

Malaysian-German Sustainable Forest Management Project



Jabatan Perhutanan
(Forestry
Department)



Deutsche
Gesellschaft für
Technische
Zusammenarbeit

A GUIDE TO MANAGEMENT UNIT NO. 19/ SANDAKAN

Deramakot and Segaliud-Lokan Forest Reserve

1 GENERAL INFORMATION

1.1 Name, Location and Legal Status

The Forest District Sandakan is 500,665 ha in size and is comprised of the following:

Protection Forest Reserve, Class I	3,748 ha
Commercial Forest Reserve, Class II	112,323 ha
Amenity Forest Reserve, Class IV	59 ha
Mangrove Forest Reserve, Class V	69,095 ha
Virgin Jungle Reserve, Class VI	16,240 ha
Stateland	299,200 ha
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TOTAL	500,665 ha

This management plan is prepared for FMU No. 19, Sandakan, comprising two Commercial Forest Reserves namely, Deramakot Forest Reserve (DFR: 55,083 ha) and Segaliud-Lokan Forest Reserve (SLFR: 57,240 ha).

All other forest areas within the District would also require management plans. These can only be prepared, after a reconciled District Land-use Plan will regulate the future permanent land-use, especially of Stateland areas.

Both reserves are located at the Central East of the State. DFR is situated between Longitude 117°20' E and 117°42' E and between Latitude 5°19' N and 5°20' N. SLFR is situated between Longitude 117°23' E and 117°39' E and between Latitude 5°20' N and 5°27' N.

Final gazetification of both forest reserves took place in 1984 when DFR and SLFR were delineated covering an area of 55,083 ha and 57,240 ha, respectively.

1.2 Ecological Environment

1.2.1 Climate

TEMPERATURE

The temperature data are taken from the station Telupid, which is situated about 50 km North of Deramakot. The average annual temperature is 27°C, with an average maximum of 31°C and minimum of 23°C.

RAINFALL

The rainfall data available are from Lamag, Tangkulap, Uiu Dusun (21 years), Batu Bajau (21 years), Tulit, (32 years), Tangkulap (30 years), Lamag, Bukit Garam (48 years). The average annual rainfall is about 2,347mm, with a minimum in the months of March and April.

The monthly variation is shown in figure 1, the annual variation in figure 2.

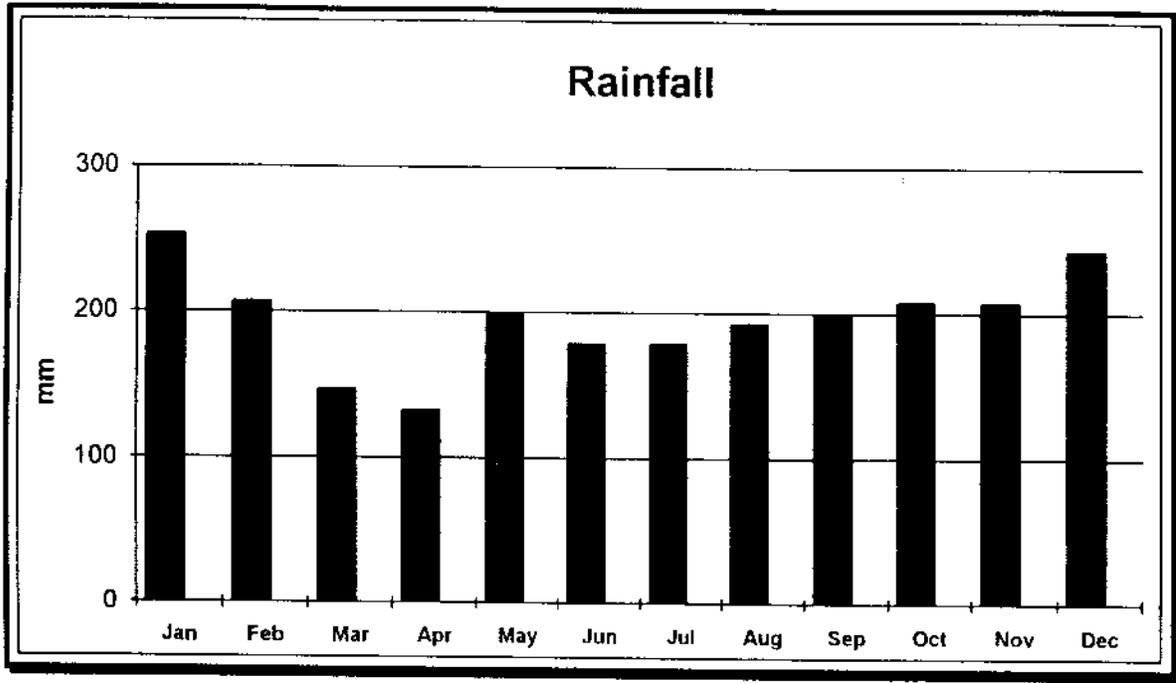


Figure 1 Monthly rainfall of the Station Telupid

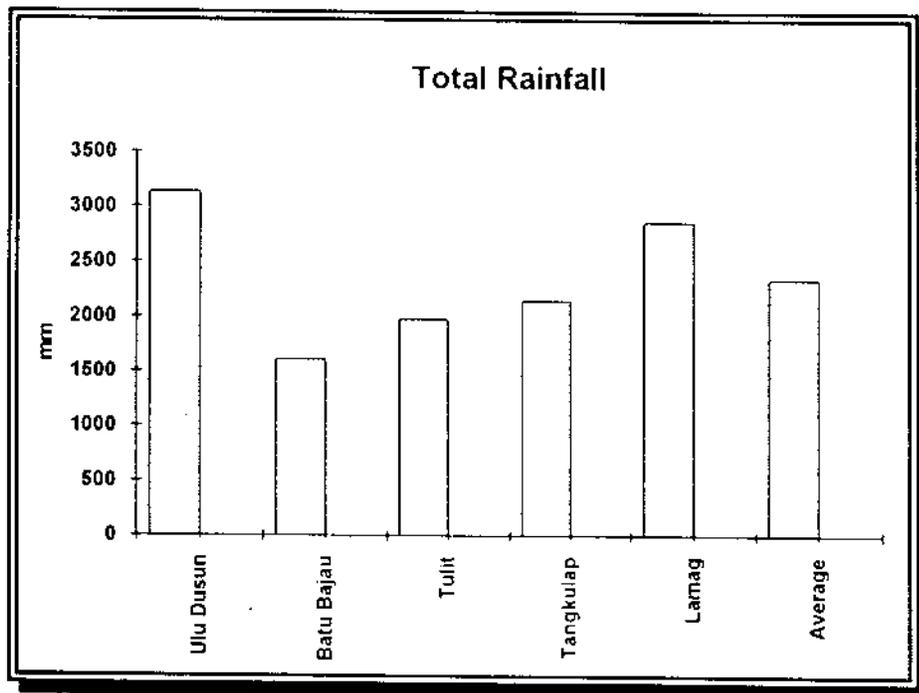


Figure 2 Rainfall data from stations near to FMU No.19

1.2.2 Geology

The geology of DFR and SLFR is dominated by tertiary sedimentary formations. The most prominent rock type is red and purple silt-(mud) and sandstone. Smaller patches of ultra basic rocks like serpentinite are also reported. The big valleys of the rivers Rawog and Lokan are made up of old alluvial deposits. Gravel and stone beds are found along the banks of both rivers to respectable depths. The soils derived from these rocks are rather infertile with limited stocks of plant-available nutrients.

1.2.3 Soils and Site Conditions

Deramakot Forest Reserve

In DFR Acrisols (91.1%) prevail while Leptosols and other soils types (6.9%) cover smaller areas.

Acrisols developed on old land surfaces and prolonged weathering lead to a general loss of nutrients. Moreover they are easily erodible. These two factors are the major serious limitations to any type of land management.

Leptosols found on steep slopes are shallow limiting root penetration. Generally these soils are dry due to their high rock content and timber management is not recommended as erosion may wash away the already thin soil layer.

The Soil families found (Kapilit, Paliu and Lithosols) are among the most impoverished in terms of plant-available nutrients described in the Soils of Sabah. Special care has to be taken when the protective forest cover is removed.

More than 99% of the soils have less than 5,000 kg/ha of exchangeable macro-nutrients and can be classified as poor to very poor.

85% of the area is affected by erosion. More than 71% show only slight erosion with no formations of rills or gullies. However, the past management lead to strong compaction on 13% of the area. Only 42% is not compacted.

Segaliud-Lokan Forest Reserve

The SLFR has similar soil types (91% Acrisols) and soil families.

More than 97% of the area is covered with soils containing less than 5,000 kg/ha plant-available macro-nutrients. Only 2.6% of the area has soils with more than 10,000 kg/ha.

Erosion has been described as affecting the entire area, out of which 19% is severe. Strong compaction occurs on 32% of the area and leaves only 34% uncompacted.

1.2.4 Topography and Hydrology

Deramakot Forest Reserve

The forests of Deramakot occupy parts of the basin formed by five rivers; Sungai Rawog Besar to the north, Sungai Tabalin Besar to the East, Sungai Tangkulap Kecil to the west and Sungai Balakung and Sungai Deramakot to the south. All five rivers drain south into the Kinabatangan River and form part of the upper Kinabatangan Drainage System. The land forms found in the reserve are mainly slopes (77% of the area) and ridges (5%) of varying steepness. Only 24% of the land is flat (<5°).

Segaliud-Lokan Forest Reserve

These forests occupy part of the basin formed by three rivers; Sungai Lokan to the north and Sungai Rawog Besar and Sungai Tabalin Besar to the south. Sungai Rawog flows east and into the Sungai Lokan which in turn flows south to meet the Kinabatangan River. Like in Deramakot, all the three rivers form part of the upper Kinabatangan Drainage System. The land forms found are mainly slopes (88% of the area) and ridges (5%) of varying steepness. Only 9% of the land is flat (<5°).

1.2.5 Vegetation Types

The lowland dipterocarp forest of both DFR and SLFR belong to the *Parashorea tomentella/Eusideroxylon zwageri* Forest Type. This forest type covers much of the Sandakan area; from the Segama River northwards through Paitan, Sugut and into the center of Sabah along major rivers. Generally, this forest type is dominated by *Parashorea* (20%) and its principal *associate* species are *Shorea leptoclados*, *Dryobalanops lanceolata* and *Dipterocarpus caudiferus*. Together, these four dipterocarps account for about 40 percent of the large trees.

1.2.6 Faunal Diversity

Although abundance of wildlife species are expected to be low in tropical rain forests, the diversity of species is enormous. Habitat alteration in any form reduces this diversity, while some species adapt to the changes and thrive.

There have been few previous faunal studies either in the DFR or SLFR, but more recently there have been a number of studies in the adjoining forests in the lower Kinabatangan. Based on these and the recent large mammal survey in DFR and SLFR, the faunal diversity in the Management Unit can be extrapolated. While density of more robust species are expected to be relatively high, a fair loss in endemic species and diversity in general, is a certainty due to previous forestry activities. FMU No. 19 is expected to have at least 75 species of mammals (excluding bats), 220 species of birds and over 100 species of reptiles, amphibians and fish.

