evolutionary adaptation for swimming and walking on mangrove mud (Bennett, 1986). This species is the most aquatic of all extant primates.

The local names for the proboscis monkey vary from different parts of Borneo, the most common being Bekantan, Beladan, Bangkatan, Pikas, Rasong and Orang Belanda. In DSNP, most of the locals use the name Pikas.

### **Distribution of Proboscis Monkeys on Borneo**

The Proboscis monkey is endemic to Borneo and restricted to lowlands habitats. In Malaysian Borneo, the species is scattered and survives only in isolated pockets. The largest known populations in Sarawak are in the west, in the areas of Samunsam and the Bako-Sarawak Mangroves areas. The Samunsam Wildlife Sanctuary was established specifically to protect this population of proboscis monkeys (Basiuk, 1985). Recently gazetted extensions to this sanctuary in 2000 have brought the total area to 228 km<sup>2</sup>, encompassing over 90% of the population's range. In Sabah, viable populations of proboscis monkeys occur in the freshwater wetlands of the Kinabatangan Floodplain



(Boonratana 1993; Sharma 1992), while the mangroves and estuaries of Brunei Bay, Brunei Darussalam, support another population (Bennett and Gombek, 1993).

In Kalimantan, the strongholds for the species are Gunung Palung National Park, West Kalimantan (AWDB, 1993; Bennett and Gombek, 1993); Tanjung Puting National Park, Central Kalimantan, (AWDB, 1993; Bennett and Gombek, 1993); the Mahakam river basin (MacKinnon *et. al.*, 1996; AWDB, 1993; Eve and Guige, 1989) and Kutai National Park (AWDB, 1993), both in eastern Kalimantan.

There are only four populations occurring inland on Borneo: Danau Sentarum (Sebastian, 1994; Giesen, 1987); upper Sungai Barito (MacKinnon *et. al.*, 1996; Bennett and Gombek, 1993); Mahakam lakes (MacKinnon *et. al.*, 1996) and the Kinabatangan wetlands (MacKinnon *et. al.*, 1996; Bennett and Gombek, 1993). Of these four, only Danau Sentarum and the Mahakam lakes are wetland ecosystems discontinuous from the coast.

### Diet

The proboscis monkey is described as being a folivore/frugivore (Yeager, 1989). Yeager (1989) found that in Tanjung Puting National Park in Indonesia, they utilized 47 different plant species, of which 17 plants were consumed for their fruit, seeds, or flowers and 30 species were consumed for their leaves. In the Kinabatangan floodplain in Sabah, Boonratana (1993) estimated that young leaves account for 72.7% of the diet of the harem groups at Sukau (riverine forest) and 49.7% at Abai (mangrove forest). Proboscis monkeys are very selective feeders and groups move directly between food sources, sometimes covering large distances (Yeager, 1989; Bennett and Sebastian, 1988).

Early work on this species suggested that they were dependent on mangrove forests for food and cover (Kawabe and Mano, 1972; Kern, 1964), but recent studies have shown them to be as commonly found in riverine forests, peat swamp and freshwater swamp forests (Salter *et al.*, 1985). The reason proposed for the apparent preference of this colubine for coastal forests and areas along rivers is because the soils of the interior are low in minerals and salts, which are needed in the diet (Bennett and Sebastian, 1988).

### Social Organization

This primate lives in harems centered around single, dominant males, though often group movements are led by females (Rajanathan and Bennett, 1990). Groups vary in size; in Samunsam Wildlife Sanctuary the average size of six identified groups was nine animals (Bennett and Sebastian, 1988), while the average size of ten identified groups in Tanjung Puting National Park was 12.1 animals (Yeager, 1993). Young and sub-adult males are excluded from the harems and form all-male "bachelor" groups which are flexible and non-permanent associations. These bachelor groups follow established harems closely.

Harems also frequently travel together, forming large associations of more than one harem but are always discernable as different groups by the dominant males. Two levels of social organization are suggested for this species: the group and the band (Yeager 1990, 1992). The primary social unit is the harem group while the band represents a secondary level of social organization with fission-fusion of stable harems within bands. These bands can comprise over sixty animals and may travel together for many days.

### Ranging

The proboscis monkey is found only along forested waterways. Home ranges can vary greatly depending on density of population and habitat types. Three major studies

have found harem group home ranges to vary; 9 km<sup>2</sup> in Samunsam, Sarawak (Bennett and Sebastian, 1988); 2.21 km<sup>2</sup> in Sukau and 3.15 km<sup>2</sup> at Abai, Sabah (Boonratana, 1993); and 1.3 km<sup>2</sup> at Tanjung Puting, Indonesia (Yeager, 1989).

Although this species is known to have very large home ranges, groups never range very far from rivers. Bennett and Sebastian (1988) found that groups never ventured more than 600 meters from a river's edge. In Sukau, Boonratana (1993) and Sharma (1992) found this distance to be 1 km. This effectively restricts their range to long strips along rivers, but this is not the case in swamp forests and mangroves where extensive waterways are interlinked.

Home ranges of harem groups also overlap freely and no evidence of territorial behavior has been recorded to date. Yeager (1989) found the average spatial overlap of riverbank habitat used by four harems in Tanjung Puting to be between 92.0 and 97.7%.

### River-refuging Behavior

The use of riverine habitat at night for sleeping serves an important need for groups to remain in contact. Bennett and Sebastian (1988) found that harem groups in Samunsam Wildlife Sanctuary spent the majority of nights within 50m of another and more than 70% of the nights within 100m. Groups frequently keep in contact with other groups by calls and the adult males make distinct loud, far-carrying resonant calls, intermittently throughout the night. Sleeping along the river's edge is thought to increase visibility and suggests that proboscis monkeys require both vocal and visual contact. This behavior is a characteristic of this species but has never been satisfactorily explained.

### Predators

The affinity for water is thought to have an anti-predation function. Well-adapted for swimming, proboscis monkeys may use water as an escape from arboreal predators, although the Clouded Leopard *Neofelis nebulosa* is probably the only arboreal carnivore on Borneo capable of taking proboscis monkeys. Davis (1962) documents predation by *N. nebulosa* and more recently in 1992, this has been observed in Sukau, Sabah (Cede Prudente, *pers. comm.*). Galdikas and Yeager (1984) describe a crocodilian, False gavia *Tomistoma schlegelii*, preying on proboscis monkeys in Tanjung Puting. Although the False gavia is considered to be exclusively fish-eating, they grow to very large sizes and may occasionally take swimming proboscis monkeys. In 1994, a 4m long False gavia was found accidentally killed in a *jermal* net at DSNP. Its stomach contained distinct fur balls, suggesting that it preyed on mammals. (Giesen, *pers. comm.*) However, it is more likely that estuarine crocodiles *Crocodylus porosus* will take swimming proboscis monkeys given the opportunity. An observation by the author of a crested serpent eagle *Spilornis cheela* stooping into a tree of proboscis monkeys in Tanjung Puting National Park at dusk could also have been an attempt at predation. Boonratana (1993) recorded a similar attack by a serpent eagle in Sukau, Sabah. This may suggest that *S. cheela* may be a greater predator on proboscis monkeys that was previously thought, though this medium-sized eagle can only take young animals.

### Conservation Status

Proboscis monkeys probably occurred throughout the coastal lowlands of Borneo in the past. The increase in human population and urbanization over the last 100 years has resulted in large areas of the coastal lowlands being converted to cultivation and towns. This conversion has predominantly occurred close to rivers and estuaries, thus wiping out most of the habitat for this species. Today, proboscis monkeys are restricted to remaining

undisturbed stretches of riverine forest, mangroves, swamp and floodplain forests and their numbers are greatly depleted. Isolation of remaining populations and extensive fragmentation of habitat has seriously threatened the survival and long-term viability of the species. The IUCN Red Data Book (IUCN, 1996) lists the proboscis monkey as Vulnerable and it is listed under Appendix I of CITES. It is also protected by law throughout its range.

Only three populations are known to occur entirely within a protected area: Tanjung Puting National Park, Samunsam Wildlife Sanctuary and DSNP. Varying portions of populations elsewhere come under legal protection where their ranges extend into sanctuaries, national parks and wildlife reserves. It is a high conservation priority to ensure the long-term maintenance of genetic diversity of the species throughout Borneo and thus, more protection must be afforded to this species.

### **THE PROBOSCIS MONKEY POPULATION AT DSNP**

#### **Origins of the Danau Sentarum Population**

There are very few significant populations of proboscis monkeys that occur away from the coast, and DSNP may support the largest inland population on Borneo. Though primarily a coastal species, inland ecosystems similar to those more commonly found on the coast, such as floodplain wetlands, have the potential to support proboscis monkey populations.

Proboscis monkeys have been recorded inland in the past, away from any river or waterway. These records have been attributed to natural, occasional dispersal of the population. Occasionally, an individual or a group may leave an area and turn nomadic, wandering until another suitable habitat is chanced upon (Bennett and Gombek, 1993).

The author postulates that this population in Danau Sentarum may have originated from the river basin of the Batang Lupar and Batang Saribas in Malaysian Sarawak, rather than the Kapuas River itself. The geographical location of the Kapuas lakes is much closer to the northern coast of Borneo than the western coast, and may have been part of the catchment of the northward flowing river basin in the geological past. Small populations of proboscis monkeys still occur in the delta of these two rivers in Sarawak.

#### **Population Size**

The exact size of the proboscis monkey population of DSNP has not been determined. The only assessment of this population was conducted in 1993–1994, before gazettelement of the park. Sebastian (1994) estimated the total population size by assigning an average group size based on known group sizes from other sites where long-term studies have been conducted. Bennett and Sebastian (1988) found average group sizes in Samunsam Wildlife Sanctuary to be nine, Sharma (1992) found the average to be 11 in the Kinabatangan Floodplain while in Tanjung Puting National Park, Yeager (1993) found the average to be 12.1 animals (refer Table II). This is based on the assumption that this population of proboscis monkeys does not differ greatly from others in terms of their group sizes.

Using a group size of 10.7, and working with a total area of 80,000ha, the estimated population permanently resident within the boundaries of DSNP was a minimum size of 600 (Sebastian, 1994). Given the available habitat surrounding the park, an estimate of an additional 30% would not be unreasonable, giving a possible population within the

environs of DSNP as 800. This figure would make this the largest population of proboscis monkeys on Borneo, and therefore worldwide.

The total area of DSNP has been increased to 130,000ha in 1996, with the inclusion of proposed extensions. This is a 60% increase in the size of the protected area. DSNP needs to be re-surveyed to obtain a more accurate account of this globally significant population of proboscis monkeys.

### Population Distribution

The population within DSNP does not fluctuate significantly in response to wet and dry seasons. During the 1993-94 surveys, about 74% of the population is resident within the park throughout the year, and the remaining 26% uses habitats outside the park boundaries (Sebastian, 1994). Virtually all the habitats used by the population outside the reserve then are now within the park.

The main difference in the dry season is the increased area of habitat accessible to the population, resulting in slight dispersal. During the wet season, large areas of dwarf forest (Giesen, this volume) are almost completely submerged, with only their crowns above water. Proboscis monkeys will not use such areas. Although the population adapts its behavior (sleeping requirements) to use the dry areas, they basically remain in the same general areas. The rapidly rising water levels can concentrate the population into the areas of remaining habitat during the wet season.

The population within DSNP is unevenly distributed, and occurs mainly in the western half of the park. The distribution of habitat types has a major influence on the population distribution. Table I compares the details of the four main concentration areas with those of another outside the park boundary.

### Population Density

An estimated 475 km<sup>2</sup> of forest area remains above the floodwaters during the wet season. Forest cover significantly above the water line is vitally important to proboscis monkeys. Of this, it is estimated that the available habitat for proboscis monkeys within the reserve during the wet season does not exceed 270 km<sup>2</sup> (Sebastian, 1994).