Among mammals, primate diversity is relatively rich. Orang utans (*Pongo pygmaeus*) occur throughout the area, while gibbons (*Hylobates muelleri*) are heard calling quite frequently. Two sympatric colobines (proboscis monkey and the maroon langur) have been recorded in Sungai Lokan. Long-tailed and pig-tailed macaques are seen often. SLFR was once thought to have a viable population of Sumatran rhinoceros (*Dicerorhinus sumatrensis*) and were reported to be present here at least until the late 1980's, but there have been no records since then. The Asian elephant (*Elephas maximus*) occurs in the entire area and its range extends to the adjoining reserves. Tembadau (*Bos javanicus*) occur in the flat areas where grass is more prolific, together with large populations of sambar deer (*Cervus unicolor*) and bearded pig (*Sus barbatus*), which are the two most common wildlife species. The most common large carnivore is the Malay sun bear (*Helarctos malayanus*) whose signs are often encountered. Clouded leopard is very rare but do occur in DFR. Small carnivore diversity includes the leopard cat, marbled cat, Malay badger, yellow-throated marten, banded linsang, several species of civet, small-clawed and smooth otters.

Six of the eight species of hornbill found in Sabah are expected to occur in the Management Unit. Large flocks of rhinoceros hornbill (*Anthracoceros coronatus*) have been sighted in fruiting ficus trees and this species and the helmeted hornbill (*Rhinoplax vigil*) are frequently seen flying overhead, while the white-crested hornbill (*Berenicornis comatus*) has been sighted in the middle-storey. The monitor lizard (*Varanus* sp.) is a common sight on logging roads, while occasionally snakes are encountered. The region by the main Kinabatangan river is also expected to be part of the last undisturbed breeding grounds for the esturine crocodile (*Crocodylus porosus*).

1.3 Forest Area Classification

1.3.1 Forest Functions

The two forest reserve areas are sub-divided according to forest functions as shown in table 1.

Table 1 Area distribution of forest functions

Forest Reserve	Total Area (ha)	FUNCTION			
		Protection (ha)	Production (ha)	Community Forestry (ha)	Recreation (ha)
Deramakot	55,083	3,605	51,478	-	-
Segaliud-Lokan	57,240	10,576	46,664	-	-
Total (ha)	112,323	14,181	98,142	-	-
%	100	12.6	87.4	-	-

Legend:

Protection:

- slopes > 25° (e.g. protection of water resources)
- slopes < 25° (e.g. wildlife)

Production:

- slopes < 25°

Community forestry:

- areas adjacent to human settlements
- suitable for community based land-use

Recreation:

- areas suitable for all sorts of recreation

The areas are delineated on a topographic map on compartment basis (figure 3 and 4).

1.3.2 Net Production Area

All areas, irrespective of their functions, are subject to medium-term forest management planning. Forest inventory is carried out within the areas classified as production forest. Not all areas within the production forests are productive. In order to arrive at the net production area, roads and riparian reserves are deducted from the gross production areas as shown in table 2.

Table 2 Net production area

Type of Area	Deramakot Forest Reserve (ha)	Segaliud Lokan Forest Reserve (ha)	Total (ha)
Gross production	51,478	46,664	98,142
Permanent infrastructure	- 334	- 786	- 1,120
Riparian reserves (including water course)	- 1,770	- 3,464	- 5,234
Net production area	49,374	42,414	91,788

Legend:

Riparian reserves:

- area along permanent rivers 30m wide on both sides and at least 3m water course

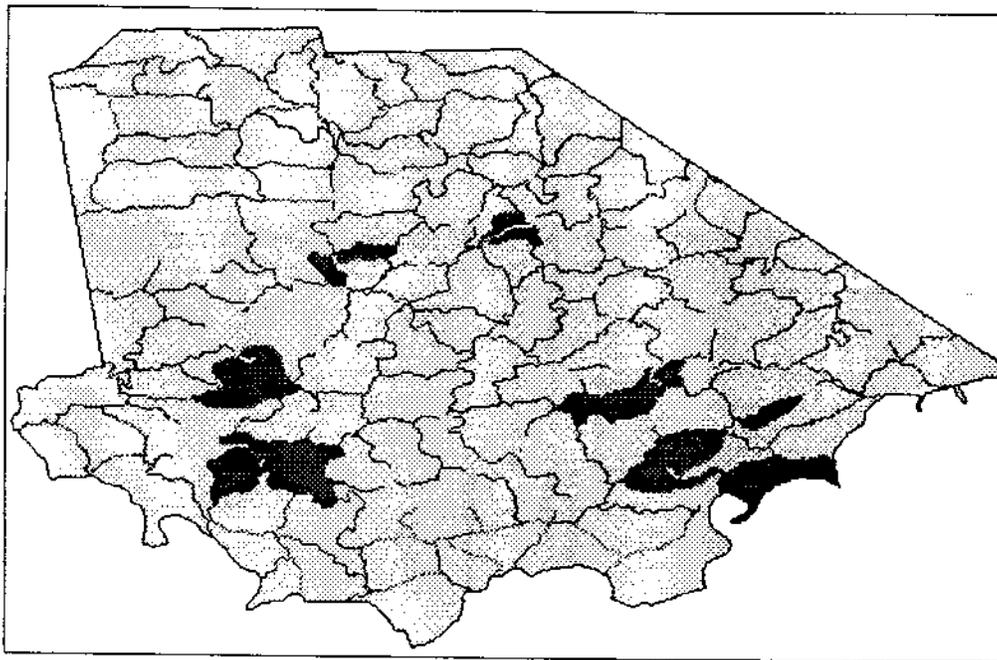


Figure 3 Forest functions in DFR

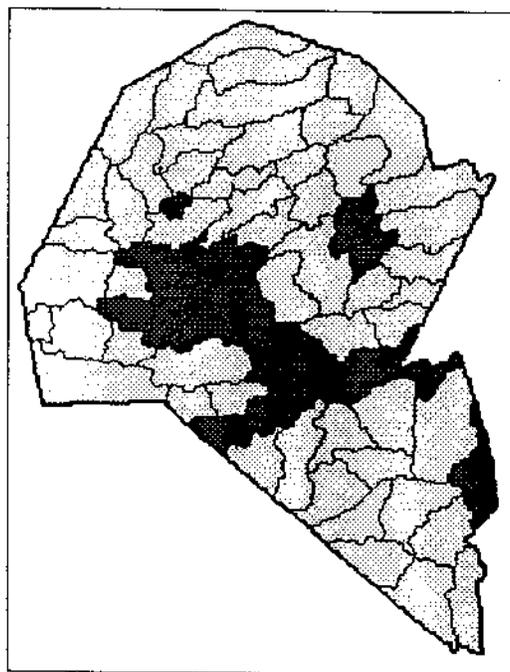


Figure 4 Forest functions in SLFR

Legend:

	Protection
	Production
	Recreation
	Community Forestry

1.4 Infrastructure

1.4.1 Roads and Buildings

Deramakot Forest Reserve

Buildings

A base-camp for "Management Unit 19, Sandakan" is located at the southern border of compartment 51 (DFR). It consists of eight junior staff quarters and two senior staff houses, a DFO office and a rest house.

The base-camp is equipped with:

- generator houses with two 40 kwh and one 60 kwh generators
- freshwater tank (22,300 litres)
- pump house with 15 HP electrical pump
- 4,000 gal diesel tank
- store room

An additional junior staff house is located in Compt. 16, DFR.

Forest Roads

The road inventory results are as follows:

Road Classification	Length (km)	Road density (m/ha)
Secondary Roads	35.1	0.6
Feeder Roads	49.8	0.9
Total	84.9	1.5

Out of the 50 km feeder roads only 31 km are at present trafficable. In general, the road network is in a bad shape, with severe gully erosion on steep slopes. Bridges and culverts are largely not operational.

Additional information on number of bridges, culverts, and general conditions of individual roads are listed in the Forest Road Record Book.

Segaliud Lokan Forest Reserve

In general, the basic-road network in SLFR is in a better condition than in DFR due to recent logging operations. The majority of the basic as well as the operational road network have been constructed a few years ago only and are maintained fairly well. Alignment and construction standards are similar to those in DFR.

The road inventory results are as follows:

Road Classification	Length (km)	Road density (m/ha)
Secondary Roads	100.0	1.75
Feeder Roads	348.6	6.09
Total	448.6	7.84

1.4.2 Mechanization

Harvesting

Table 3 Present level of mechanization of harvesting operations in the Sandakan Region

Activity	Level of Mechanization	Description
Felling	semi-mechanized	<ul style="list-style-type: none"> • use of chain saw • safety equipment for operators insufficient
Bucking	semi-mechanized	<ul style="list-style-type: none"> • use of chain saw and wedges • safety equipment for operators insufficient
Debarking	manual	<ul style="list-style-type: none"> • use of debarking iron
Yarding by tractor	fully mechanized	<ul style="list-style-type: none"> • use of D7-tractors • no winching of trees towards skid trails • safety measures for operators insufficient
Yarding by LDCCS	fully mechanized	<ul style="list-style-type: none"> • use of Gantner USW80 • appropriate safety measures applied
Transport and log loading	fully mechanized	<ul style="list-style-type: none"> • use of trucks and log loaders

Road Construction

Road construction and maintenance is fully mechanized based on the SFD's own equipment as listed in table 4.

Table 4 Equipment presently used in construction and maintenance of roads

Type of Equipment	Quantity	Purpose
Tractor	1	Road Construction
Back-Hoe	1	Road Construction
Dump-Truck	3	Road Construction
Roller	1	Maintenance
Grader	1	Maintenance
Pick-ups + jeeps	5	Transportation of manpower

1.5 Manpower

The staff of the District Forest Office, Sandakan presently (Sept.93) comprises a total of 40 persons:

Permanent staff (26 posts):

- 2 Forest Officers (DFO and ADFO)
- 3 Forest Rangers
- 9 Foresters
- 1 Forest Clerk
- 2 Drivers
- 7 Boatmen
- 8 Boat driver

Temporary staff (14 posts):

- 1 Typist
- 13 Laborers (incl. messenger, etc.)

The organizational set-up of the District Forest Office is depicted in figure 5.

Since the District Forest Offices have not been reorganized according to the new Forest District boundaries, none of the staff is employed in DFR or SLFR. Furthermore, the present organization by range (mukim) is not suitable for function-oriented forest management.

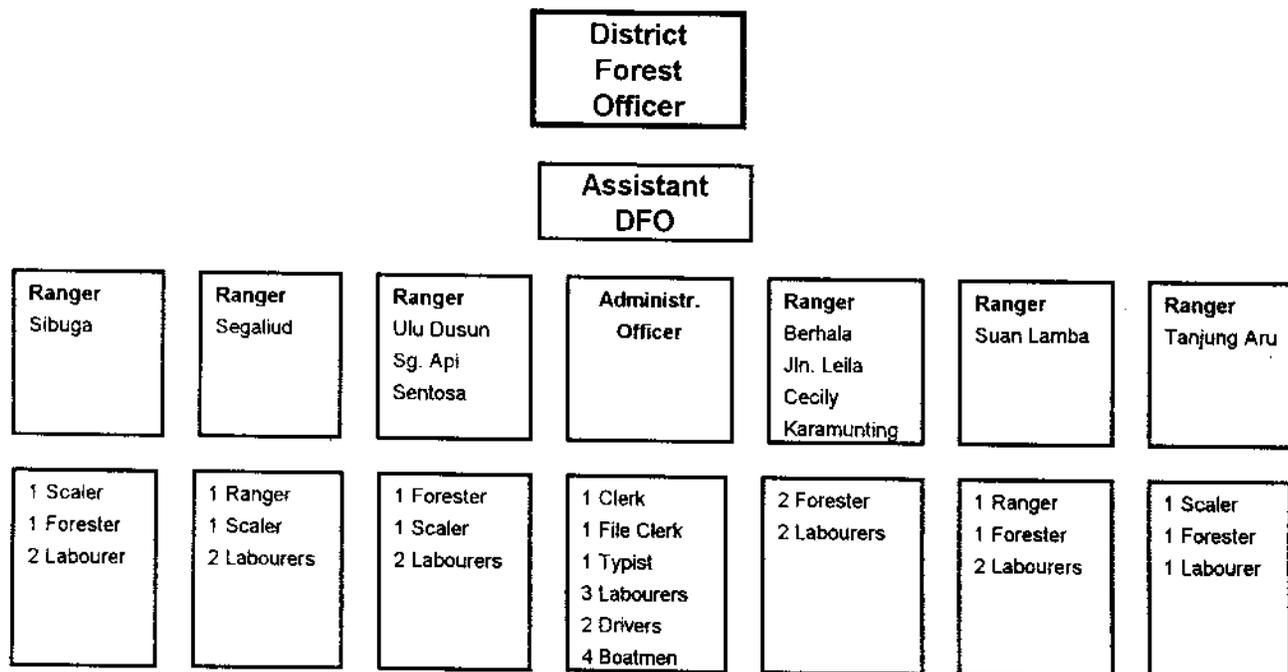


Figure 5 Organizational chart of the District Forest Office, Sandakan

1.6 Socio-Economic Environment

1.6.1 Population

There are no settlements within the boundaries of DFR and SLFR. Settlements are located on the southern fringes of the FMU on Stateland along the Kinabatangan and Milian River (table 5).

Table 5 Settlements and their population along the fringes of FMU No.19

Name of settlement	No of households 5-6 persons per household
Kg. Tamoi	184
Kg. Kuamut	565
Kg. Balat	300
Kg. Sungau	64
TOTAL	1113

Most of the people in these settlements belong to the ethnic groups of Orang Sungai and Dusun Sungai. In addition to the native settlements an unknown number of labour camps, mainly inhabited by Indonesian migrant workers, are situated within oil-palm plantations bordering the Forest Management Unit in the north and east.

No customary rights are established for the FRs. Native rights according to the Forest Enactment (Pt. V, S.4) are practiced by the villagers on Stateland. Any collection of forest produce under native rights within the Forest Reserves has to be authorized by the Forest District.

Of the four kampungs, only Kg. Balat is directly adjacent to the Forest Management Unit. Kampung Tangkulap is closer to Forest Management Unit No. 17 and 16, the major part of Kg. Kuamut is located on the southern side of the Kinabatangan River, while Kg. Sangau is completely surrounded by stateland. The following chapters refer to Kg. Balat only but apply with little variation to the other settlements as well.

1.6.2 Infrastructure and Social Services

Kg. Balat is presently only **accessible** by boat, since the logging road within DFR is not motorable. With the oil-palm plantation development in the surrounding area, Kg. Balat will eventually be connected to the nearest township Bukit Garam (64 km).

The village avails of an elementary school for about 70 students. Among the adult population educational attainment is low. Survey data (10% sampling) revealed that almost half of the population had no schooling.

Electricity is provided to the village by generator sets distributed by the government.

Water sources are neither piped nor treated, water-borne diseases are common during the rainy season. A proper road connection with Bukit Garam is made a pre-condition by the Department of Drainage and Water Works to supply the village with treated water.

Kg. Balat has no **rural clinic**. Once a week a rural health team from Kg. Kuamut provides some basic services.

The village has a **community hall** and **surau**.

1.6.3 Economic Activity

The people primarily depend on fishing and farming. Hunting and the collection of other forest produce is part of their subsistence activities, although some of the products are sometimes sold in the village. Major off-farm income is through employment as fisherman (sea fishing) and unskilled laborer in nearby timber camps and elsewhere. Some villages have work in nearby timber-camps. An undetermined number of persons harvest rattan for cash income and/or make a living from the illegal felling of trees in riparian reserves. One third consider themselves unemployed. Almost half of the villagers in Kg. Balat live below the poverty line (less than 580 M\$ per month and household).

Due to distance to the nearest market, most of the farm produce (tapioca and hill rice) is for own consumption. The area, however, is not self-sufficient in rice production.

Due to limited education and employment possibilities, a considerable number of the household members become migrant workers. According to the survey, about 40% of the people (mainly productive age group) in Kg. Balat have moved to Bukit Garam and Sandakan (albeit not yet permanently).

1.6.4 Impact on the Forest Management Unit

At present, the impact of the settlements along the fringes of Deramakot and Segaliud-Lokan Forest Reserves is low. Agricultural activities are limited to Stateland areas while the unregulated hunting as well as the collection of other forest produce are on small scale only and do not warrant immediate attention. However, measures to curb illegal felling have to be taken.

2 PAST MANAGEMENT

2.1 History

Segaliud-Lokan Forest Reserve

The Reserve was finally constituted as a Commercial Forest Reserve in 1961. It originally covered an area of 163,169 ha, which extended to Sungai Muanad to the north, the Sekong Bay to the northeast, and the boundary of the Supu Forest Reserve along the Sungai Kinabatangan to the east. It was one of the former forest areas under the logging monopoly of the British Borneo Timber Company Ltd. founded in 1920. In 1952 this monopoly was terminated and the Reserve became part of the company's 21-year logging concession area of 258,482 ha with an annual coupe of 12,173 ha. In 1961 the company agreed to the new terms of a Standard Concession Agreement which constituted a simple working plan based on area control. The company changed their name to Sabah Timber Company Ltd. (STC) in 1963.

The SFD started a pilot tree plantation in Lungmanis in 1968. The objective was to plant 405 ha of logged-over forest with a variety of species at different spacing and treatments.

In 1976 the working area of STC was confined to 39,013 ha. During that year 18,415 ha of the Reserve was given to Sabah Foundation whilst other areas totaling 31,023 ha to 6 Special Licenses. A major de reservation exercise for agricultural development in 1979 reduced the area to 63,360.58 ha, and to the present size of 57,240 ha in March, 1984. In 1979 and 1980 parts of the present area was issued to Sri Kedua Sdn. Bhd. and Syarikat Saliha Sdn.Bhd. respectively under Special License. STC ceased operation in 1982.

The Reserve was earmarked for tree plantation purposes in 1985. The restriction on the felling diameter limit of 60 cm dbh was lifted and multiple relogging of the area took place until 1993. In 1993 K.T.S. Sdn. Bhd., a Sarawak based company, was granted a 96-year occupation lease to establish tree plantations in the area.

Deramakot Forest Reserve

The Reserve was finally constituted as a Commercial Forest Reserve in 1961 covering an area of 52,060 ha. Slight alterations were made to the area in the seventies, and in March, 1984 the area was increased to 55,083 ha.

Logging commenced at Sungai Deramakot under annual license in 1956. The Reserve then became the Special License area of United Timbers in August, 1959. The company ceased operation in 1976, and during that year an area of 945 ha was given to Seranum Sdn. Bhd. In 1977 another area of 1,204 ha was given to Lai Fook Kim (Brothers).

By the end of 1979, the following Special Licenses were issued in the area:

Seranum Sdn. Bhd:	945 ha
Lai Fook Kim Bros. Sdn. Bhd:	1,215 ha
Elopura Maju Sdn. Bhd:	10,116 ha (including Tangkulap FR)
Laju Jaya Perusahaan Sdn. Bhd:	1,215 ha
Syarikat Mempoyan Sdn. Bhd:	3,423 ha

Elopura Maju was given the balance of virgin forests at the northeastern part of the Reserve, whilst Syarikat Mempoyan the relogging of the 1965 - 1972 coupes in Balat.

In 1987 a Special License was issued to Abadi Mewah Sdn. whilst an annual license to Syarikat Jaimi Sdn. Bhd. for relogging. An area of approx. 4,500 ha in the northern part of the Reserve was reported to had been relogged illegally by unknown persons in 1987-1988.

Since the fifties, there has been occasional illegal felling activities in the southern boundary along the Sungai Kinabatangan particularly during the flood season. In 1983 a sizable area in Balat was destroyed by bush fire during the *El Nino* drought.

2.2 Planning

Prior to 1976, the Concession Agreement or Special License served as a simple working plan based on area control. The area was divided into 100 working blocks whereby a block (1/100 of the license area) is worked as an annual coupe. Giving 20 % allowance to hilly terrain and unworkable areas, the hypothetical rotation period was 80 years. An annual coupe was processed and approved 1 year before logging. The silvicultural system used was the Modified Malayan Uniform System. In this system the felling diameter limit for all commercial tree species is 60 cm dbh (6 feet girth). Upon the completion of logging the coupe area was closed after a "closing inspection report" was prepared by the DFO. Normally this was followed by silvicultural treatment.

In 1976 logging by area control was abandoned, and previously logged areas were relogged. Also all poison girdling operations immediately after logging ceased in 1977.

In 1985, SLFR was earmarked for tree plantation and consequently the minimum girth and prohibited species restrictions were lifted. All existing licenses issued therein were amended accordingly. However, DFR remained closed to logging.

2.3 Production

Segaliud-Lokan Forest Reserve

Enumeration carried out in STC's 1954 coupe indicated a stocking of 180 m³/ha. As the reserve previously covered a wider area, only the production figures from Lungmanis are considered to be relevant to the present area. Though logging started earlier, the first recorded production from Lungmanis was in 1958 when 68,851 m³ was produced. Production increased to a peak of 1,104,247 m³ in 1973. The total production for the period 1958 to 1975, the last year record is available, was 7,035,072 m³. Based on available data of production related to area, the average production during the period 1959 to 1968 was 109 m³/ha.

Deramakot Forest Reserve

Timber production rose from 74,065 m³ in 1961 to a peak of 467,757 m³ in 1973. Total production for the period 1961 to 1975, the last year production records from annual reports are available, was 3,161,348 m³. Based on available production figures related to area, the average production from 1962 to 1968 was 110.6 m³/ha.

2.4 Silviculture

Under the modified Malayan Uniform System which was applied in DFR and SLFR, there are four different types of silvicultural treatments prescribed viz:

- **First Silvicultural Treatment:** climber-cutting and tree marking for retention before felling.
- **Second Silvicultural Treatment:** LSM (linear sampling milliacre survey), climber-cutting and poison girdling.
- **Third Silvicultural Treatment:** LS 1/4 (linear sampling quarter-chain survey) and poison girdling.
- **Fourth Silvicultural Treatment:** LS 1/2 (linear sampling half-chain survey) and poison girdling.