The calculated overall population density within DSNP is 0.16 groups/km<sup>2</sup> or 1.70 individuals/km<sup>2</sup> (Sebastian, 1994). However, the population shows marked concentration in certain parts of the park (refer Table I). The highest densities were recorded in the Sg. Belitung - Sg. Punggau swamp forest (1.2 groups per km<sup>2</sup>) and the Sg. Tawang area (0.6 groups per km<sup>2</sup>).

The density of proboscis monkeys in DSNP appears to be considerably lower than other populations studied (refer Table II). There are two possible reasons for this. Firstly, DSNP is a very large area of dendritic waterways, making it impossible to survey all the rivers and waterways simultaneously. Thus prevents an accurate census. Furthermore, groups that do not sleep by the water's edge are impossible to census from a boat. This means that the actual densities at DSNP may be considerably higher.

The second possible reason is food. The floodplain ecosystem of DSNP is characterized by long periods of inundation alternating with drought-like conditions, and consequently has a reduced floral diversity, and a dominance of certain species. Added to the fact that the soils are nutrient poor, food may not be plentiful, nor of high nutritional value. If this is so, this might explain why the proboscis monkey is the only colubine to colonize this habitat. In areas where food is scarce, one would expect larger colubines to survive in favor of smaller species (Bennett, 1983). The proboscis monkey is the largest

and heaviest of the Southeast Asian colubines, and thus is the most likely to be able to derive sustenance from the lower quality food source at DSNP.

### Habitat Preference

37.5% of harem groups were recorded in vegetation with canopy height of 10m or lower and 56.3% were recorded in 11-20m tall vegetation.

The vegetation types within the park are not diverse. Single species dominance is common, especially in small tree / shrub vegetation (dwarf swamp forest; Giesen, this volume) and areas within the park differ significantly depending on flood levels and periods of inundation. Giesen (this volume) describes three main vegetation types; **Dwarf swamp forest**, 5-8(-10)m tall, with Putat *Barringtonia acutangula* and a few other species; **Stunted swamp forest**, 12-20(-22)m, with two main types: one characterized by Kamsia (*Mesua hexapetalum*), Kenarin (*Diospyros coriacea*) and Menungau (*Vatica* cf. *umbronnata*), the other by an absence of Kenarin and Menungau, and a presence of Kawi *Shorea balangeran*, which can be locally dominant; and **Tall swamp forest**: dominated by the occurrence of tall (25-30(-35)m) straight-stemmed trees, in areas that are flooded for 2-3 months annually by 1-2.5m of water. Two types recognized: (a) Kelansau-Emang-Melaban tall swamp forest, characterized by the occurrence of Kelansau *Dryobalanops abnormis*, Emang *Hopea mengerawan* and Melaban *Tristaniopsis obovata* is the most common type of tall swamp forest; and (b) Ramin-Mentangur Kunyit tall swamp forest which may formerly have been more widespread, but as Ramin *Gonystylus bancanus* is much sought after by commercial timber companies, it is now uncommon, and now occurs only very locally.

On the drier levees of the bigger rivers and waterways, taller riparian forests of between 15-25m height occur. Riparian forest in much of the area appears to have many of the same species as the Kenarin-Menungau-Kamsia stunted swamp forest, but is characterized by the presence of typical riparian species such as Rengas *Gluta reinghas* and Bungur *Lagerstroemia speciosa*. This vegetation type occurs on levees of the larger rivers in the Park (e.g. Sg. Tawang, Belitung and Empanang), and has a flooding regime similar to that of the stunted swamp forest.

Proboscis monkeys show a distinct preference for tall forest in DSNP. This is consistent with findings from other parts of Borneo where they prefer tall riverine forests (Salter *et al.* 1985). Therefore, during the wet season, the main concentrations of the population occur in the tall swamp forest and extend into the stunted swamp forest areas. Inundated dwarf swamp forest will be used to cross between taller forest areas, but are seldom used to sleep. During the dry season, the dwarf swamp forest areas become available to the population, which disperses more widely into these areas.

Proboscis monkeys in DSNP will readily come to the ground and are therefore often recorded in low vegetation along rivers during the day, but invariably seek taller trees to spend the night in. The lack of extensive and continuous tall habitat within the park appears to have resulted in the monkeys adapting to lower vegetation for sleeping.

### Behavior

The most significant behavioral observation recorded for this population is the instances where harem groups were seen not to sleep by rivers at night. Three instances were recorded where harem groups spent the night away from the river's edge (Sebastian, 1994). The furthest distance from a river was 770m.

This behavior of sleeping beside a river or water body remains one of the most enigmatic characteristics of this species. Proboscis monkeys are known to invariably sleep by rivers, and the main reasons suggested for this are social factors such as visibility and vocalizations and to a lesser extent, displacement and predation avoidance.

The records of harem groups not sleeping by a river in DSNP is of considerable interest to this debate. The question raised by this finding suggests that the forest edge may be of greater importance than the presence of water. However, another explanation may be valid given the habitat of DSNP. During the dry season, the water body shrinks significantly, leaving only small channels and eventually, only the main river still flowing. Foraging groups have to constantly navigate the maze of dry channels, necessitating ground crossings to get from one forest area to the next. The demand that these movements place on energy expenditure may be high. Therefore, remaining where they are, despite the lack of water, may be more energy efficient than traveling the large distances back to the river every night.

Observations in November 1999 at Samunsam Wildlife Sanctuary recorded at least four harem groups traveling away from the river's edge at dusk (unpublished data, Sebastian and Bennett). This was the first record of this behavior at Samunsam, and the reasons for this remain unknown.

## FACTORS AFFECTING THE POPULATION AT DSNP

### Habitat Availability

In DSNP, areas of suitable habitat for proboscis monkeys are fragmented, and the distances between these remaining habitat pockets place a constraint on their usage by the population. Therefore, only a certain portion of the park can support a viable population in the long term.

In addition to loss of habitat, availability of favorable habitat varies during the dry and wet seasons. The wet season inundation of large areas of potential habitat causes a further reduction of available habitat within the park. This results in a concentration of the population in remaining suitable areas and the movement of some of the population to the periphery of the park along rivers.

### Fragmentation and Isolation

The continuing conversion of riverine forests outside the park to agriculture effectively restricts this population to within the park boundaries. This loss of habitat is exacerbated by indiscriminate burning, which occurs within DSNP as well (Dennis, this volume). The resulting fragmentation of habitat causes isolation of small populations. Within the park itself, there are already at least three distinct populations: Sg. Seputung/Sg. Sengirin, Sg. Batang Ketam/Sg. Belitung and Sg. Tawang/Hutan Nung (Sebastian, 1994).

Fragmentation of the population is not caused only by human activity. The characteristics of the floodplain vegetation itself contributes to isolation. The width of most of the rivers which remain navigable during the dry season is significant. This requires groups to come to the ground, walk considerable distances to the water's edge and then swim a distance of at least 20m in most cases, to the other bank.

### Human Activity

There is a high level of human activity along rivers in DSNP during the dry season. This presents a significant problem for a riverine species such as the proboscis monkey. During the dry season, activities such as fishing, fish-salting and smoking, trapping and also temporary encampments all take place along riverbanks. This may be an important factor keeping harem groups away from the water's edge (Sebastian, 1994).

There is also human activity within the forest, such as collection of rattans, bee-honey (though mostly during the wet season), and firewood.

No hunting of proboscis monkeys is known within the park. Observations however, suggest that disturbance occurs. Groups that move out of the park may be subject to hunting pressure there.

### Food Availability

Food availability during the dry season is an important limiting factor for the population. This would be particularly significant if they are unable to move elsewhere when food supplies are low. Furthermore, the availability of food within the park may be seasonal, as is often the case in areas of monotypic vegetation. A preliminary study of plant phenology, based on monitoring a limited number of species (30) for a year, has shown that about ¼ tend to flower and fruit, at low densities, throughout the year, about 1/8 flower and fruit in the dry season and that the majority (about 5/8<sup>th</sup>) flower/fruit in the wet season (Giesen, this volume).

The quality of food may also be an influencing factor. A large animal such as the proboscis monkey can subsist on a lower quality diet, i.e. it can subsist on foods with a lower protein to fiber ratio than smaller colubines (Bennett, 1983). Therefore, if the food quality is indeed low in DSNP, the larger proboscis monkey may be the only colubine that is able to survive there.

## MANAGING THE POPULATION AT DSNP

Management of the proboscis monkey population at DSNP will not require any specific actions to be taken involving the monkeys directly. The key to ensuring the long-term viability of this population is to address all the current direct threats and to apply management to the sources of indirect threats.

All the issues relating to the conservation status of proboscis monkeys at DSNP can be placed into two main categories: addressing loss of habitat and controlling human activities that adversely impact upon the population.

### Protection of Core Proboscis Monkey Habitat

Five areas hold virtually the entire population of proboscis monkeys in Danau Sentarum (Sebastian, 1994). They also represent the only substantial areas of tall forest, comprising *Shorea balangeran* forests, freshwater, peat swamp and flooded forest. These habitat types are crucial to the long-term viability of the population. The five core protection areas proposed by Sebastian (1994) are:

- Sg. Tawang Forest–Hutan Nung
- Sg. Batang Ketam
- Sg. Seputung Forest
- Sg. Embaluh Leboyan
- Sg. Belitung–Sg. Punggau

Sg. Belitung is used as an entry route to the park. Potential development of nature-tourism activities within DSNP, where proboscis monkeys would feature prominently, would benefit greatly from the easily accessible population along this river.

In addition, Sebastian (1994) outlines a proposal for a proboscis monkey sanctuary within DSNP. The area identified is along the Sg. Sianda, covering the area of best habitat in the western part of the reserve. The proposed proboscis sanctuary covers an area of 32 km<sup>2</sup>.

#### **Extending Legislative Protection**

DSNP currently protects more than 90% of the population. Ideally, the entire population's range should be included within the boundaries of DSNP. Sebastian (1994) identified four critical areas to be afforded legislative protection, three of which have already been included within the park. These areas represent refuges for animals during periods of high water levels. The rivers also retain some flowing water throughout the dry season, providing access to freshwater. These are:

- the upper reaches of the Sg. Leboyan and its adjacent lakes;
- the lakes of Danau Bekuan and Danau Sekawi, through which the rivers Sg. Belitung and Sg. Punggau flow;
- the area of freshwater and peat swamp forest between them Lakes of Bekuan and Sekawi; and
- the Sg. Batang Putus which flows from Danau Bekuan to the Kapuas river and the adjacent ox-bow lakes.

Only the Sg. Batang Putus area remains unprotected at present, and should be proposed as an extension to the park.

#### **Reducing Habitat Fragmentation**

Management with the integral involvement of the resident communities will be required to reduce habitat fragmentation within DSNP. Any top-down approach towards management at DSNP, without the participation of local communities will inevitably fail. For the areas currently outside the park (which are used by the population), extending the boundaries of DSNP will bring these into the management coverage. The critical areas requiring management are:

- Prevent further removal / degradation of tall forest on levees
- Ensure maximum habitat contiguity within the park, taking into account dry and wet season range and movements of the population
- Rehabilitation of key corridors which have been degraded
- Eliminate indiscriminate burning within the park

#### **Control of Human Activity**

The various activities carried out by villagers within the park have been in existence for decades. Leaving matters as they are would, under ordinary circumstances, not be detrimental to the proboscis monkey population as a whole. However, things have changed over the past decade, mainly as a result of the increased movement of people into the park.

Conflicts have arisen between the traditional villages within the park and new immigrants. New areas are being cleared for settlements and agriculture, and there is



competition for fishing zones. These factors need addressing to ensure the proboscis monkey population does not suffer.