The first silvicultural treatment was carried out 2 years before felling, the second silvicultural treatment immediately after logging. The third and fourth silvicultural treatment was done 5 years and 10 years after logging, respectively.

The poison used in the girdling operation was Sodium Arsenite at a rate of 6.5 g to a gallon of water. The girdling operation consisted of poisoning of all commercial trees 6 feet girth (60 cm diameter) that were left unfelled and all climbers of 2 inch diameter and up. In dense islands of unlogged forests, all commercial trees over 6 inches diameter were also killed. The areas silviculturally treated in these two reserves are shown in table 6:

Table 6 Silviculturally treated areas in DFR and SLFR

FOREST RESERVE	2ND SILVICULTURE TREATMENT (ha)	3RD SILVICULTURE TREATMENT (ha)	4TH SILVICULTURE TREATMENT (ha)
DERAMAKOT	31,557	8,604	8,217
SEGALIUD LOKAN	14,288	-	-

All poison girdling operations immediately after logging ceased in 1977. In the same year, based on LS 1/2 results, liberation treatment to remove weed species and climbers using

butyl ester (2,4,5-T) with diesoline started at Balat and Lungmanis. Silvicultural treatments of natural forest were discontinued in 1986.

2.5 Infrastructure

Segaliud-Lokan Forest Reserve

Prior to 1960 the living quarters for SFD staff in Lungmanis were provided by the company. SFD only started to build labor lines in 1960 and staff quarters in 1963. In 1966 nine detached prefabricated duplex quarters for laborers were constructed.

In the fifties to the mid-sixties the method used for transporting logs to Sandakan was by tractor to 2-foot gauge railways, and thence by a 3-foot gauge main railway to a rafting point at Sungai Segaliud. A serious problem of locating sources of suitable stone for rail track building was reported in 1957. In 1964 the first roads were constructed. In 1965 the first 12.8 km of road was constructed linking the company's railway at Kilometer 15 (Mile 10) to the government road to Telupid at Kilometer 72 (Mile 45), and this greatly improved communication. By 1968 roads became the chief means of log transport to their rafting point at Kolapis. The use of the railway was abandoned in 1972.

In the late sixties Lungmanis was one of the largest and better organized logging camps in Sabah. The camp had a 10-pin bowling alley, the first in Sabah, a cinema hall and other recreational facilities.

Deramakot Forest Reserve

A forest checking station and a boatman quarter were built by SFD at Karis-Karis in 1963 and at Balat in 1965. The station also served as living quarters for the Forest Ranger in-charge.

In the fifties a 2-foot gauge railway was used. Road was introduced in 1965. By 1966, the following logging camps were in operation in the area:

- a. Balat - the largest of the camps, owned by Teck Heng Loong Veneers Ltd., made use of graveled roads, log loaders at landings, heavy logging trucks and a huge A-frame made out of selangan batu logs for unloading logs to the river.
- b. Karis Karis - owned by the Lai Brothers Ltd. which made use of logging trucks fitted with a crane (san taiwong). Their area was generally on steep terrain and road gravel was scarce. This seriously hampered logging during the wet season and also caused indirectly the higher road density in that area.
- c. Arawon - owned by Chin Piang Syn Ltd. which made use of locomotives and trolleys on 2-foot gauge rails.

Previously the only access to the Reserve was by the Sungai Kinabatangan, until 1972 when logging roads linked Karis-Karis and Balat to Sandakan via the Segaliud-Lokan Forest Reserve.

2.6 Mechanization

In the fifties logging in Lungmanis and Deramakot was by kuda-kuda i.e. using sledge hauled by manpower. For longer hauls, this was supplemented by a 2-foot gauge railway with trolleys. Axes and hand saws were the implements used for felling, but these were soon replaced by chain saws in 1961. In 1959 tractor yarding was introduced. In the mid-sixties, as logging reached the hilly areas, the method of log extraction was mainly tractor yarding either to roadside where the logs were transported by trucks or to railside using trolleys. The trend towards the use of heavier tractors and trucks continued. Before 1976 log transport to Sandakan was generally by rafting down the Sungai Kinabatangan via a narrow channel in the mangrove forests of Trusan Duyung. Sinker logs were transported by barges, but some were rafted by tying each log between 2 floaters.

2.7 Organization and Manpower

Previously, SLFR and DFR were under the jurisdiction of District Forest Officer, Sandakan South and District Forest Officer, Lamag respectively. In 1991 the northern part of SLFR was placed under District Forest Officer, Telupid whilst the southern part under District Forest Officer, Kota Kinabatangan. In the case of DFR it was still under District Forest Officer, Lamag (re-named Kota Kinabatangan in 1991) but later placed under the charge of District Forest Officer, Sandakan in 1993.

Due to the shortage of staff and manpower, and the lack of basic infrastructure, the supervision of both reserves was ran by a minimum number of personnel. In Segaliud-Lokan where logging activities were more active a Senior Forest Ranger aided by a Forest Ranger and 2 Foresters were stationed in Lungmanis, the main ranger station. 2 additional Foresters were fully engaged in supervising 20 laborers in poison girdling operations. In Deramakot, there were only 2 Forest Rangers and 4 Foresters stationed in Karis Karis and Balat, and 2 of the Foresters were fully engaged in supervising poison girdling operations.

2.8 Implications for Future Management

In view of the prevailing condition of the exploited forests in both reserves, the forest stands have to be rehabilitated. Access and infrastructure have to be improved to facilitate forest management planning and the implementation of the plans. A sufficient number of personnel and workers have to be trained to undertake planning, inventory, silviculture treatment, forest protection, and to supervise harvesting and log sales. This would mean that adequate manpower and budget is an indispensable pre-requisite for these purposes. In order to achieve sustainable management, the Forest Reserve areas which form the FMU must by all means be secured and protected.

3 FOREST RESOURCE BASE

3.1 Growing Stock

All information required for the description of the forest resources are obtained from the medium-term forest management planning inventory (560 sampling plots) covering the entire gross production area of the Forest Management Unit.

3.1.1 Deramakot Forest Reserve

Volume

The total growing stock (gross volume in m³/ha) is shown in table 7. The growing stock is compiled separately for dipterocarps (10 species groups), commercial non-dipterocarps (hardwoods including pioneers) and non-commercial species.

Table 7 Growing stock of DFR

SPECIES GROUP	TREES <60 cm/DBH				TREES >60 cm dbh	TREES >20 cm dbh
	20-39 cm	40-49 cm	50-59 cm	20-59 cm		
	m ³ /ha	m ³ /ha				
DIPTEROCARPS						
Red Seraya	9.6	4.3	4.4	18.3	20.6	38.9
White Seraya	2.3	1.1	1.8	5.2	9.3	14.5
Melapi	0.3	0.1	0.1	0.5	0.5	1.0
Yellow Seraya	1.5	0.5	0.7	2.7	3.8	6.5
Kapur	1.1	0.8	1.6	3.5	8.1	11.6
Keruing	2.0	1.7	2.7	6.4	10.0	16.4
Selangan	0.5	0.4	0.4	1.3	0.8	2.1
Selangan Batu	1.1	0.6	0.9	2.6	6.0	8.6
Resak	0.6	0.2	0.2	1.0	0.00	1.0
Pengiran	0.00	0.00	0.00	0.00	0.3	0.3
SUB-TOTAL	19.0	9.7	12.8	41.5	59.4	100.9
NON-DIPTEROCARPS						
Hardwoods	2.9	4.3	5.2	22.4	20.4	42.8
Pioneers	4.2	2.2	1.8	8.2	1.6	9.8
SUB-TOTAL	17.1	6.5	7.0	30.6	22.0	52.6
NON-COMMERCIAL TIMBERS						
	31.0	7.0	3.5	41.5	4.0	45.5
GRAND TOTAL	67.1	23.2	23.3	113.6	85.4	199.0

Legend:

Dipterocarps: 10 groups according to their market names

Non-Dipterocarps: marketable non-dipterocarp

–hardwoods: light to heavy timbers

–pioneers: very light timbers (e.g. Laran, Binuang, etc.)

Non-Commercial Timbers: presently non-marketable timbers

Gross volume refers to the bole volume inside bark. The bole is defined as the length of the stem between the point at stump height (60cm above ground) for non-buttressed trees or at top of buttress and 30cm top end diameter for all trees > 40cm dbh. For trees < 40cm dbh the top end diameter is 10cm.

The total volume (Commercial and Non-commercial species of trees above 20cm dbh) in the production forests of DFR is estimated at 200 m³/ha with an accuracy of ± 5.3 % at the 95% probability level. The average stocking of dipterocarp trees >60cm dbh amounts to about 60m³/ha. Approximately 1/3 of the volume belongs to the Red Seraya group followed by Keruing (10m³/ha), White Seraya (9m³/ha) and Kapur (8m³/ha). Additionally about 22m³/ha are available from commercial non-dipterocarp species.

A comparison of the volume for trees above 60cm dbh to those below 60cm dbh shows considerably different proportions of dipterocarps, non-dipterocarps and non-commercial timbers. Trees above 60cm dbh are clearly dominated by the dipterocarps. Higher percentages of non-dipterocarps and non-commercial timbers in the lower diameter classes (20 - 60m) suggest that in future the stands might not reach the stand structure dominated by dipterocarps as in the past.

Timber Quality

Visual inspection of individual logs (6 meter log length) for standing trees of >40cm dbh included assessment of the straightness of the bole and visible defects. Table 8 shows the total commercial volume for the main timber groups and size classes for the four timber qualities.

Table 8 Timber quality by size classes and timber groups

SIZE (dbh)	TIMBER GROUPS	PRIME LOG %	SAW LOG %	OTHER UTILIZATION %	NO UTILIZATION %
TREES >60cm	DIPTEROCARPS	69.9	13.8	12.0	4.3
	NON-DIPT. HARDWOODS	60.5	16.7	16.0	6.8
	PIONEERS	52.2	16.4	17.6	13.8
	TOTAL	67.2	14.6	13.7	5.1
TREES 40cm - 59cm	DIPTEROCARPS	66.6	14.9	14.7	3.8
	NON-DIPT. HARDWOODS	60.3	17.2	16.4	6.1
	PIONEERS	65.0	20.5	13.0	1.5
	TOTAL	64.6	16.2	15.0	4.2

More than 60% of the commercial volume is "Prime Log" quality while about 18% is "Saw Log" and 16% "Other Utilization" quality.

Number of Trees

The number of trees and the corresponding basal areas per hectare are shown in table 9 for all diameter classes and species groups.

Table 9 Number of trees and basal area of DFR

SPECIES GROUP	TREES <60 cm dbh									TREES >60 cm dbh		TREES >10 cm dbh	
	SAPLINGS	10 - 19 cm		20 - 39 cm		40 - 59 cm		10 - 59 cm		n/ha	m ² /ha	n/ha	m ² /ha
	n/ha	n/ha	m ² /ha	n/ha	m ² /ha	n/ha	m ² /ha	n/ha	m ² /ha				
DIPTEROCARPS													
Red Seraya	168.8	25.7	0.4	12.4	0.8	3.2	0.6	41.3	1.8	2.8	1.3	44.1	3.1
White Seraya	153.5	9.8	0.2	3.5	0.2	1.0	0.2	14.3	0.6	1.0	0.5	15.3	1.1
Melapi	8.2	2.0	0.0	0.5	0.0	0.1	0.0	2.6	0.0	0.0	0.0	2.6	0.0
Yellow Seraya	47.4	5.7	0.1	2.7	0.2	0.5	0.1	8.9	0.4	0.4	0.3	9.3	0.7
Kapur	102.0	6.3	0.1	1.8	0.1	0.8	0.2	8.9	0.4	0.8	0.5	9.7	0.9
Keruing	112.7	5.7	0.1	2.5	0.2	1.1	0.2	9.3	0.5	1.0	0.5	10.3	1.0
Selangan	75.1	2.2	0.0	0.6	0.0	0.3	0.1	3.1	0.1	0.1	0.0	3.2	0.1
Selangan Batu	40.0	1.8	0.0	1.4	0.1	0.6	0.1	3.8	0.2	0.6	0.3	4.4	0.5
Resak	79.2	2.9	0.0	1.3	0.1	0.1	0.0	4.3	0.1	0.0	0.0	4.3	0.1
Pengiran	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB-TOTAL	787.7	62.1	0.9	26.7	1.7	7.7	1.5	96.5	4.1	6.7	3.4	103.2	7.5
NON-DIPTEROCARPS													
Hardwoods	1,391.0	86.7	1.3	24.6	1.5	4.2	0.8	115.5	3.6	2.7	1.3	118.2	4.9
Pioneers	92.2	12.2	0.2	6.8	0.5	1.8	0.3	20.8	1.0	0.3	0.1	21.1	1.1
SUB-TOTAL	1,483.2	98.9	1.5	31.4	2.0	6.0	1.1	136.3	4.6	3.0	1.4	139.3	6.0
NON-COMMERCIAL TIMBERS													
	2,243.3	136.3	2.1	56.7	3.6	6.0	1.0	199.0	6.7	0.7	0.3	199.7	7.0
GRAND TOTAL	4,514.0	297.3	4.5	114.8	7.3	19.7	3.6	431.8	15.4	10.4	5.1	442.2	20.5

Legend.

Dipterocarps: 10 groups according to their market names

Non-Dipterocarps: marketable non-dipterocarp

-hardwoods: light to heavy timbers

-pioneers: very light timbers (e.g. Laran, Binuang, etc.)

Non-Commercial Timbers: presently non-marketable timbers

There are approx. 7 trees/ha of dipterocarps and 3 trees/ha of commercial non-dipterocarps above 60cm dbh and 1 tree/ha of non-commercial species. The size classes below 40cm dbh are dominated by the commercial non-dipterocarps and non-commercial trees.

Volume Classes

Stratification of the inventory plots according to gross volume for trees of >60cm dbh allows for the calculation of the area covered by individual volume classes (table 10).

Table 10 Volume classes by area in DFR

Volume Class	Volume (m ³ /ha)	Area (%)
1	> 150	18
2	101 - 150	13
3	51 - 100	23
4	26 - 50	15
5	< 25	31

These volume classes represent the range of growing stock conditions found in the area. They form the basis for more detailed evaluation of the silvicultural status of the forest using the diameter distribution of commercial trees within each volume class as shown in table 11.

Table 11 Diameter distribution by volume classes in DFR

VOLUME Classes	NUMBER OF TREES PER HECTARE				
	10 - 19 cm	20 - 39 cm	40 - 59 cm	> 60 cm	TOTAL > 10 cm
1	238	71	18	23	350
2	177	57	16	15	265
3	145	61	13	10	229
4	174	57	13	7	251
5	115	48	11	2	182

About 18% of the area (volume class 1) is very well stocked with commercial timber species in all diameter classes (more than 20 trees/ha of >60cm dbh). The largest part of the area has a lower growing stock (volume classes 2 to 4) ranging from 7 to 15 trees >60cm dbh. All the other tree sizes within these volume classes show similar figures per ha. Very low stocking occurs on 30% of the area with almost no big trees left and poor condition of immature trees.

3.1.2 Segaliud-Lokan Forest Reserve

Volume

The total growing stock (gross volume m³/ha.) is shown in Table 12.

The total volume (commercial and non-commercial species of trees above 20cm dbh) in the production forests is estimated at 75 m³/ha compared to 199 m³/ha in DFR. The average stocking of commercial trees >60cm dbh amounts to only about 15 m³/ha (DFR: 60 m³/ha).

Table 12 Growing stock of SLFR

SPECIES GROUP	TREES <60 cm/DBH				TREES >60 cm dbh	TREES >20 cm dbh
	20-39 cm	40-49 cm	50-59 cm	20-59 cm		
	m ³ /ha	m ³ /ha				
DIPTEROCARPS						
Red Seraya	4.5	1.3	1.7	7.5	4.3	11.8
White Seraya	1.4	0.9	1.4	3.7	0.4	4.1
Melapi	0.4	0.0	0.1	0.5	0.0	0.5
Yellow Seraya	1.3	0.2	0.5	2.0	1.4	3.4
Kapur	0.6	0.4	0.3	1.3	0.4	1.7
Keruing	1.0	1.3	1.2	3.5	0.0	3.5
Selangan	0.4	0.1	0.2	0.7	0.0	0.7
Selangan Batu	0.0	0.0	0.3	0.3	1.2	1.5
Resak	0.4	0.0	0.2	0.6	0.0	0.6
Pengiran	0.0	0.0	0.0	0.0	0.0	0.0
SUB-TOTAL	9.9	4.2	5.7	19.8	7.7	27.5
NON-DIPTEROCARPS						
Hardwoods	9.9	3.1	3.0	16.0	6.3	22.3
Pioneers	2.1	0.8	0.2	3.1	0.5	3.6
SUB-TOTAL	12.0	3.9	3.2	19.1	6.8	25.9
NON-COMMERCIAL TIMBERS						
	14.4	2.2	2.3	18.9	2.3	21.2
GRAND TOTAL	36.3	10.3	11.2	57.8	16.8	74.6

Legend:

Dipterocarps: 10 groups according to their market names

Non-Dipterocarps: marketable non-dipterocarp

-hardwoods: light to heavy timbers

-pioneers: very light timbers (e.g. Laran, Binuang, etc.)

Non-Commercial Timbers: presently non-marketable timbers

Timber Quality

Table 13 shows the total commercial volume for the main timber groups and size classes for the four timber qualities.

Table 13 Timber quality by size classes and timber groups in SLFR

SIZE (dbh)	TIMBER GROUPS	PRIME LOG %	SAW LOG %	OTHER UTILIZATION %	NO UTILIZATION %
TREES >60cm	DIPTEROCARPS	52.6	14.6	25.8	7.0
	NON-DIPT. HARDWOODS	19.8	26.3	39.0	14.9
	PIONEERS	76.5	5.9	17.6	0.0
	TOTAL	62.5	20.2	32.0	10.5
TREES 40cm - 59cm	DIPTEROCARPS	42.5	21.4	28.8	7.3
	NON-DIPT. HARDWOODS	31.8	17.1	38.7	12.4
	PIONEERS	38.3	29.1	23.6	9.0
	TOTAL	38.3	20.3	32.1	9.3

About 45% of the commercial volume is "Prime Log" quality, 20% "Saw Log" and about 30% "Other Utilization". The quality of the residual trees in SLFR is not as good as those in DFR because SLFR was logged without any silvicultural restrictions.

Number of Trees

The number of trees and the corresponding basal areas per hectare are shown in table 14 for all diameter classes and species groups.

Table 14 Number of trees and basal area of SLFR

SPECIES GROUP	TREES <60 cm dbh								TREES >60 cm dbh		TREES >10 cm dbh		
	SAPLINGS	10 - 19 cm		20 - 39 cm		40 - 59 cm		10-59 cm		n/ha	m ² /ha	n/ha	m ² /ha
	n/ha	n/ha	m ² /ha	n/ha	m ² /ha	n/ha	m ² /ha	n/ha	m ² /ha				
DIPTEROCARPS													
Red Seraya	102.6	12.8	0.2	5.8	0.4	1.0	0.2	19.6	0.8	0.6	0.3	122.8	1.1
White Seraya	153.9	5.1	0.1	2.2	0.2	0.9	0.2	8.2	0.5	0.1	0.0	162.2	0.5
Melapi	10.3	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	10.6	0.0
Yellow Seraya	10.3	2.6	0.0	1.6	0.2	0.4	0.1	4.6	0.3	0.3	0.1	15.2	0.4
Kapur	66.7	3.4	0.1	1.0	0.1	0.3	0.1	5.2	0.3	0.1	0.0	72.0	0.3
Keruing	35.9	1.3	0.0	1.3	0.1	0.3	0.1	2.9	0.2	0.0	0.0	38.8	0.2
Selangan	15.4	0.0	0.0	0.3	0.0	0.2	0.0	0.5	0.1	0.0	0.0	15.9	0.1
Selangan Batu	10.3	1.3	0.0	0.0	0.0	0.1	0.0	1.4	0.1	0.2	0.1	11.8	0.1
Resak	20.5	0.0	0.0	0.3	0.0	0.1	0.0	0.4	0.1	0.0	0.0	20.9	0.0
Pengiran	0.0	1.3	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	1.3	0.0
SUB-TOTAL	425.9	28.3	0.4	12.8	1.0	3.3	0.7	44.8	2.2	1.3	0.5	471.5	2.7
NON-DIPTEROCARPS													
Hardwoods	841.0	38.5	0.6	18.9	1.2	3.1	0.5	60.5	2.3	1.3	0.5	902.8	2.8
Pioneers	41.0	5.2	0.1	5.1	0.3	0.8	0.1	11.1	0.5	0.05	0.0	52.1	0.5
SUB-TOTAL	882.0	43.7		24.0	1.4	3.9	0.6	71.5	2.7	1.3	0.5	954.9	3.2
NON-COMMERCIAL TIMBERS													
	1,184.6	82.0	1.4	32.7	2.0	2.5	0.4	116.2	3.8	0.4	0.1	1,302	3.9
GRAND TOTAL	2,493.0	154.0	2.5	69.5	4.4	9.7	1.7	233.5	8.8	3.0	1.2	2,729	9.8

Legend

Dipterocarps: 10 groups according to their market names

Non-Dipterocarps: marketable non-dipterocarp

hardwoods: light to heavy timbers

-pioneers: very light timbers (e.g. Laran, Binuang, etc.)

Non-Commercial Timbers: presently non-marketable timbers

Generally, SLFR is highly degraded with considerable lack of commercial trees in the lower diameter classes. The main reason is that the area was subject to repeated logging thereby increasing damages to the residual stand.