Fishing and collection of forest produce are an integral part of the existence and culture of the local communities. The approach should be to obtain recognition, through a participatory effort, for the core protection zones (and the sanctuary) for the population. Through this recognition, certain self-control mechanisms can then be put into place with regards to these specific areas. Proposed controls are:

- o Reduced human presence in designated core protection areas
- o Minimize ground travel in these areas, allowing boat traffic
- o Relocate fishing activities (traps, nets, fish-salting, encampments on banks, etc) to the periphery of these areas.

### **Tourism in the Future**

The proboscis monkey has become one of the main attractions for visitors to Borneo. The Kinabatangan River in Sabah is one of the main nature tourism destinations in Malaysia, focused primarily on proboscis monkey viewing along the Menanggal River. No statistics are available, but the seven lodges operating from the village of Sukau attract an estimated 10,000 foreign visitors a year. Similarly, Bako National Park in Sarawak, also offering excellent views of proboscis monkeys, attracts over 50,000 visitors a year.

Any place where proboscis monkeys can be viewed in the wild is a potential tourism destination. Danau Sentarum qualifies as a high quality destination with its combination of stunning landscapes, traditional fishing villages, longhouses and rich wildlife including proboscis monkeys.

Following the successes of eco-tourism initiatives elsewhere on Borneo, Indonesia will eventually follow suit. DSNP will undoubtedly be eventually developed as such a destination. The proximity of Sarawak, with its growing nature tourism focused around Batang Ai National Park (located just across the border) will make access easier. Improving road networks and more efficient border crossing facilities all contribute to the potential for nature tourism to be a viable economic venture for DSNP, and its local populace.

A management regime designed specifically at preserving the remaining core habitat areas for proboscis monkeys will be crucial to ensure the sustainability of this resource.

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**TABLE I. THE DISTRIBUTION OF THE PROBOSCIS MONKEY POPULATION AT DANAU SENTARUM FROM WET SEASON SURVEYS (From Sebastian, 1994).**

SITE LOCALITY AND DESCRIPTION	EST. AREA OF HABITAT (km <sup>2</sup> )	NO. OF GROUPS	EST. NO. OF ANIMALS	DENSITY (grp per km <sup>2</sup> / ind. per km <sup>2</sup> )
Sg. Tawang Forest, an area of levee, flooded and swamp forest along Sg. Tawang. Includes fringe of Hutan Nung along Danau Pengumbang and the lakes of D. Pemerak and D. Sepatas.	53.0	34	364	0.6 / 6.9
Sg. Batang Ketam, the stretch of river from Kpg. Sekolat, separated from the lakes only by a broad levee, dividing Danau Belida from Danau Genali.	12.0	4	43	0.3 / 3.6
Sg. Scputung Forest, an area of freshwater swamp forest between D. Sumbai and D. Luar, includes Sg. Sengirin and a tributary of Sg. Putang west of D. Sumbai.	18.0	6	64	0.3 / 3.6
Lower reaches of Sg. Embaluh Leboyan within DSNP, including the upper reaches outside the reserve.	20.0	2	21	0.1 / 1.1
Sg. Belitung, joining D. Sekawi to Sg. Kapuas, rejoining the lake via Sg. Punggau (9.0 km surveyed)	9.0	11	117	1.2 / 13.0

**NOTES**

- Area of available habitat is calculated as the length of river/waterway/lake edge surveyed, extending away from the water for 500m.
- Surveys were conducted when total area of reserve was 80,000ha.

**TABLE II. COMPARISON WITH OTHER LONG TERM STUDIES ON PROBOSCIS MONKEYS (From Sebastian, 1994).**

SITE	TOTAL AREA (km <sup>2</sup> )	AREA SURVEYED (km <sup>2</sup> )	AVAIL-ABLE HABITAT (km <sup>2</sup> )	DEN-SITY (ind./km)	AVER-AGE GROUP SIZE	SOURCE
Santunsam Wildlife Sanctuary	60 <sup>a</sup>	27	27	5.93	9	Bennett and Sebastian (1988)
Kinabatangan Floodplain	2,800	?	?	20.46	11	Sharma (1992)
Tanjung Putting National Park	3,700	2	?	62.6	12.1	Yeager (1993)
Danau Sentarum National Park	829	109	475	1.47	10.7 <sup>b</sup>	Sebastian (1994)

**NOTES**

- Size prior to extensions. Current size: 228 km<sup>2</sup>.
- Figure derived from average of previous three group size estimates

DECLINING ORANGUTAN POPULATIONS IN AND AROUND THE  
DANAU SENTARUM NATIONAL PARK, WEST KALIMANTAN,  
INDONESIA

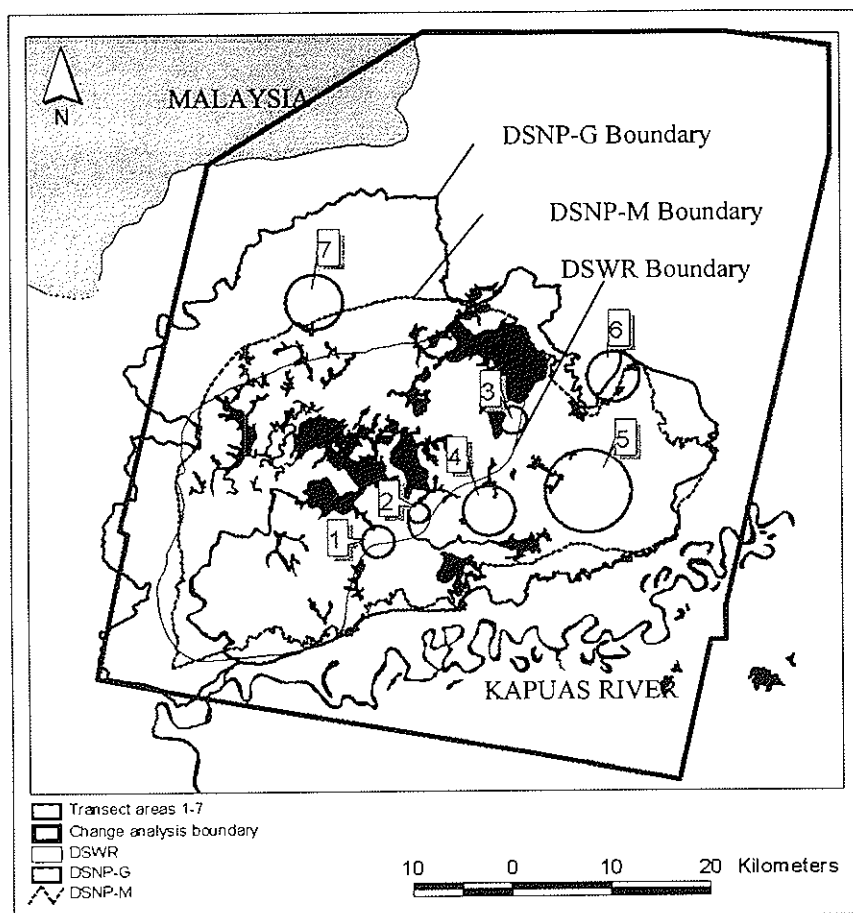
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This paper presents the combined results of two separate orangutan survey efforts and an assessment of land cover change analysis in the Danau Sentarum National Park (DSNP), West Kalimantan, Indonesia. These studies show that the DSNP and surrounding areas contain high numbers of orangutans, making these populations of global significance to the species' survival in the wild. However, in the Park and its surrounding areas, 40,339 ha habitat disappeared between 1973 and 1990, and 32,586 ha between 1990 and 1997. This equals a total decrease of 29% in the total orangutan habitat over the last 27 years. In that same period contiguous habitat patches judged to be large enough to support a substantial orangutan population also decreased in number and in size. Therefore, orangutan populations in DSNP are likely in decline. In addition to this, the most recent land cover changes and land-use plans indicate that much primary orangutan habitat is still targeted for logging or conversion into plantations. The main reason for the decreasing trend in orangutan populations is that the present Park boundary does not include the most important contiguous orangutan habitats in the north and east of the Park. We therefore recommend extending the boundary of the present park to include prime unprotected orangutan habitat. Also, connecting the Park to the nearby Bentuang Karimun National Park would join two important, now segregated orangutan

populations and therefore improve the long-term survival prospects for the species in this region.



**Figure 1.** DSNP area protection boundaries, nest-count survey transect sites, and study area for vegetation analysis (solid black areas are lakes).

### Introduction

The orangutan is now found exclusively on the islands of Sumatra and Borneo and over 90% of its habitat lies within the Republic of Indonesia. Rijksen and Meijaard (1999) estimated the 1997 orangutan population of Borneo to be 15,000 and that of Sumatra to be 12,000. Van Schaik *et al.* (in press) found that the orangutan's situation in Sumatra's lowland forests had drastically deteriorated since 1997 and updated Rijksen and Meijaard's estimate for the total Sumatran population to about 7,500. Van Schaik *et al.* predict that over the next ten years the Sumatran population will further decline to 4,500 in the most optimistic scenario, and to 1,500 in the more realistic one. The situation in Borneo is probably even worse. Experts now predict that the orangutan will go extinct

in the wild within the next 20 years unless significant changes in forest conservation are achieved (Rijksen and Meijaard 1999; van Schaik *et al.* in press). A major reason for the continuous decline in orangutan numbers is that humans and orangutans favor the same habitats, namely, alluvial flood plains and valleys. The outcome of the conflict is invariably losses for orangutans (Rijksen and Meijaard 1999).

Swamp forests are important for the conservation of orangutans because they represent prime orangutan habitat and are often less affected by logging and agricultural development than dry-land forests (Meijaard, 1997). These forest habitats offer high yields of soft-pulp fruit, orangutans' dietary mainstay, and can support orangutans at more than twice the density of other habitat types (Payne and Andau 1994; van Schaik *et al.* 1995b; Sugardjito and van Schaik 1992). The Danau Sentarum National Park (DSNP) region, with its core of seasonal lakes and freshwater swamps surrounded by peat swamp forest and hills, provides ideal habitat for orangutans (see Figure 1).

Despite the attractive habitat and suspected orangutan presence, incidental interviews and sightings suggested very few orangutans in the DSNP region by the mid-1980s (Giesen 1987). The probable reasons are, first, that orangutan presence is very hard to detect without specific search techniques and second, that human disturbance in the form of hunting and logging had driven orangutans away. Hunting in the region most likely concerns illegal trade in wildlife, not food. Orangutans live in close proximity to humans throughout the DSNP region (Meijaard *et al.* 1996); the human population in the greater DSNP area (DSNP-G in Figure 1) had reached 6,900 to 9,000 by the mid 1990s (Aglionby 1995). Inhabitants are mostly Muslim Malay fisherfolk and Iban Dayaks, who are unlikely to hunt orangutans for food for reasons of religion and cultural taboo. There are, however, some Iban that hunt and eat orangutan, and certainly the Maloh Dayaks that also occur in the area reported to be very keen on orangutan meat (Rijksen and Meijaard, 1999; pers. obs.). Logging has been a major source of human disturbance in the region and it commonly degrades areas of prime orangutan habitat (Payne and Andau 1994; Sugardjito and van Schaik 1992). Commercial logging from the late 1970s through the mid-1990s seriously degraded the swamp forest directly adjacent to DSNP. Much of that forest to the north, east, and west of DSNP was designated as Production Forest (Ministry of Forestry-National Forest Inventory 1993; see Giesen 1987; Meijaard *et al.* 1996).

Giesen (1987) had concluded that few orangutans remained around DSNP and those few ranged more or less permanently on relatively undisturbed high ground beyond the reserve's boundary. Two major issues provided the impetus to reassess the situation. As recently as 1995, almost no detailed information was available on Bornean orangutan distribution to guide habitat protection proposals (Rijksen *et al.* 1995; Soemarna *et al.* 1995). Meijaard *et al.* (1996) undertook a survey to establish orangutan presence in the DSNP region as part of a major effort to locate all remaining orangutan populations in Borneo (Rijksen and Meijaard 1999). Second, redefining the boundary and status of DSNP was under discussion. The original Danau Sentarum Wildlife Reserve (DSWR), designed to protect the region's unique wetland habitat, was gazetted in 1982 as an area of about 80,000 ha with a core of open lakes. Two extensions to the reserve were subsequently proposed (Figure 1), one of which has been implemented as a National Park (DSNP). The present DSNP boundary, a moderate extension of the Wildlife Reserve, appended about 50,000 ha of the hill areas to the southeast of DSWR plus the immediate catchment of peat swamp and low hills (Giesen, Deschamps, Dennis 1994). A second,

greater extension (DSNP-G) proposed to append an additional 60,000 ha covering much of the unprotected swamp forest beyond DSNP (Jeanes 1996). Neither proposal was designed for the specific protection of orangutans, so current quantitative estimates of orangutan distribution could help determine which proposal offers better protection of orangutan habitat. Russon *et al.* (1996) carried out a nest count survey to generate quantitative estimates of orangutan distribution in these three protected/potentially protected areas. In addition to the surveys, an assessment was made of the change in orangutan habitat between 1973 and 1997 in each of these three Danau Sentarum areas, based on remotely sensed data and field checks.

This paper summarizes present knowledge of the status of orangutans in the wider Danau Sentarum area. We analyze the most recent developments in the area and assess their potential impact on the remaining orangutans. Based on this we provide management recommendations for the Park.

### **Interview Survey**

Meijaard *et al.*'s (1996) Danau Sentarum orangutan surveys were part of a Borneo-wide orangutan survey effort conducted between 1994 and 1997 (see Rijksen and Meijaard 1999). During that period, Meijaard made 4 visits to the greater Danau Sentarum area, followed by another recent one in October 2000. EM gathered information on orangutan presence mainly by interviewing local villagers and employees of timber and oil palm companies, and by collecting information from researchers and government staff in the DSNP area. Whenever possible, statements about orangutan presence were verified with concrete evidence (e.g., orangutan nests, locally captured orangutans, or hunting trophies like skulls). The data collected on orangutan presence were plotted on maps and compared with the distribution of potential orangutan habitat. Potential habitat was defined as all forest below 500 meter a.s.l., based on the 1995 forest cover data set made by the World Conservation Monitoring Centre (WCMC). An overlay of orangutan presence records and potential habitat generated an estimated distribution range.

These survey data indicated greater current presence of orangutans than expected and concentration of orangutans in swamp areas to the east and north of the lakes. Reports of orangutan presence in and south of Bentuang Karimun National Park, which lies 40 km to the northeast of DSNP, indicated that the DSNP orangutans were at the western-most limit of a much bigger population. Rijksen and Meijaard (1999) estimated the total remaining habitat available to the DSNP area orangutan population at some 600,000 ha, most of which is outside either of the two protected Park areas and rather fragmented. Present-day pressures on non-protected forest are such that the long-term survival of the orangutan outside the two Parks is considerably threatened. Considering the remaining amount of habitat and its suspected quality, these surveys suggested that the larger Danau Sentarum area could be of global importance for the survival of orangutans (Meijaard *et al.* 1996). The surveys also turned up evidence that trading in orangutans over the border into Sarawak, in Sawit (Kecamatan Badau), most likely involves orangutans from the DSNP region. Meijaard noted limited control of goods over the Indonesia-Sarawak border, near Badau, which would facilitate the smuggling of protected species like orangutans. However, because of the exploratory nature of the surveys, additional quantitative surveys were required to estimate population size and the conservation status of the area's orangutan population.



### Orangutan nest survey

Subsequently, Russon, Erman and Dennis (in press) conducted a nest survey to generate quantitative estimates of orangutan distribution and the total orangutan population. Following van Schaik *et al.* (1995b), if nests are censused along line transects, the number of nests identified provides an estimate of nest density per km<sup>2</sup>. This can be translated into estimates of orangutan density and of the total orangutan population.

Nests were censused along line transects in seven areas where Meijaard *et al.* (1996) obtained reports of recent orangutan presence. For each area, ± 3 km of line transect were sampled (per van Schaik and Azwar 1991). To minimize habitat variability within transects, area samples took the form of three 1-km or two 1.5-km transects (van Schaik *et al.* 1995b). Within the original Wildlife Reserve (DSWR), three areas were sampled (see Figure 1 for locations), (1) Hutan Nung, the protected forest southwest of Sekulat, (2) northwest of Bukit Pegah, and (3) a logged forest northeast of Leboyan. In the extension that generated DSNP, three areas were sampled, (4) Semujan and (5) Piat/Menyukung, two hill regions in the southeast, and (6) lowlands near Meliau. In the DSNP-G extension, one area was sampled, (7) lowlands in the largest block of the extension, to the north of DSNP. For more detailed description of methods, see Russon *et al.* (in press).

To factor differences in habitat quality into estimates, the habitat along each transect was classified in terms of two factors known to affect orangutan distribution, vegetation type and disturbance/degradation level (e.g., Rijksen *et al.* 1995; van Schaik *et al.* 1995b; Sugardjito and van Schaik 1992). Vegetation was classified into four types according to their capacity to support orangutans, based on vegetation features observed along each transect: 1. swamp/peat forest, 2. lowland hill forest, 3. open and fragmented forest (farmland, clearing, secondary forest), and 4. unusable (agriculture, regeneration after fire, recently burnt, settlement, water). Disturbance level was classified as low, medium, or high based on the overall degree of habitat damage observed along each transect (e.g., logged, burnt, farmed). Both classifications were verified against a 1990 Landsat Land Cover Map of the Kapuas Lakes region. Coverage of each habitat type was obtained from a Geographic Information System developed for the Kapuas Lakes region (Dennis, 1997) and recently updated on the basis of field surveys (Dennis and Kurniawan, 2000).

The nest census found few orangutan nests within DSWR. In the moderate extension, the present DSNP, moderate to high numbers of nests were found even though the areas sampled were designated Production Forest. Transects up hills and along the foot of a highly disturbed hill tended to reveal fewer nests than transects in adjacent lowlands. Nest counts along two transects near the Iban Dayak town of Meliau beg explanation. One transect passed through farming areas and a corridor of forest that ran between fruit gardens. In total 40 nests were located along this corridor although it was narrow, under 100 m long, and the only forest along this transect. The second transect, along the shoreline of a lake, generated a relatively high number of nests even though only one side was forested and that forest represented poor orangutan habitat (stunted inundated forest, repeatedly burned) (Giesen 1995). The likely explanation for these unexpected results is that both transects sampled an area just west of a large expanse of tall swamp forest, and transient or overflow orangutans from the swamp forest were traveling to feed on fruit

trees in this area. The swamp forest is classified as unprotected Production Forest and it lies just beyond the eastern DSNP boundary.

**Table 1. Orangutan population estimates for the original DSWR, the present DSNP, and the greater proposed extension.**

Habitat Type	DSWR			DSNP		DSNP-G		
	total pop.	habitat area <sup>a</sup> in km <sup>2</sup> (% of total area)	added area <sup>a</sup> (km <sup>2</sup> )	added pop. (total pop.)	habitat area <sup>a</sup> in km <sup>2</sup> (% of total area)	added area <sup>a</sup> (km <sup>2</sup> )	added pop. (total pop.)	habitat area <sup>a</sup> in km <sup>2</sup> (% of total area)
swamp and peat forest	123 <sup>b</sup>	287 (36%)	189	573 (696) <sup>c</sup>	476 (36%)	403	1326 (2022) <sup>d</sup>	879 (44%)
Lowland hill forest	2	1 (0.1%)	63	113 (115)	64 (5%)	0	0 (115)	64 (3%)
open and fragmented forest	22 <sup>b</sup>	52 (6%)	31	35 (57) <sup>b</sup>	83 (27%)	143	61 (118) <sup>b</sup>	226 (12%)
Unusable	0	465 (58%)	225	0	690 (53%)	104	0	794 (40%)
<b>TOTALS</b>	<b>147</b>	<b>805</b>	<b>508</b>	<b>721 (868)</b>	<b>1313</b>	<b>650</b>	<b>1387 (2255)</b>	<b>1963</b>

<sup>a</sup>all estimates of habitat areas are based on 1997 data.

<sup>b</sup>density estimate for highly disturbed swamp/peat forest (0.43/km<sup>2</sup>).

<sup>c</sup>density estimate for swamp/peat forest within DSNP (based on transects representing low to moderate disturbance, 3.03/km<sup>2</sup>).

<sup>d</sup>density estimate for moderately disturbed swamp/peat forest (3.29/km<sup>2</sup>). This area was represented by three transects yielding exceptionally high density estimates, so we used a more conservative estimate for the whole area.

Transects in the greater extension, DSNP-G, generated the highest nest counts per km. These transects passed mostly through prime orangutan habitat, tall swamp forest with some peat near waterways. They tapped the edge of a large contiguous expanse of swamp forest that extends to the north and west of DSNP, up to the hills to the northeast and northwest and almost to the Sarawak border to the north. Numerous reports of orangutans from this forest and the forest's relatively low levels of disturbance suggest that orangutan densities may be similar across much of it. This swamp forest is contiguous with the swamp forest to the east of DSNP. It is currently unprotected Production Forest or Non-Forest (i.e. outside the area managed by the Ministry of Forestry).

Habitat-specific density estimates were used to estimate the orangutan population in each proposed protected area (see Table 1). Calculated population estimates are DSWR–147, DSNP–868, DSNP-G–2255.

These estimates are potentially upwardly biased. This nest survey, like others, was biased to higher density areas because of the statistical and practical difficulties of studying a sparsely distributed species (Rijksen *et al.* 1995; van Schaik *et al.* 1995a). Compensation was made for this bias by estimating relative to habitat type but travel difficulties also biased sampling to areas near waterways, which support

disproportionately high orangutan densities (Payne and Andau 1994; van Schaik and Azwar 1991). Upwardly biased estimates are problematic because they fail to detect the critical pattern for orangutans, dangerously small populations. Experts recommend correcting calculated estimates for systematic upward bias by a factor of 0.75, although the basis for this value is tenuous (Rijksen *et al.* 1995; van Schaik *et al.* 1995a; Tilson *et al.* 1993). Correcting the calculated estimates by 0.75 gives DSWR-110, DSNP-651, DSNP-G-1691. Corrected values may be interpreted as lower bound estimates (Rijksen *et al.* 1995), for 1996.

#### Forest cover and land use assessment

To relate the observed orangutan distribution to changes in forest cover and land-use patterns, RD conducted a land cover change analysis. Imagery used for the study of the Danau Sentarum area covered the period August 1990 through to May-July 1997 (Dennis and Kurniawan 2000) and included both Landsat TM and SPOT XS imagery. In a further project, the change analysis was extended back to July 1973 with Landsat MSS imagery. A site for vegetation change analysis was selected based on areas completely covered by the imagery from 1990 to 1997 (see trapezium shape in Figure 1). The resulting test site area is 425,650 ha and therefore includes a significant part of the vegetation beyond the National Park. In the test site, in total 21 different land cover classes were identified from the imagery and verified during fieldwork. For descriptions of the technical process, see Dennis and Kurniawan (2000).