3.2 Aerial Photo Interpretation

Interpretation of aerial photos taken in 1990 aiming at classifying the area of DFR into strata of different stocking conditions lead to the following distribution (table 15).

Table 15 Stocking conditions by area in DFR

Stratum	Criteria for Interpretation (number of trees/ha > 60cm dbh)	Average Volume (> 60cm dbh) (m ³ /ha)	Area	
			(ha)	%
	N/ha			
1	0 - 4	65	29,969	54.6
2	5 - 8	75	13,690	24.9
3	9 - 16	90	6,911	12.5
4	> 16	120	4,513	8.0

The results show that only 20% of the area is well stocked with mature timber. Spatial distribution of the strata within individual compartments is used in harvesting scheduling to calculate expected timber output.

3.3 Regeneration

3.3.1 Deramakot Forest Reserve

A summary of the number of trees per hectare of different size classes from saplings to those >60cm diameter by commercial timber groups is shown in table 16.

Table 16 Number of trees of commercial timber groups by diameter classes in DFR

TIMBER GROUP	NUMBER OF TREES PER HECTARE					TOTAL
	SAPLINGS	10 - 19cm	20 - 39cm	40 - 59cm	> 60cm	
Dipterocarps	789	62	27	8	7	893
Non-Dipt.						
Hardwoods	1,391	87	25	4	3	1,510
Pioneers	92	12	7	2	-	113
TOTAL	2,272	161	59	14	10	2,516

With an average of approx. 800 dipterocarp saplings and almost double this amount of commercial non-dipterocarps per hectare the forest seems to be able to provide an adequate number of recruits for self-regulation. Comparing these results with regeneration figures of the individual volume classes shows that some problems in regenerating the stands by natural means will occur in future on 30% of the production forest area.

The 10 - 39 cm diameter class (poles) is subject to an assessment of the crown and bole damages. Table 17 shows the tree numbers per hectare (in % of species group) for different quality classes.

Table 17 Quality classes by species groups in DFR

SPECIES GROUP	QUALITY CLASS				
	SOUND TREE	TREE WITH BROKEN CROWN	TREE CLIMBER INFESTED	TREE WITH STEM DAMAGE	OTHER DAMAGE
	10 - 19cm dbh				
Dipterocarps	61.3	24.0	12.1	-	2.6
Non-Dipt.					
Hardwoods	46.8	25.2	21.2	0.7	6.1
Pioneers	51.7	21.7	18.3	-	8.3
TOTAL	48.0	27.5	17.4	0.3	6.8
	20 - 39cm dbh				
Dipterocarps	63.3	17.5	11.9	1.0	6.3
Non-Dipt.					
Hardwoods	48.4	23.4	19.9	1.3	7.8
Pioneers	58.7	20.2	13.6	0.7	6.8
TOTAL	52.2	23.5	15.6	1.0	7.4

In general, the regeneration in DFR is adequate, although there is considerable under stocking of trees 20 - 60 cm dbh. A high proportion of the 20-39 cm diameter class are sound trees (52%) and qualify as potential crop trees. About 25% are trees with broken crowns, 16% are infested with climbers and only 1% show damaged stems. Other damages amount to 7%. The same trend is true for the 10-19cm diameter class. The potential crop trees will form the basis for stand and growth improvement.

3.3.2 Segaliud-Lokan Forest Reserve

A summary of the number of trees per hectare of different size classes from saplings to those >60cm diameters by commercial timber groups is shown in table 18.

Table 18 Number of trees of commercial timber groups by diameter classes in SLFR

TIMBER GROUP	NUMBER OF TREES PER HECTARE					TOTAL
	SAPLINGS	10 - 19cm	20 - 39cm	40 - 59cm	> 60cm	
Dipterocarps	426	28	13	4	1	472
Non-Dipt Hardwoods	841	38	19	3	1	902
Pioneers	41	5	5	1	-	52
TOTAL	1,308	71	37	8	2	1,426

Trees with diameter 10 - 39cm (poles) were subject to an assessment of the crown and bole damages. Table 19 shows the tree number per hectare (in % of species group) for different quality classes.

Table 19 Quality classes by species groups in SLFR

SPECIES GROUP	QUALITY CLASS				
	SOUND TREE	TREE WITH BROKEN CROWN	TREE CLIMBER INFESTED	TREE WITH STEM DAMAGE	OTHER DAMAGE
10 - 19cm dbh					
Dipterocarps	9.1	63.6	27.3	-	-
Non-Dipt. Hardwoods	-	64.3	35.7	-	-
Pioneers	-	25.0	75.0	-	-
Other Timbers	10.9	31.3	56.2	-	1.6
TOTAL	7.6	44.9	46.7	-	0.8
20 - 39 cm dbh					
Dipterocarps	27.5	45.0	27.5	-	-
Non-Dipt. Hardwoods	13.5	35.3	35.2	19.0	-
Pioneers	18.8	43.7	37.5	-	-
Other Timbers	14.7	33.3	46.1	2.0	3.9
TOTAL	17.0	40.6	38.3	2.3	1.8

The total number of saplings is approx. 60% as compared to DFR. More than 70% of all pole-size trees (10-39 cm dbh) are either damaged or heavily infested by climbers. These results underline that this forest is not anymore capable of regenerating itself naturally in acceptable time frames.

3.4 Growth Statistics

3.4.1 Deramakot Forest Reserve

Uneven-aged forests are characterized by the fact that they do not have a definite beginning and ending in time and trees of all ages are spatially intermixed. Due to the past management the forest structure became extremely heterogeneous. Presently the forest consists of a wide range of structural features, from open gaps to very dense stands.

Growth projections are based on the individual tree growth model (DIPTEROCARP FOREST GROWTH SIMULATION MODEL, DIPSIM) using all 490 sampling units of the medium-term forest management inventory of DFR. The model automatically accounts for growth rates, mortality and recruitment. The results of 40 years of growth projection assuming no harvesting interventions or silvicultural treatments are summarized in table 20. Growing stock and corresponding increment figures are given for individual 5-year periods.

Table 20 Growth projection without harvesting for DFR

Period (yrs)	Growing Stock Volume of commercial trees >10 cm dbh (m ³ /ha)	Mean Annual Increment (M.A.I.)		M.A.I.- Period (yrs)
		>10 cm dbh (m ³ /ha/a)	>60 cm dbh (m ³ /ha/a)	
1993 - 1997	155	0.73	0.0	5
1998 - 2002	162	1.26	0.17	10
2003 - 2007	171	1.53	0.22	15
2008 - 2012	182	1.66	0.28	20
2013 - 2017	192	1.74	0.27	25
2018 - 2022	204	1.90	0.40	30
2023 - 2027	217	1.97	0.53	35
2028 - 2032	226	1.92	0.51	40

As shown in the table the growing stock (i.e. volume of commercial trees) increases from the present level of 155 m³/ha to 226 m³/ha after 40 years. This improvement of the growing stock leads to a considerable increase of the M.A.I. for both, the total (trees > 10 cm dbh) and the mature stand (trees > 60 cm dbh).

Although no projections beyond 40 years were made, it seems that the M.A.I. of the total stand has its maximum at a growing stock level of approximately 210 - 220 m³/ha. The rather moderate increment of trees above 60 cm dbh is the result of past harvesting operations according to the MUS and the fact that a considerable amount of relic trees die due to significant changes in the stand structure and logging damage.

The diameter distribution of the number of trees/ha in figure 6 clearly shows that considerable improvement of the stocking takes place in the size classes 20-50 cm dbh, whereas there is only a slight increase of trees 60cm dbh and above.

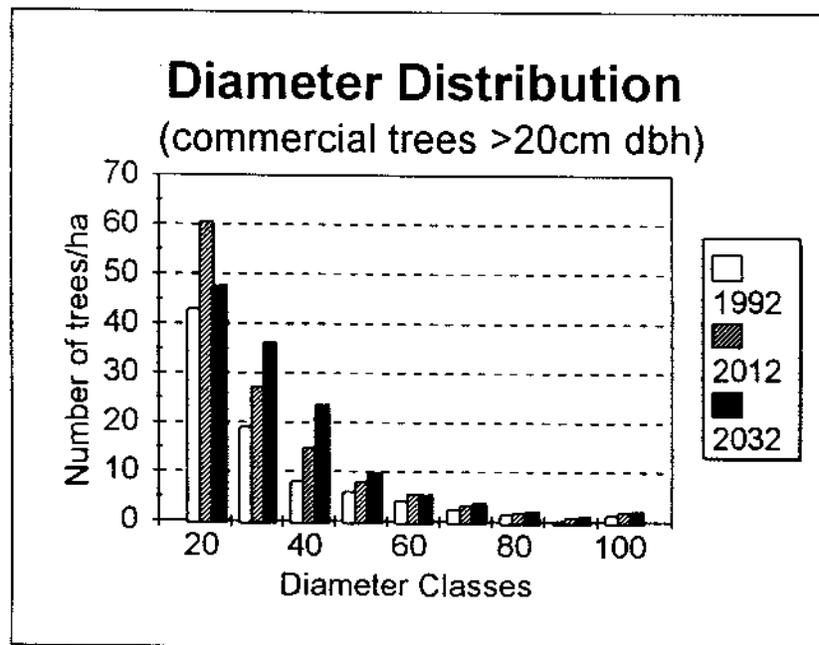


Figure 6 Predicted diameter distribution for a 40 year period for DFR

The growth figures underline that the forest is still in an early state of recovery after heavy exploitation which took place between 1960 and 1989. The establishment of natural regeneration is hampered partly by heavy climbing bamboo infestation and the fact that in extensive areas the stands were deprived of their seed source.

3.4.2 Segaliud Lokan Forest Reserve

Due to the fact that the entire commercial area of SLFR will be managed under a rehabilitation project, growth statistics of the heavily damaged natural forests are irrelevant to this plan.

3.5 Wildlife

An integral part of the forests is its faunal resource which can be utilized in a sustainable manner, one way or another. Wildlife resources within DFR and SLFR have received little attention in the past as the primary objective was timber management. Timber production will remain the dominant factor in planning land use within the Management Unit, but recent legislation and forest policy shifts call for standards to meet the requirements of wildlife conservation. The needs of these two apparently incompatible objectives can be met with balanced land use planning and some active management measures.

As timber production will take precedence over other concerns, the best interests of wildlife would be served by concentrating on the needs and measures required to conserve globally endangered species representing different orders. In addition, species that are abundant or those whose populations can be built up through protection, should also be targeted as an important resource base. The basis for doing this is through data gathered in the inventory, which includes the distribution, abundance and occupancy of endangered species found in the Management Unit. The limiting factors to the species future survival - critical habitat requirements, behavioural characteristics and social organization - should be considered and coordinated with other aspects when planning land use.

Of the six globally threatened large mammal species found in Sabah, four are definitely known to occur in FMU 19. These are the orang utan, elephant, tembadau and clouded leopard. The possibility that a relict Sumatran rhino population exists should not be discounted. A profile of key threatened species found in the FMU, and critical habitat requirements and behavioural characteristics that need to be considered when planning land use is given in Table 21. Each of these species, belonging to three orders, occupy a different niche in the ecosystem. Large animals occupy large areas and taking measures to conserve them would automatically help in protecting other smaller species that occupy the same habitat.