The resulting vegetation maps for 1973, 1990, and 1997 were overlaid with the orangutan distribution. As no orangutan distribution maps exist for 1973 or 1990 it was assumed that orangutans occurred wherever there was suitable habitat, i.e., closed canopy forest. Although orangutans may temporarily occur in open or fragmented forest, it is assumed that these vegetation classes do not provide suitable long-term habitat. Results by Russon *et al.* (in press) support these assumptions. On this basis, the orangutan distribution for 1973 and 1990 was estimated by extrapolation. For each of the 3 years the total amount of orangutan habitat was calculated as the amount of closed forest. Furthermore, the mean size of each closed forest polygon was calculated to provide an estimate for average habitat patch size. Finally, the different habitat classes were evaluated for the proposed DSNP boundary.

Between 1973 and 1990, in the vegetation change test site, there was a 16% decrease in closed canopy forest and a 31% and 117% increase respectively in open and fragmented forest. The most obvious changes in orangutan habitat occurred in the swamps to the north and east of DSNP, where large gaps, especially around rivers, started to appear in what were previously closed and homogenous forest polygons. During these 17 years, some 40,000 ha of orangutan habitat disappeared.

**Table 2. Overall change matrix 1973–1997.**

Class name	Date: 1973 units: ha	Date: 1990 units: ha	Annual rate % 1973–1990	Date: 1997 units: ha	Annual rate % 1990–1997
Closed Forest	255,116	214,777	- 1	182,191	- 2.2
Open Forest	19,891	26,173	+1.9	44,501	+ 10
Fragmented Forest	11,949	25,938	+7.3	21,866	- 2.2
Forest Re-	8002	8724	+9	12,367	+ 6

growth					
Shifting Cultivation Mosaic	61,507	41,650	-2	48,924	+2.5
Wood and Shrub, Grassland and Non-forest Regrowth	29,897	27,119	-9	27,027	-1.8
Semi-permanent Agriculture	0	33,251		34,370	+0.5
Burnt Areas (incl new <i>ladangs</i> )	4,976	13,635	+10.8	20,224	+7
Water	33,901	33,903	0	33,903	0
<b>Total</b>		<b>425,650</b>		<b>425,650</b>	

Between 1990 and 1997, in the vegetation change test site, there was an 11% decrease in closed canopy forest, a 66% increase in open forest, and a 24% decrease in fragmented forest. Some of the most important changes from closed into open and from closed into fragmented forest occurred in freshwater and peat swamp forest to the west and east of the present reserve, in areas that our surveys showed to contain orangutan populations. More specifically, the total area of closed canopy forest decreased by some 24,000 ha, as shown in Table 2.

An analysis of the fragmentation effects of logging indicated that in 1973 there were 79 contiguous closed forest areas in the vegetation change test site with a mean size of 3,230 ha. This figure is strongly skewed by one very large contiguous forest area of 121,082 ha combined with a large number of smaller patches. In 1990, the number of contiguous forest areas decreased to 67 and their average size remained similar to that of 1973 (i.e. 3,205 ha). The size of the largest forest patch decreased by 20,000 ha to 100,964 ha. As of 1990, only one contiguous forest area appeared large enough to support a viable orangutan population, assuming an average density of 2 orangutans/km<sup>2</sup> and a minimum viable population of 2,000 (Sugardjito and van Schaik 1992; but other experts suggest that long-term survival may require a population of at least 5,000, e.g., Rijksen and Meijaard 1999). To identify areas in DSNP that could support substantial sub-populations, a minimum threshold of 10,000 ha was used (i.e., 200 orangutans). With this threshold, the number of contiguous orangutan habitat patches decreased from 6 to 5 between 1973 and 1997. This indicates that there remain 5 areas that may support substantial sub-populations; with active management (i.e. provision of extra feeding in times of food scarcity, enforcement of full protection from poaching, and possibly human-assisted gene flow between habitat patches), there may be a possibility that these sub-populations could survive in the long term. Figure 2 shows the change in closed forest areas between 1973 and 1997.



Figure 2. Forest fragmentation in DSNP between 1973 and 1997.

### Discussion

The three surveys generated four main findings. First, a population of around 2,000 orangutans survives in the Kapuas Lakes region. The region supports an important orangutan population that may represent as much as 15-20% of the remaining Bornean population. Second, most of this population ranges in unprotected areas beyond DSNP. Findings concur with Giesen's (1987) impression, that the eastern hills beyond DSNP but within DSNP-G are important to the area's orangutans. Third, the highest orangutan densities are in swamp forests within DSNP-G, beyond DSNP. This is consistent with previous findings that the richest habitats for orangutans are good quality swamp/peat forest and lowland alluvial forest; they have potential to support orangutans at almost twice the densities of other habitats, like adjacent uplands (e.g., Payne and Andau 1994; van Schaik and Azwar 1991). Orangutans found in poorer habitat may migrate between habitat types according to food availability (te Boekhorst *et al.* 1990; Leighton and Leighton 1983). Fourth, both the total orangutan habitat and the mean size of contiguous habitat patches in the greater DSNP area decreased significantly between 1973 and 1997. Assuming that the overall habitat quality within the habitat patches remained constant, it can be concluded that the total number of orangutans in the DSNP area has declined between 1973 and 1997.

Finding unexpectedly high orangutan densities in some areas is more disturbing than encouraging. Some estimates were much higher than any found elsewhere Borneo. The likely explanation for exceptionally high nest densities in logged areas is that habitat disturbances elsewhere were displacing orangutans into these areas. The highest nest counts were from areas in the proposed extension just beyond the DSNP boundary. Orangutans could have been migrating into these areas from outer regions because of disturbances there (Meijaard *et al.* 1996) or from inside DSNP because of continuing disturbance due to increasing human pressure. Other areas of Borneo show similar patterns (Rijksen and Meijaard 1999) so the high counts may reflect population stress.

The assessment of the size of contiguous habitat patches in the wider Danau Sentarum area indicates that only one forest area may be large enough to contain a viable population of orangutans, assuming a minimum population size of 2,000. If the higher threshold of 5,000 is used, a contiguous forest area of at least 250,000 ha would be required. The present DSNP does not contain such areas, but an extension of the Park to the east and a link to the 800,000 ha Bentuang Karimun National Park to the northeast would encompass sufficient orangutan habitat to secure long-term survival (also see

Meijaard *et al.* 1996). Orangutan populations in other forest blocks in DSNP probably require management interventions. The degree to which this is necessary probably depends on the degree to which individual forest blocks are isolated from one another. Orangutans have been reported to travel distances of several km across degraded areas to reach better habitat (e.g. in the Kinabatangan River area, Sabah; near Samarinda, East Kalimantan). In DSNP, forest blocks are normally separated by waterways but waterways may dry up during seasonal droughts every 3-4 years. These dry periods would allow orangutans to migrate, so an important management issue would be ensuring that forest near waterways remains as undisturbed as possible to minimize crossing distances.

Findings show that the DSNP-G extension would offer important benefits to orangutans. Because of the distribution of habitat types, the 1.5-fold increase in reserve size offered by DSNP-G versus DSNP could support a 3-fold increase in orangutan numbers. The signs of population stress, however, indicate that protecting the area's orangutans requires extension beyond DSNP-G. GIS data show that DSNP-G stops short of unprotected swamp forests to the east, north, and west of DSNP. Orangutans ranging in the DSNP area likely depend on these swamp forests, perhaps migrating back and forth because of the area's pronounced seasonality. These data bolster recent recommendations to extend the park to cover all surrounding orangutan habitat and to create a forest corridor linking the extended reserve with the nearby Lanjak Entimau and Bentuang-Karimun National Parks and their important orangutan populations (Blouch 1997; Rijksen and Meijaard 1999).

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AFTER THE CONSERVATION PROJECT:  
DANAU SENTARUM NATIONAL PARK AND ITS  
VICINITY—CONDITIONS AND PROSPECTS<sup>1</sup>

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### Introduction

The Danau Sentarum conservation project, initiated in 1992 with funding from the British Overseas Development Administration (ODA),<sup>2</sup> aimed to develop management guidelines for the wildlife reserve (now national park). The project ended in July 1997, at a time that ushered in a new and uncertain period for Indonesia. A currency crisis (*krisis moneter* or *krismon*) plunged both economy and politics into chaos, ending in the downfall of the Suharto presidency and the eventual election of the current "reform" government led by Abdurrahman Wahid. Along with *krismon*, some other parts of the widespread Indonesian archipelago have seen continuing violence (i.e. Timor and Maluku). The provinces of Kalimantan have been relatively free of any major conflicts, although West Kalimantan saw some renewed violence against Madurans by Malays and Dayaks in 1998 and in late 2000.

Political and economic uncertainty has continued, however. The national movement toward formal regional autonomy (scheduled for 2001) has been preceded by an informal, *de facto* autonomy. This has allowed some sectors in West Kalimantan to benefit from more intensive economic ties with foreign countries, especially Sarawak and particularly through the legal and illegal export of agricultural and forest products. Politically, however, there is even more uncertainty about how to deal with autonomy and shrinking subsidies from Jakarta, and this has led to what most locals see as increased corruption by government officials.

These uncertainties have left conservation in West Kalimantan in a very weak position. Not only is there indecision by conservation agencies on how to proceed in the new political climate, but there are strong economic demands being made on West Kalimantan's natural resources, particularly through increased logging and forest conversion activities.<sup>3</sup> In this research note, we take a brief look at the Danau Sentarum National Park (DSNP) and its vicinity after the end of the ODA conservation project. We describe the current threats to the Park which largely come in the form of confusion over Park boundaries, oil palm plantations, logging, gold mining, changes in catchment hydrology, local boundary disputes, fire, and over-fishing. All is not gloomy though, and we consider some bright spots such as NGO activities that have followed the conservation project, positive aspects of local logging, and increased community autonomy. Finally we discuss prospects for DSNP management in this new era.

### Current Threats

**A new boundary and status of DSNP.** Danau Sentarum was officially declared a National Park on 4 February 1999, forming only the latest of many boundaries for the

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<sup>2</sup>Now the Department for International Development (DfID).

<sup>3</sup>Conservation throughout Indonesia is also under threat, mainly related to the high local value of natural resources for export, expansion of agriculture, and lack of law enforcement (e.g. *Kompas* 2000; *Riau Pos* 2000; *Jakarta Post* 2000).

conservation area. However, the new boundary is perhaps one of the most important in light of the proximate threats to the integrity of the area. During the course of the conservation project, three boundaries were proposed. One of these, amounting to 132,000 ha, was taken up in the provincial structure plan in 1996 with the proposed status of National Park. In 1997, the conservation project (Jeanes 1997) proposed a buffer-zone addition to this boundary bringing the total area to 197,000 ha. Much of the "buffer zone" area included areas of tall peat swamp forest.

**Table 1. Land Cover Composition of DSNP (132,000 ha) and Buffer Zone (65,000 ha). (Land cover map derived from interpretation of SPOT satellite imagery dated May/June 1997).**

Land Cover Type	Area in hectares	Percentage of total area
Lowland hill forest (closed canopy)	5,721	2.9
Lowland hill forest (open canopy)	580	0.3
Heath forest	758	0.4
Swamp forest (closed canopy)	34,717	17.6
Swamp forest (open canopy)	6,099	3
Peat swamp forest (closed canopy)	53,224	27
Peat swamp forest (open canopy)	11,749	5.9
Dwarf swamp forest	25,187	12.8
Forest re-growth	4,249	2.1
Swamp grass	281	0.1
Agriculture	7,900	4
Burn scar	18,204	9.2
Water	28,311	14.3
Total	197,000	100

Little happened with boundary and status proposals for Danau Sentarum until February 1999 when the area was officially gazetted as a National Park. However, the area and boundary information was not released until much later that year. Recent discussion with the Directorate General of Nature Protection and Conservation (PKA) clarified the current status of the new boundary. In the agreement with accompanying maps (signed by the Minister of Forestry and Estate Crops [MOFEC] in February 1999), the size of the National Park is 132,00 ha with a buffer zone of 65,000 ha. The total size (including buffer zone) is 197,000 ha, which equates to the boundary proposed by Jeanes

(1997). Geographic Information System (GIS) analysis (Table 1) calculates that at least 57% of the National Park and buffer zone is forest, with the largest percentage being peat swamp forest. Looking at the Park minus the buffer zone, we find that the percentage of forest falls to 46%. The buffer zone area contains large areas of peat swamp forest, nearly 44,000 ha, which are an important part of the immediate water catchment of the lakes.

The National Park and buffer zone boundary, as detailed above and described in Jeanes (1997), is a logical boundary covering both a variety of habitat types and ensuring the immediate catchment is protected for both biodiversity and the current and future livelihood of local people. However, recent findings suggest that the buffer zone is not yet completely agreed upon, certainly not within West Kalimantan. The most obvious disparity appears in the north of the area where an oil palm concession overlaps the buffer zone by approximately 32,000 hectares. There also seem to be disparities between the provincial planning maps. The Regional Spatial Planning map (1999) shows the area to the north to be production forest whereas the *Paduserasi* map (1999) (which is the "harmonization" of the Spatial Planning map and the Forest Status map) shows this area to be dryland agriculture and no longer forest land. The DSNP boundary on the *Paduserasi* map is only 170,000 ha; that is, the proposed DSNP boundary minus the area of the oil palm plantation.

In the field, the situation is similarly unclear. The oil palm company admits that it is unsure of the boundary and has heard part of its concession may be within the buffer zone. In the meantime, however, the company has started clear felling and planting some areas in the buffer zone. In other parts of the buffer zone, there are active logging concessions. One is located in part of the eastern swamp forest and was recently granted an extension. Another concession is still actively logging in the western part of the buffer zone.

The continuing confusion over the boundary of DSNP, especially the buffer zone, is worrying, as is the difficulty of actually locating boundary markers in the field. Activities, such as oil palm establishment and illegal logging in the buffer zone are potentially immense threats to the integrity of the buffer zone forest and ultimately the lakes and surrounding swamp forest. It is of utmost importance to physically mark the Park and buffer zone boundaries and ensure that activities in the buffer zone are monitored and do not destroy the integrity of these forest areas.

**Oil palm plantations.** An oil palm plantation is being established to the north of DSNP by PT Plantana Razindo. The company is a joint venture between the Razindo group (an Indonesian holding company with a 31% stake), Hak Corporation Berhad (a Malaysian oil palm company with 49%), and PT Yamaker (a timber company that originally held a huge concession along the border, with 20%).<sup>4</sup> The original concession is considered to have a high environmental value because it overlaps the buffer zone of DSNP. It also includes a number of local communities' *hutan adat*.

In March 1996, PT Plantana Razindo was granted a location permit for 47,000 ha. The company was able to acquire this land through its connections with PT Yamaker. Besides close ties with the military, the company has also been publically supported by a former Minister of Defense and the Governor of West Kalimantan. In 1998, the

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<sup>4</sup>PT Yamaker's concession has been taken over by PT Perum Perhutani III, a "private" government company (*perusahaan swasta pemerintah*).

concession was reduced by 10,250 ha because this land fell within an active timber concession that sought to extend its licence. MOFEC then released 36,750 ha for oil palm development in January 1998. However, at the time of this writing, there is still doubt about the final size of the oil palm concession because of potential overlaps with the DSNP buffer zone.

In addition, PT Plantana Razindo is encountering problems in negotiations with local communities within the concession. The company said that they had decided to enter into negotiations with the Iban community of Tangit IV because of difficulties obtaining other land within the concession. They were not able to come to any agreements with communities in the Seriang area because most of the land was already in the forest fallow cycle for farming. (Apparently, in 1996 when the company first began negotiations with the *bupati* and local communities, they promised not to establish oil palm plantations on fallow sites. The company would also have to pay more compensation to communities if they wished to acquire such land.)

In August 1999, after an agreement had been reached with Tangit IV, PT Plantana Razindo started building a road south from the community into the peat swamp forests north of DSNP. The plan was to "open" a 3,000 ha block for planting oil palm. Indeed, Tangit IV residents have worries and doubts about the agreement because, according to them, the company only wants access to their forests. They say the company insisted on acquiring land containing tall forest and were not interested in other land the village showed them. But the company said it was the only land that they could get the community to agree to release. The company's estate manager said they still intend to plant oil palm but also wanted to profit from the timber extracted. (He also admitted that their Malaysian logging contractor has already been operating illegally in the area.) Because it is unlikely that the company will be able to develop a large area of land with oil palm and that the peat swamp land near Tangit IV may be unsuitable for oil palm development, it is increasingly evident that the company is more interested in the timber still available in the area.

Although local communities are disadvantaged because their land has been put under timber and plantation concessions without their agreement, they are not powerless and have already demonstrated their ability to negotiate with the company and in some cases reject the company's offers. Tangit IV has already negotiated up to 11 times with the company to improve the conditions of their agreement. Although the agreement still undoubtedly benefits the company, the ability of the community to maintain negotiations with the company demonstrates that they are able to maintain some bargaining power. Community leaders were aware that if they did not enter into negotiations, they would run the risk of losing the timber on their land without any compensation as MOFEC already granted the land to the company.

Many locals know about the problems with oil palm schemes from their relatives in Sarawak. According to local opinion, they would not have better lives being involved in oil palm. It would especially limit their swidden activities by removing land from the cultivation cycle, and they say land planted in oil palm is no longer fertile because of the land-clearing method. (The soil is turned up such that the thin humus is exposed.) Land like this will not grow secondary forest, but instead would become a field of *Imperata* grass, an indication of nutrient-poor soil. Thus, in the end, the locals fear becoming landless workers for the company.

In addition, there is the problem of clean water as the northern periphery of DSNP forms an important source of water for the lakes. Run-off from chemical fertilizers and pesticides used on the plantations will be a severe threat to the national park, its flora and fauna, and the people who live off its resources. After having obtained the various permits from the local government and MOFEC, the company plans to build an oil palm refinery just north of the lakes. As this factory will be located upstream, its waste run-off will flow into the lakes, and unless it is filtered or otherwise cleaned, it will change the nutrient status of these black water, nutrient-poor lakes. Furthermore, the disappearance of the forest cover and subsequent drainage of the peat for planting oil palm will lead to oxidation of the peat and an increased risk of peat fires during the dry season. Significant changes to the water-retaining function of peats and changes in water nutrient status may affect fisheries and threaten the survival of those species dependent on black water environments (see Jeanes and Meijaard, this volume).

It thus appears that oil palm development could have severe negative impacts on the ecology of DSNP, but on the other hand, if well organized, the plantations could provide an economic boost to the area around DSNP. If such development could somehow be organized to alleviate pressures on DSNP, it could have a positive impact, for instance, by providing work to people that now live in and use the Park. Clearly, for this to happen, the oil palm plantation would have to be very well developed and monitored. A professionally executed environmental impact assessment would need to show what the possible impacts on DSNP could be and how these can be counteracted. Also, possible changes in concession boundaries may need to be considered. It is not too late to demand such activities, and it may be the only way for conservation and development to go hand in hand.

**Illegal logging.** Since the 1970s, the forests within and surrounding DSNP have been allocated to timber concessions such as PT Yamaker, Rimba Ramin, Tawang Meranti, Benua Indah, and Lanjak Deras. Yet illegal logging activities in the conservation area began long before the project ended in 1997. In general, the loggers were locals who received capital for logging from legitimate logging companies. These would then buy the wood without official documents. Locals refer to this method of logging as *tebang banjir*—overflow cutting. The logging companies themselves have long used the waterways of DSNP as a means of transporting rafts of logs, and the smaller illegal rafts are added to the larger, documented rafts for transport to sawmills on the main Kapuas river. However, such illegal logging is generally low-capacity.

Since *krismon*, however, the level of illegal logging has increased and the flow of illegally-cut timber has shifted dramatically. Today, local communities and Malaysian financiers are the chief players, rather than the Indonesian timber concessionaires. In February 2000, there were about twelve small financiers (known in Indonesia as *cukong*, and locally as *tokay*) operating in locations along the border between Nanga Badau and Lanjak. All are from Sarawak. Four of these *tokay* have built substantial sawmills near the main government road that runs to the north of DSNP. In fact, according to local reports in August 2000, two additional sawmills have been built in the Seriang and Guntul areas. It is likely that the area being logged will expand to accommodate sawmill capacity.

The forests being logged are mainly along the northern periphery of DSNP, and in some cases into the northern buffer zone. Timber cutting is also occurring within DSNP.

The timber cut is sold as *kayu balok* or beams of various sizes which are transported across the border into Sarawak by truck along the government road (see Wadley 1998). Much of the cutting is within forests claimed by local communities. In the past, communities that fell within the logging concessions had little power over their forests. Now even Indonesian timber companies with concessions elsewhere in the province are hiring community negotiators and public relations officers to deal with local community demands for more compensation. In the DSNP area, with only two concession still operating, the timber companies must cooperate more publicly with local communities, and organizing communities into development co-operatives is the way they are doing this.<sup>5</sup>

**Gold mining.** An additional threat to clean water comes from illegal gold mining along the tributaries of the upper Kapuas River, which has been on the increase since 1998. Gold mining along the Kapuas has occurred since historical times, and many shopkeepers in the area keep mining equipment for the periodic “gold rushes” (see Giesen 1987). Unfortunately, in addition to soil erosion from the use of pumps, mercury washes out into nearby waterways, having been used by miners to separate gold from other minerals. Samples of fish taken in the early 1990s revealed background levels of mercury. However, a recent study by Universitas Tanjungpura<sup>6</sup> found mercury levels in the Kapuas at Semitau to be 69 times above tolerable levels; mercury was also detected elsewhere in the Kapuas River (see also *Indonesian Observer* 2000). The lakes of DSNP and the Kapuas River form an interdependent system with the tributaries where illegal gold mining is occurring. Water flows back and forth between the Kapuas and the lakes in the annual flood-drought cycle (see Klepper 1994), and this may bring mercury run-off into parts of DSNP. This has profound dangers for the food chain dependent on the lakes—from plankton and fish to birds such as eagles, kingfishers, and storks. Local human reliance on fishing is also threatened, not to mention the downstream and cross-border consumers who buy upper Kapuas fish in the markets.

**Changes in catchment hydrology.** Changes in hydrology and water quality due to changes in the Kapuas River basin also form a threat. For example, in 1986 floods were already more pronounced than in past decades, and this trend will continue with further changes in land cover. In addition, changes in water quality may become more evident, with negative repercussions for the Park, its biota, and human inhabitants. Pollution is the obvious form, and mercury and oil (making fish unpalatable) immediately spring to mind. However, more insidious but with significant long-term effects is gradual eutrophication (nutrient enrichment) of the waters. This may occur due to pollution (e.g. domestic wastes and fertilizer residues) but also due to erosion, as an increase in soil particles in water will also increase nutrient levels. As a result, there may be an increase in algae (in the worst case, toxic blooms of blue-green algae), increased turbidity, and increased opportunities for weeds such as water hyacinth (*Eichhornia crassipes*) to proliferate. The Mahakam Lakes in East Kalimantan were very similar to the Kapuas Lakes in the early

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<sup>5</sup>Co-operatives operate under the Peraturan Pemerintah Republik Indonesia Nomor 6 Tahun 1999 tentang Pengusahaan Hutan dan Pemungutan Hasil Hutan pada Hutan Produksi, namely Pasal 10.

<sup>6</sup>Dr. Thamrin Usman, Ketua Pusat Studi Agroindustri dan Agrobisnis, Untan, using a GRAB sample method.