Table 21 Profile of some key threatened and locally abundant wildlife species found in FMU 19

GLOBALLY THREATENED SPECIES							
Species	Density or relative density index, and distribution	Reasons for decline		Critical behavioural/ biological traits	Ecological limiting factors	Threats within FMU	Status within FMU
		Global	Sabah				
Sumatran rhinoceros <i>Dicerorhinus sumatrensis</i>	Not known Limited to SLFR if still found in the area	Poaching for horn	Poaching Habitat destruction	Territorial Solitary Slow breeding	Food - herbaceous material preferred Minerals Space - 15-30 km/individual Water - wallows	Human disturbance through conversion/ harvesting	Not known - but if still found, highly threatened.
Asian elephant <i>Elephas maximus</i>	0.18/sq km Widespread in north DFR and central SLFR	Habitat and population fragmentation Poaching for ivory, meat	Habitat fragmentation and reduction activities	Gregarious - cow/calf herds; single mates. Migratory Very slow breeding	Food - fruits, grasses Space - Habitat contiguity at least 70-100 sq km per herd. Minerals in food plants	Habitat fragmentation in SLFR. Poaching.	Threatened - ages classes indicate recruitment into population
Orang utan <i>Pongo pygmaeus</i>	0.1/sq km Widespread in north DFR, limited in SLFR	Habitat destruction and fragmentation Illegal trade in live animals	Habitat reduction via conversion. Poaching.	Territorial Solitary Relatively slow breeding	Food - mainly fruit Space - habitat contiguity, 10-15 sq km/individual Shelter - Trees for roosting	Habitat destruction through conversion/ harvesting. Limited food availability. Poaching.	Threatened
Tembadau <i>Bos javanicus</i>	Relatively wide-spread in north DFR and central SLFR Very low density	Habitat destruction and fragmentation Over-hunting for meat	Habitat reduction. Poaching.	Gregarious - mixed herds. Moderate fecundity.	Food - grasses preferred. Space - not known.	Poaching.	Threatened
Clouded leopard <i>Neofelis nebulosa</i>	Very low density	Hunting/trapping for pelt. Habitat reduction	Habitat reduction. Over-hunting of prey base by people. Habitat destruction.	Territorial. Solitary. Moderate fecundity	Food - small to medium mammals Space - 5-10 sq km/individual	Limited food availability. Poaching	Highly threatened.
Helmeted hornbill <i>Rhinoplax vigil</i>	Relatively widespread in north DFR	Habitat destruction.	Habitat destruction.	Single/pairs	Food - fruiting trees. Shelter - tall trees for nesting. Space - not known.	Limited food resources and shelter.	Highly threatened

Table 21 Profile of some key threatened and locally abundant wildlife species found in FMU 19 (contd).

Species	Density or relative density index, and distribution	Reasons for decline		Critical behavioural/ biological traits	Ecological limiting factors	Threats within FMU	Status within FMU
		Global	Sabah				
Malaysian Peacock - pheasant <i>Polyplectron malacense</i>	Very low density, limited to some pockets in north DFR.	Habitat destruction	Habitat destruction/ disturbance Trapping for meat	Solitary	Shelter - nesting areas. Space - not known	Hunting/trapping	Highly threatened.
Estuarine crocodile <i>Crocodylus porosus</i>	Very low densities	Hunting Egg collection	Habitat disturbance Hunting	Solitary High fecundity	Food - small mammals, fish. Shelter - nesting areas in riparian forests	Hunting. Disturbance of riparian habitats.	Highly threatened.
LOCALLY THREATENED SPECIES							
Bornean gibbon <i>Hylobates agilis</i>	Low density, moderately widespread in north DFR and in SLFR	Habitat destruction Trade in live animals Hunting	Habitat destruction Trade in live animals Hunting	Territorial - loud singing every morning. Bonded pairs/ family groups 2-3 individuals	Food - leaves and fruit in tall canopy. Space - 30 ha/pair.	Habitat degradation	Threatened
Sun bear <i>Helarctos malayanus</i>	Very low density in both DFR and SLFR	Hunting and trade in live animals. Habitat destruction	Habitat destruction and capture of live animals for pet trade	Very little known about the species. Solitary/mother-cub groups.	Food-termites, grubs and some fruit	Habitat disturbance	Threatened
LOCALLY ABUNDANT SPECIES							
Bearded pig <i>Sus barbatus</i>	Relative density high in south DFR		Uncontrolled hunting	Gregarious, fast breeders, highly adaptable species.	Omnivores.	Over hunting.	Abundant
Sambar deer <i>Cervus unicolor</i>	Relative density high in south DFR		Uncontrolled hunting	Female/young herds between 2-5 individuals. Relative fast breeders, thrive in secondary forests	Both grass and browse taken.	Over hunting	Relatively abundant.

Habitat availability and distribution of key wildlife species

Evaluation of habitat is based on data gathered during the management inventory of the area. In general DFR has better stocking conditions than SLFR. Near climax vegetation occurs on only about 10% of the area, particularly on the upper slopes and ridge tops. However, for large mammal populations habitat contiguity in the form of natural forest cover is critical in determining the long term prospects of viable populations. A rule of thumb of area required for large mammal population viability, eg elephant, is approximately between 70,000-100,000 ha in tropical rain forests. NFM methods prescribed in this management plan, including intensity of harvesting and harvesting methods aim to minimize the detrimental effects locally. But if the areas in which these practices are to be implemented are fragmented, then breeding populations would still decline. Fragmentation of habitat through different forms of land use and forestry practices would fragment populations and make them vulnerable to poaching, loss of genetic vigour and depressed breeding. Therefore, when land use is planned particular attention should be placed to habitat contiguity, both in terms of space as well as forestry practices.

Of the globally threatened species found in the Management Unit (see figure 7 and 8), elephants appear to use the generally flatter parts of north DFR and central portions of SLFR. The density of elephants found in the FMU is similar to that derived in other areas including the adjacent forests of the lower Kinabatangan. Their range in the area extends from the Pinangah hills in the west through parts of the Tangkulap forest reserve west of DFR, into SLFR, state land and the Lokan VJR to its east. Most boundaries of these forest reserves to the north are shared with oil palm plantations. The future of this elephant population will therefore be determined by the type of land use within FMU 19. Orang utans are fairly widespread with some concentrations in the steeper areas of SLFR. Logging intensity, especially in SLFR, has no doubt severely reduced the population size. Density estimates of tembadau could not be determined, but a relatively large population is found in the FMU, but the distribution is limited to the flat areas of north DFR and SLFR. However, there has been a lot of evidence of poaching for the species. Rhinos were known to exist in the general area of SLFR until the late 1980's. But the repeated logging in the area has in all probability wiped out the population in this reserve.

Globally threatened birds species that are particularly vulnerable to forestry activities are the lowland specialists such as the Malaysian Peacock-pheasant and Crested Fireback. Many other resident forest species such as the helmeted and wrinkled hornbills and Storm's stock generally occur in low densities naturally and the amount of habitat required for population viability is not known, making it difficult to judge their vulnerability to intensive forestry practices. But determining their status in relative terms is simple because they are highly conspicuous through sight as well as by their calls.

Of the locally abundant species that are potentially available for controlled hunting, the sambar deer and bearded pig are found in high densities, especially in the southern parts of DFR. Barking deer and mouse deer densities are generally low. The difference in densities within the DFR may be a reflection of over-hunting (poaching) in the northern parts which are more accessible.

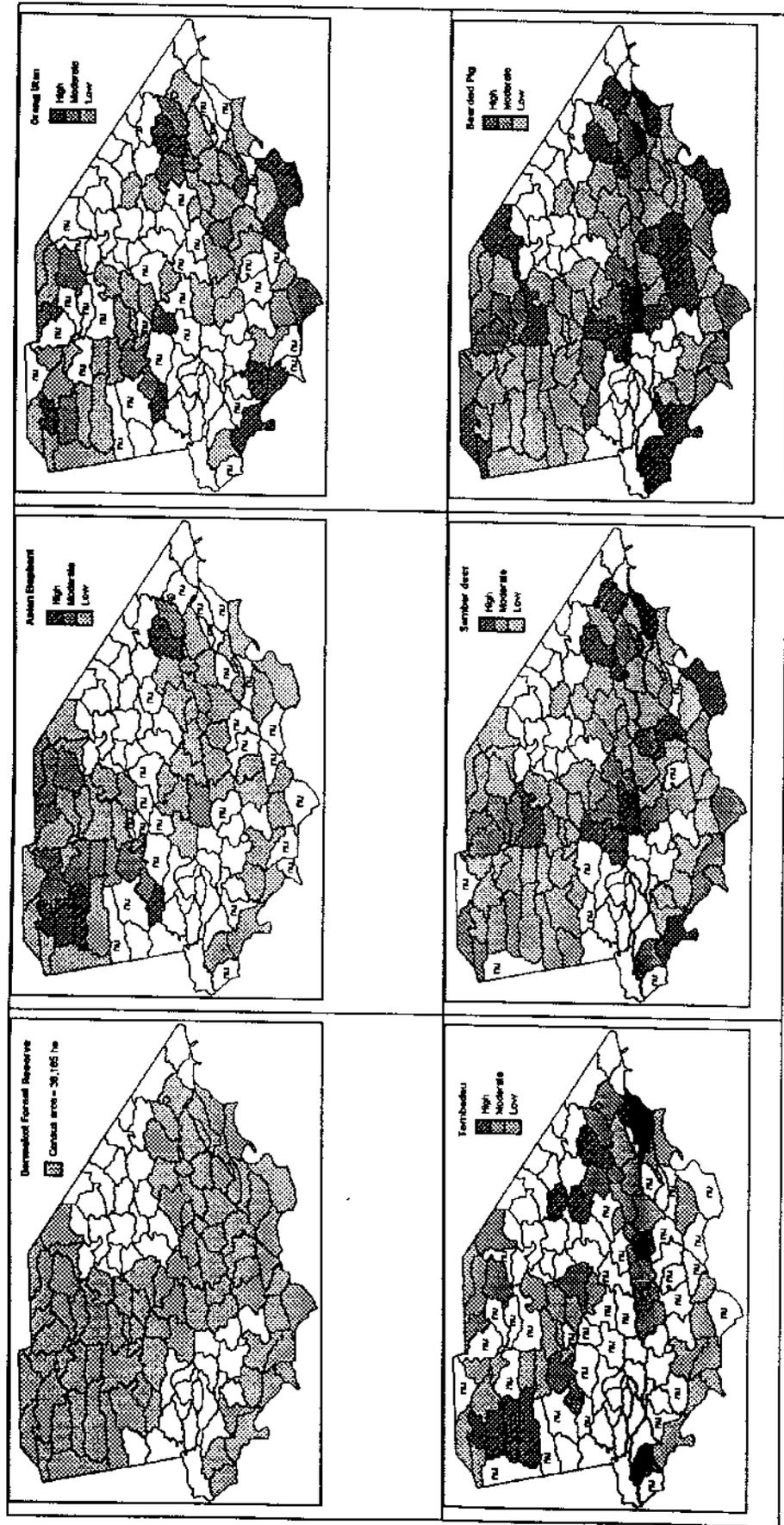


Figure 7 Distribution of some threatened and abundant key wildlife species in DFR