20<sup>th</sup> century. But at present the Mahakam Lakes are severely degraded, choked with water hyacinth and giant mimosa, with poor water quality and a significant decline in fisheries production. According to fisheries studies in the 1980s, this decline went hand in hand with logging in the catchment. Although the conclusion was never made, the obvious link is via water quality.

**Local boundary disputes.** Since the expansion of illegal logging, boundary disputes have been occurring between local communities. In at least one case, the dispute was over forest land that had never been part of any traditional community territory. And in another still-unsettled case, one community is making use of maps drawn under a conservation project's community-mapping program. In some instances, the disputes were settled by cockfight with the winning community gaining possession of the disputed land and forest. This has created bitter feelings between neighboring and generally closely related communities. Locals recognize all this as a rush to make claims on timber land so that the local profits from logging might go to them. Although mostly outside DSNP boundaries, these disputes have important implications for the conservation area (namely over local use and challenge of conservation project-derived maps), something with which any future projects will have to contend.

**Fire danger.** Since the early 1990s, the incidence and extent of fires in the swamp forests of DSNP has been increasing rapidly. Dennis and Erman (this volume) estimate that between mid-1990 and mid-1997 the burnt area within the swamps increased from 8,502 hectares to 18,410 hectares—an 117% overall increase. During this period, there were two El Niño years (1991 and 1994) resulting in very dry conditions that exacerbated the risk of fire. The El Niño that followed in 1997 had the most severe consequences of any El Niño in the 20<sup>th</sup> century. In 1997, fires were reported in DSNP, but no estimates of the area burned are available. It is likely that the area burned during the 1990s could now be over 20,000 hectares. Research in the swamps of DSNP shows that once an area has burned it is much more likely to burn again. Therefore, we can expect that unless serious measures are taken to prevent and control fires in the future, the area of burning will increase every dry season.

Up until now there has not been a perceived fire problem in the areas surrounding the swamps of DSNP. Fire is used regularly in a controlled manner as part of the swidden agriculture system. However, increased logging activities, both legal and illegal, are now damaging the forest in such a way as to make them more prone to fires. Opening up of the forest canopy is leading to a general drying out of the forest. The establishment of the oil palm plantation is also a cause for concern. Experience from other parts of Indonesia shows that oil palm companies often use fire in land clearing activities with some of the fires escaping from the intended area of burn. Fires lead to significant changes in the vegetation, particularly dominance by fire-tolerant and pioneer species. On the whole, the trend is towards impoverishment—significantly lower biodiversity, lower biomass, and reduced conservation value. This would also affect fisheries, as DSNP fish and fisheries are dependent on forest biomass.

**Fisheries.** Since *krismon*, the fisher people of DSNP superficially benefitted from rises in local fish prices. For example, one kilogram of cage-reared *toman* (*Channa micropeltes*) cost Rp. 2,500 before compared to Rp. 4,500 after the crisis. For the aquarium fish, *ulang uli* (*Botia macracanthus*), the pre-*krismon* price was Rp. 250 per fish, rising to Rp. 1,500 after the crisis. The price of processed fish also

increased—smoked *lais* (*Krytopterus* sp.) with prices of Rp. 15,000 before and Rp. 25,000 per kg after, and also salted/dried fish (*ikan asin*) rising from Rp. 2,500 to Rp. 4,500. The price of *betutuk* (*Oxyeleotris marmorata*) also increased from Rp. 30,000 to Rp. 75,000. In dollar terms, the price differences are not all that large, and most have actually declined. This may reflect increased fishing to make up for losses in income and/or a willingness to take lower (dollar) prices. However, for locals without access to foreign currencies (such as those not benefitting from the illegal logging boom), this means being unable to buy fish to eat.

Table 2 shows the estimated annual catch in DSNP for four types of fish. The data were collected from buyers and a cross-section of fishermen. They suggest both a decline in species availability and increased fishing effort between 1997 and 2000.

**Table 2. Estimated Annual Catch in DSNP**

Fish Type	1997-98	2000
Aquarium Fish ( <i>ulang uli</i> )	5,490,000 fish (wet season)	8,625,000 fish
Caged Fish ( <i>toman</i> )	2,218,000 kg (total year)	1,795,000 kg
Smoked Fish ( <i>lais</i> )	70,500 kg (wet season)	45,500 kg
Salted/dried Fish	364,500 kg (total year)	325,300 kg
<i>Betutuk</i>	40,350 kg (dry season)	30,750 kg

The people of DSNP manage an abundant and rich source of fish, but local fishers are already beginning to sense that species are declining due to overexploitation and that the situation is worsening rapidly (cf. Dudley, this volume). For example, fishers report that since 1997 it has become increasingly difficult to find young *toman* for rearing in cages. The *lais* fish for smoking is becoming rare, and it is increasing difficult to find large *belida* fish (*Chitala lopis*). Finding small fish as food for the caged fish is also a problem. One obvious example from the 1990s of over-exploitation at DSNP is the rare and valuable *arowana* or *siluk* (*Scleropages formosus*). It was fairly abundant throughout the 1980s but is now almost completely extinct due to over-fishing in the late 1980s. (The fish commands a very high price as an aquarium fish.)

Each village within DSNP uses local *adat* to regulate fishing (see Harwell 1997). However, local *adat* is very much focused on the regulation of fishing gear within the villages' fishing areas. It does not address currently pressing problems, such as the catching of breeding females which is a factor in species decline. Local *adat* must be allowed and encouraged to deal with these problems. Also of importance is improving the awareness of all stakeholders that for such a large and vulnerable resource as fish there must be a combined effort by local people, the fisheries service, and provincial government (especially sub-district level) to maintain the species richness and abundance.

**Other threats.** Current economic conditions have probably exacerbated the export orientation of the border economy. With the greatly weakened rupiah, the demand for Malaysian ringgit may have increased exports of certain local products. This is certainly true of timber, but it might also apply to fish caught in the lakes. Fish and turtles have

been sold across the border in the past (e.g. Wadley 1998), and this has likely increased since *krismon*. Market hunting may have also increased, although there are no data on this (Wadley 1999).

Finally, the local economic boom in logging has visibly increased the population of settlements such as Lanjak and Nanga Badau. Although local swidden rice agriculture may not have expanded to accommodate this increased population, gardening of vegetables by local women for the nearby markets has increased. In addition, waste production has likely risen, and all human wastes (from feces to discarded candy wrappers) eventually find their way into the DSNP waterways. How either of these affect the DSNP habitat needs to be studied. For example, clearing for swiddens and settlements along major rivers in the Park has contributed to a decline in riparian forest. This habitat is much like the stunted swamp forest (Giesen, this volume), but includes river-associated species such as *Gluta reinghas* (*rengas*) and *Lagerstroemia speciosa* (*bungur*). It is also a habitat for unique species, such as *Rhodoleia* sp., a new tree species discovered in 1993 (of an uncommon family, *Hamamelidaceae*, with the nearest relative on Mt. Kinabalu).

### Bright Spots

**NGO activity.** For the most part, the conservation project's activities ended with the project itself. However, the livelihood development activities involving "conservation products" initiated by the project (see Wickham 1997) were continued by Yayasan Dian Tama (YDT), a local NGO or LSM (*lembaga swadaya masyarakat*), from July 1997 to June 2000. YDT is currently seeking external funding to continue its projects in the DSNP area. The conservation products in question are honey, beeswax, *damar*, basketry, woven blankets, fish skin, and water hyacinth paper.

Although there are rules against such activities as taking timber and fishing for the endangered *arowana* fish, locals could not make a legitimate living without fishing for other species, harvesting honey and wax, and collecting rattan to make fishing and other implements.<sup>7</sup> Thus, these income-generating projects provide opportunities for locals to benefit in other ways from the surrounding natural resources. Local institutes are encouraged to exercise oversight and ensure that the benefits from the natural resources are obtained within limits. Without such oversight and self-policing, overexploitation may result.

The exploitation of rattan provides a good example: Locals typically sell rattan to the logging companies for tying up logs into rafts, and they receive about Rp. 2500 for 50 five-meter lengths. In contrast, if they make handicrafts from three five-meter lengths of rattan, they can earn Rp. 2500-5000 (depending on the size of the item made). Thus, in this way, the pressure on local forest products can be relieved, and locals can earn more money from less product.

YDT has been engaged with 24 of 55 communities within the DSNP area in a number of activities:

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<sup>7</sup>Such items have been collected and produced in the lakes area for a very long time (e.g. Algemeen Rijksarchief, The Hague, The Netherlands, Ministerie van Koloniën, Aantekeningen betreffende Borneo [1802-1827], Algemeen verslag van de boven en binnen landen ter West Kuste Borneo gelegen aan de rivier Kapouas, 20 December 1823, Provisional Gezaghebber van de Westkust C. Hartmann).

- Establish markets for conservation products. The local market is in Pontianak; national markets are in Jakarta, Bali, and Yogyakarta; and international markets are in Singapore and Great Britain.
- Train locals to ensure that natural resource management and use of the environment is done conservatively. This training includes demonstration plots for rattan in the communities of Tekenang, Pengembung, Nanga Sumpak, and Lubok Pengael. These “demplot” involve locals from the start—from seedling cultivation and planting to replacement planting and monitoring. (This activity was preceded in the early 1990s by Charles Peters who trained locals to improve *tembesu* [*Fagraea fragrans*] and rattan stocks by means of thinning young *tembesu* regrowth and replanting rattan in depleted areas.)
- Improve harvest techniques and quality of honey and beeswax from the wild bee, *Apis dorsata*. Honey is taken to Pontianak in jerry-cans, bottled by PD Dian Niaga, and sold there. Some is also sold by weight to Jakarta. PD Dian Niaga also buys beeswax to make into candles for sale in Pontianak and Jakarta. (Prior to 1997 before forest fire smoke caused a decline in honey production, locals in DSNP made dipped and bamboo candles themselves.)
- Assist locals in forest fibers basket and handicraft production. Forest fibers include rattans, *bemban* (*Donax canaeformis*), *resam* (*Dicranopteris linearis*), *senggang* (*Hornstedtia scyphifera*), water hyacinth, *panto'* (*Eugeissonia* spp.), and *ijok* (*Arenga pinata*).
- Assist production of paper from water hyacinth for envelopes, stationery, and gift boxes. (Cultivation of this plant should be restricted given its aggressive spread under favorable nutrient conditions [see above].)
- Standardize *belida* (*Chitala lopis*) fish skin and market to Yogyakarta for processing as material for making bags, wallets, belts, and the like.
- Endeavor to market conservation products collected by locals including *damar* and traditional woven blankets. The latter is considered a conservation product because dyeing materials come from leaves, roots, and fruits of wild and semi-domesticated plants.
- In addition, conduct routine meetings and visits with local project teams; increase production and sale of NTFPs to markets; increase the number of communities participating in producing and selling these products; increase training to guarantee quality products; and maintain *bandung* boats for transporting products downriver and coordinate accountancy.

“**Bicycle**” logging method. Most of the co-operative logging being carried out in the DSNP area today involves crews of Sambas Malays, with the heaviest machinery being chainsaws and bicycles: Sawyers fell selected trees and cut them into *balok*. These beams are then loaded onto bicycles which are heavily reinforced. The bicycles, carrying one or two beams on either side, are pushed along a track from the cutting site to the main road or waterway. Although most of this activity occurs outside DSNP boundaries, this

method of logging may be an excellent example of low-impact timber harvesting, a very important factor is maintaining forest cover in the DSNP catchment.