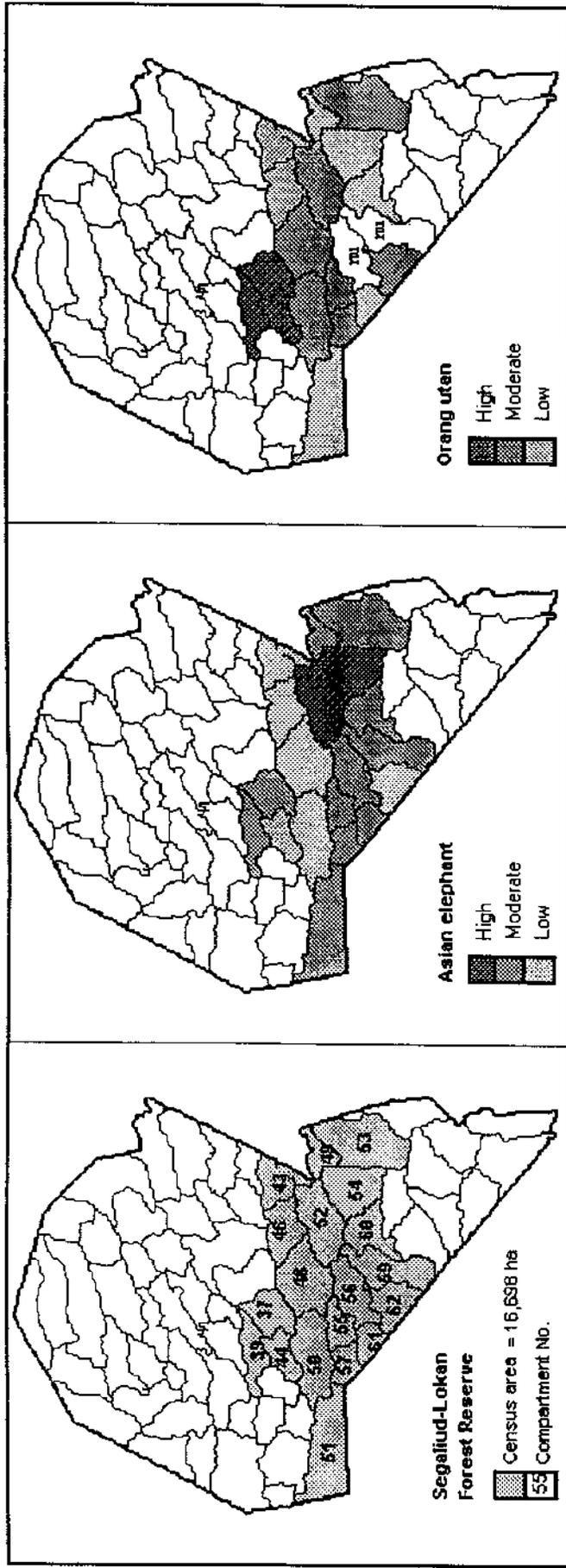


Figure 8 Distribution of some threatened and abundant key wildlife species in SLFR

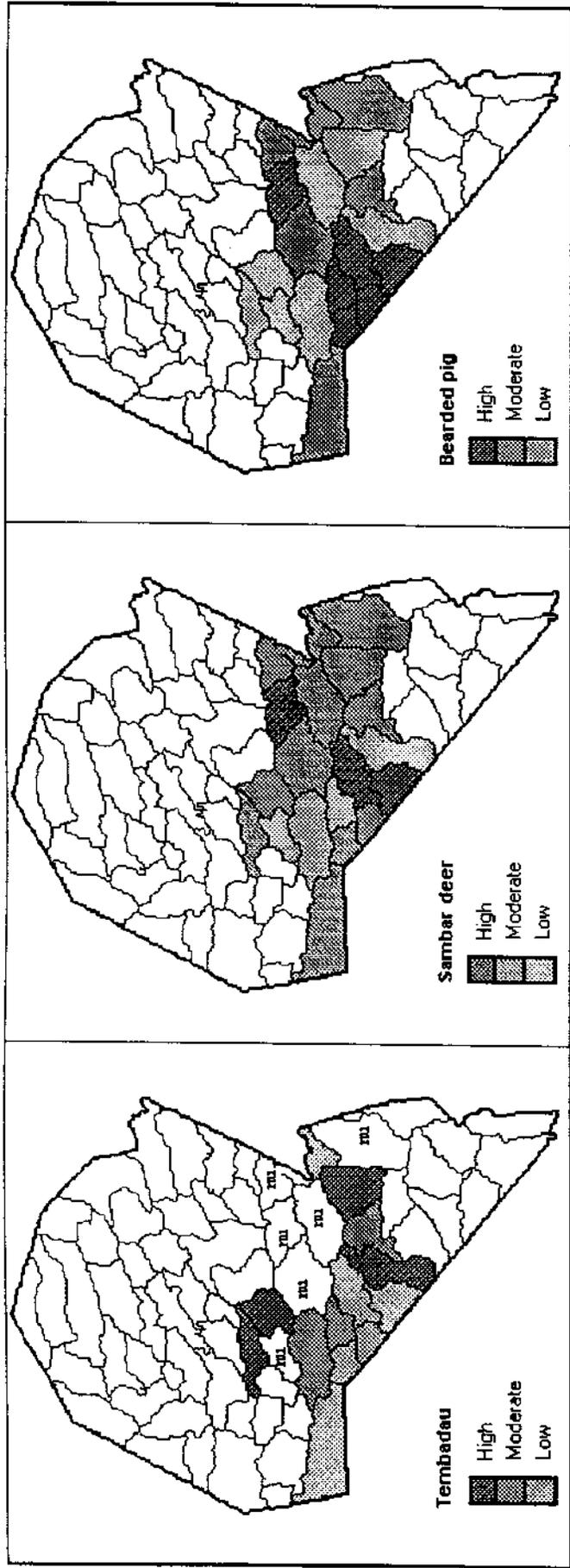


Figure 8 Distribution of some threatened and abundant key wildlife species in SLFR (continued)

3.6 Management Restrictions

In order to get a better insight into the present constraints for timber management the areas of different site degradation risks versus the actual growing stock conditions are shown in table 22 and figure 9 and 10, respectively.

Table 22 Site degradation risk and actual growing stock conditions

Forest Reserve	Site Degradation Risk	Area by volume class Growing Stock (gross volume of trees > 60 cm dbh)			Total Area (ha)
		High Volume (>100 m ³ /ha) (ha)	Medium Volume (50-100 m ³ /ha) (ha)	Low Volume (>50 m ³ /ha) (ha)	
D.F.R.	Low	0	0	99	99
	Medium	2,823	1,310	6,149	10,282
	High	9,282	7,567	12,812	29,700
	Very High	3,331	2,627	3,434	9,392
				Total:	49,374
S.L.F.R.	Low	0	0	0	0
	Medium	0	0	1,591	1,591
	High	0	0	30,408	30,408
	Very High	0	0	9,015	9,015
				Total:	41,014

In both reserves the majority of the sites belong to the medium and high risk classes due to their topography and soil conditions. Approx. 9,000 ha in each of the reserves are classified as very sensitive to erosion and therefore problematic for timber management. Within natural forest management these sites are excluded from harvesting (protection sites) as prescribed in the tree marking rules. In DFR about 50% of the area suitable for timber management is fairly well to well stocked. In the case of SLFR very low stocking occurs throughout the area irrespective of the site conditions.

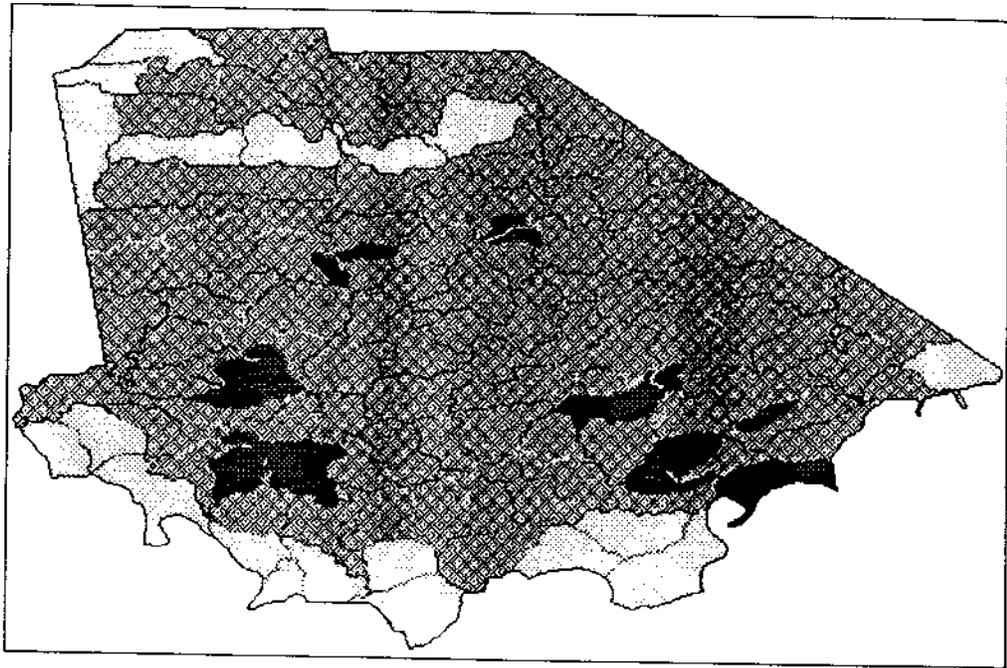


Figure 9 Site degradation risk in DFR

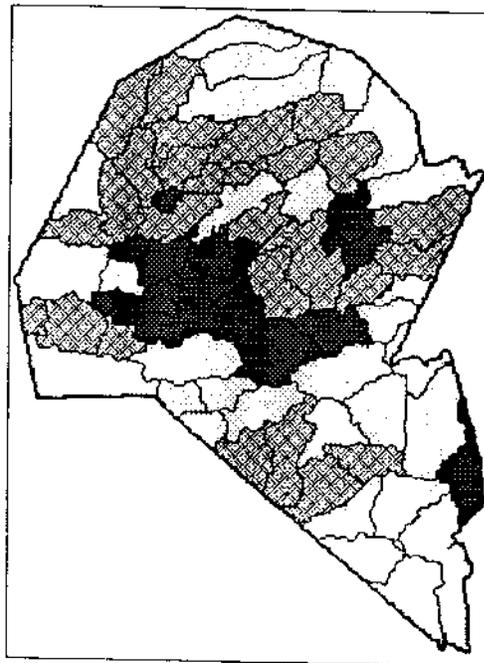


Figure 10 Site degradation risk in SLFR

Legend:

	very high
	high
	medium
	low