**Community empowerment.** The *de facto* autonomy that has swept the nation is also seen at the local level in a much greater sense of community empowerment. Communities are taking their future into their own hands, negotiating with *tokay* and their local liaisons, oil palm plantation companies, and the older timber concession companies. While some of their activities may seem short-sighted, such as allowing their forests to be logged, this empowerment presents an important though difficult opportunity for conservation efforts. While the DSNP management plan stressed the importance of community involvement, any future conservation efforts in DSNP will have to deal with communities, their concerns and demands, at a much different level—as entities that may demand much more from yet another scheme from the downriver government—be it oil palm or conservation.

### Wildlife Management

Various papers in this volume (Jeanes and Meijaard, Russon *et al.*, Frazier, Giesen, Walter, Dudley, van Balen and Dennis) have emphasized the importance of the DSNP area for the preservation of Borneo's biodiversity. The area has high biodiversity values, both in regional and global terms. However, these papers also stress that the present protected area of 132,000 ha leaves out significant sections of wildlife habitat, especially to the north and east of the Park. As it stands now, the National Park consists of only 41% of closed canopy forest, with the largest contiguous forest area being less than 40,000 ha. For some species such as the orangutan (see Russon *et al.*, this volume), peat swamp and hill stream fishes (Jeanes and Meijaard, this volume), and crocodiles (see Frazier, this volume), the available amount of habitat is insufficient to safeguard the species' long-term survival in the area. Other species that are not covered specifically in this volume, but of which there is considerable ecological understanding, may also be unable to survive because of insufficient habitat. This includes larger mammals such as sambar deer (*Cervus unicolor*), bearded pig (*Sus barbatus*), clouded leopard (*Neofelis nebulosa*), Malayan sun bear (*Helarctos malayanus*), gibbons (*Hylobates agilis*, *Hylobates muelleri*), birds that require relatively large ranges such as forest raptors, and reptiles require dry season refuges (see Frazier, and Jeanes and Meijaard, this volume).

For the long-term survival of these species it is of vital importance that more protected habitat is added to the existing Park. Several options for this have been proposed. For example, implementing the 198,000 ha boundary (Russon *et al.*, this volume), including most forest west of the Embaloh River, and/or establishing a corridor to the Bentuang Karimun National Park (Meijaard *et al.*, 1996; Russon *et al.*, this volume). All options would require considerable management input from local communities and conservation authorities. To provide not only wildlife habitat but also forests for human use (e.g. timber and non-timber forest products, wildlife products, eco-tourism), appropriate zoning of the extension would be required, separating wildlife core-zones from limited use areas and buffer zones. Locals may be particularly eager for such zoning as well as "forest enhancement" projects given the current level of threats to their community forests.

In the corridor proposal, the combined size of the two parks would add up to more than 1,000,000 ha, and thus provide a suitable area for the long-term survival of most species now present in the region. But a mosaic zone of fields and secondary forest

fallow presently separates the two national parks, and replanting some of this area would be required. The main government road between Lanjak and Benua Martinus dissects the area, and road-building is likely to increase in order to gain access to more timber. For example, the road from Ukit-Ukit down the east bank of the Leboyan river is planned to extend eventually to the Kapuas river, opening up the extensive lowland forests there for logging. These roads by themselves and as they exist now should not be a major obstruction to migrating species, as long as forests near the road is adequately protected.

The other main constraint to the survival of DSNP's wildlife is the presently inadequate level of Park management by the conservation authorities and cooperation with communities within and peripheral to DSNP. Wildlife poaching in and around DSNP is common and affects rare and globally threatened species such as orangutans. Forest areas, both inside and around the National Park, are declining in area, mainly because of legal and illegal logging activities, burning, and inappropriate land-use allocation. The latter is exemplified by licensing the development of oil palm plantations in areas still covered in primary or secondary forest, in actual contravention of Indonesian law.<sup>8</sup>

#### Danau Sentarum's Future

Following Rijksen and Meijaard (1999), there are proximate and ultimate causes of the poorly functioning conservation system in Indonesia. It is clear that successful conservation of DSNP's biodiversity will require a comprehensive management approach addressing all these impediments (cf. Wells *et al.* 1999:87-90).

- Proximate impediments
  - Poaching: **Required solutions**—Education and awareness, law enforcement, culturally appropriate livestock programs
  - Habitat destruction: **Required solutions**—Expand protected area network, improve protected management, support replanting, anti-fire campaigns
- Ultimate impediments
  - Misconceptions, local and national: **Required solutions**—Education and awareness campaigns, guide appropriate integration of conservation and development, deploy applied research and monitoring for feedback
  - Institutional deficiencies: **Required solutions**—Reorganization and technical training (e.g. train local people as conservation managers), reallocation and technical training, NGO involvement and control, international support, improve legal framework (e.g. provide legal and/or financial incentives for local communities to preserve and replant their own forests), support and encourage local *adat* and its development of new rules to meet the current needs
  - Ecological impediments: **Required solutions**—Integrate planning, expand protected area network and protected areas
  - Financial impediments: **Required solutions**—Special tax to support conservation, international support, NGO support

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<sup>8</sup>Ministerial Decree No. 376/Kpts-II/1998 stipulates that concessions should be on land that was open rather than vegetated, not owned by anyone, and officially classified as suitable for agriculture (see Potter and Lee 1998:13-14; Casson 1999).

Local solutions to the problems being faced in DSNP could include:

- Collaboration with and support of local communities and conservation authorities to improve conservation management. (Local communities must be compensated in some manner for inclusion of their land in a protected area, and given the new era of local empowerment, they will surely demand it.)
- Creating local support for conservation (through NGO involvement, and integrated conservation and development [see above; Wickham 1997; Wells *et al.* 1999]).
- Development of ecotourism. Prospects for income generation through ecotourism are promising, especially if considering how close the Sarawak capital, Kuching, is from DSNP. Once the official border crossing is opened from Lubok Antu to Nanga Badau, cooperative tours might develop with Malaysian tour companies. The road has already made it easier for illegal loggers to extract timber from the area, and it might be used to bring foreign tourists and their money back into the area. However, ecotourism may have negative repercussions, including pollution, poaching, land clearance for facilities, benefits accruing to foreign tour operators, cultural insensitivity, and prostitution. It would therefore require strict management.

The crux of long-term survival of DSNP, and its current value to conservation, depends on the willingness and ability to allocate sufficient funds for this purpose. Mobilization of local and national funds is unlikely, as national resources are dwindling and local incomes remain well below the national average. The regional economic importance of DSNP is mainly derived from extraction of fish and forest produce, and it is unlikely that non-extractive forms of land use such as ecotourism will expand and gain significance in the near future. Modest gains that have been achieved in sustainable management of the area during the past decade have been due to external assistance, and this dependence is likely to continue for the foreseeable future.

To date, most assistance has been provided by bilateral donors (esp. DfID), but other alternatives may be more appropriate for the long-term inputs envisaged, which are beyond the horizon of most bilateral donor agencies. Because of the Park's great value to conservation, Global Environmental Facility (GEF) support could be obtained if a local agency is willing and able to develop a substantial proposal for a "Block B" grant. Wetlands International made an attempt in this direction, but focused narrowly on fish and fisheries conservation. GEF emerged out of the 1992 Rio Conference and provides funding to developing countries for projects that yield local as well as global environmental benefits. GEF projects address problems in the areas of biodiversity, climate change, international waters, ozone depletion, and land-degradation. The Facility does not usually carry out projects itself, but operates through World Bank, UNDP, or UNEP. Conservation efforts at DSNP would easily qualify for funding via the biodiversity focal area (see King and Giesen 1997).

DSNP is Indonesia's second Ramsar site (i.e. a wetland of international importance), and Indonesia (by means of PKA) might approach the Ramsar Bureau in Gland, Switzerland, with a request to have DSNP placed on the Montreux Record. The Montreux Record is a register of wetland sites on the "List of Wetlands of International Importance" where changes in ecological character have occurred, are occurring, or are likely to occur as a result of technological developments, pollution, or other human

interference. Placing the Park on this list does not guarantee funding, but will draw extra international attention to the area. The "Management Guidance Procedure" may be invoked for sites on the Montreux Record, and in the past this has often been very successful, both in advising national and local authorities on technical solutions, and in drawing public attention to the issues involved in the wise management of important sites.

A third approach that may mobilize international funds is the establishment of a "Friends of Danau Sentarum" foundation, whereby private or corporate donors provide (modest) funds on an annual basis, to assist in the management of an area, and provide regular monitoring. This approach is certainly not unusual in Western countries, but remains novel in the Indonesian context.

Lastly, conservation management along similar lines as that in the Gunung Leuser Ecosystem in northern Sumatra may provide suitable options. The Leuser area (2.5 million ha) was designed based on ecological requirements such as water catchments, ranges of key conservation species, and the needs of local people. The program operates with a conservation-centered objective, and was designed to deploy a *quid pro quo* approach: It may provide support for locally-desired rural development in exchange for hard commitments to conservation by the local communities living around the Ecosystem. Implementation of the program started in 1996 with a budget covered by European Union support of some 32 million ECU, in addition to 18 million ECU in Indonesian contribution. The Leuser Ecosystem was given out as a conservation concession in the custody of the Leuser International Foundation (YLI). The Foundation is an NGO composed of influential Indonesian citizens having a strong affinity with northern Sumatra (Rijksen and Meijaard, 1999). The Leuser Programme has had setbacks and is, for instance, still constantly fighting illegal logging and poaching. However, in a recent review of 20 Integrated Conservation and Development Projects (ICDP) in Indonesia, the Leuser approach came out as one of the very few that showed promise (Wells *et al.*, 1999), while "most attempts to enhance biodiversity conservation in Indonesia through ICDPs are unconvincing and unlikely to be successful under current conditions." This suggests that the semi-privatized conservation approach followed in Leuser may provide a suitable tool for a similar program in DSNP.

Without a very large financial input, conservation will simply not work. Such funding will not be easily found in the short term, and an easy solution is to allow local communities to use the land in the way they choose. Yet, if the protected area is significantly enlarged, even if this is only a paper act, there is a future option for well-funded conservation. It might take decades to get the necessary money, but at least the land will be designated for conservation, and therefore cannot be claimed by plantations or other interests. Even if most forest will be logged in that time, they could still be replanted in cooperation with local communities.

There are no easy solutions to these problems, but the alternative is not reaching high enough. This would surely mean that extinction of species such as orangutan within the next five to ten years. (Considering the current state of other former Bornean strongholds of the orangutan such as Kutai and Tanjung Puting, it may mean losing the entire species from Borneo.) DSNP endemics would be lost altogether—over 30 plant species and perhaps more than a dozen fish species. Declining biodiversity in the area will surely also mean increased impoverishment of local people. Conservation must be taken very



seriously at all levels of society, and both immediate and long-term material sacrifice must be made locally, nationally, and internationally.

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## THE BORNEO RESEARCH COUNCIL POLICIES

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Fellows are scholars who are professionally engaged in research in Borneo or who use such research in their own studies.

The privileges of Fellows include (1) participation in the organization and activities of the Council; (2) the right to form committees of Fellows to deal with special research problems or interests; (3) support of the Council's program of furthering research in the social, biological, and medical sciences in Borneo; (4) subscription to the *Borneo Research Bulletin*.

The Fellows of the Council serve as a pool of knowledge and expertise on Borneo matters which may be drawn upon to deal with specific problems both in the field of research and in the practical application of scientific knowledge.

Fellowship in the Council is by invitation, and enquiries are welcomed in this regard.

Fellowship includes the privilege of a 10% discount on Monographs, Proceedings, and past issues of the *Borneo Research Bulletin*.

### Membership

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Research Notes differ from other contributions in that the material covered should be based on original research or the use of judgment, experience and personal knowledge on the part of the author in the preparation of the material so that an original conclusion is reached.
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All contributions should be sent to Prof. Clifford Sather, Dayak Studies, IEAS, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia <[csather@mailhost.unimas.my](mailto:csather@mailhost.unimas.my)>.