Report of Development Plan of University Forest of Mulawarman University in Indonesia

June 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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Preface

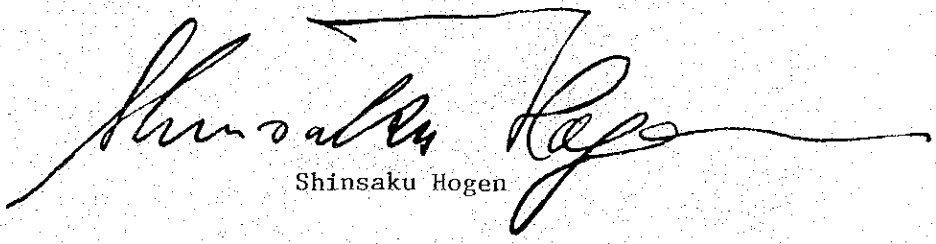
The present report is based on the result of a Survey on the Development Plan of Experimental Forest of Mulawarman University conducted in November 1978 by the Japan International Cooperation Agency following the request made by the Government of the Republic of Indonesia to the Government of Japan.

The survey was conducted at a small experimental forest of Mulawarman University, located in the suburbs of Samarinda City in East Kalimantan. This forest which constitutes a part of the Center for Reforestation Studies in the Tropical Rain Forest not only is used for research and training at the University but also is made available to the citizens for their education. The University places particular emphasis on the realization of the plan.

The report deals with a plan for zoning the forest and establishment of facilities therein. As the survey was conducted in a short period, there remain further studies to be made. However, the report will provide an important guidance in the development of the university forest.

I wish to express my sincere thanks to the people concerned of Mulawarman University and of the Directorate General of Higher Education for their close cooperation and assistance extended to the survey team.

June, 1979

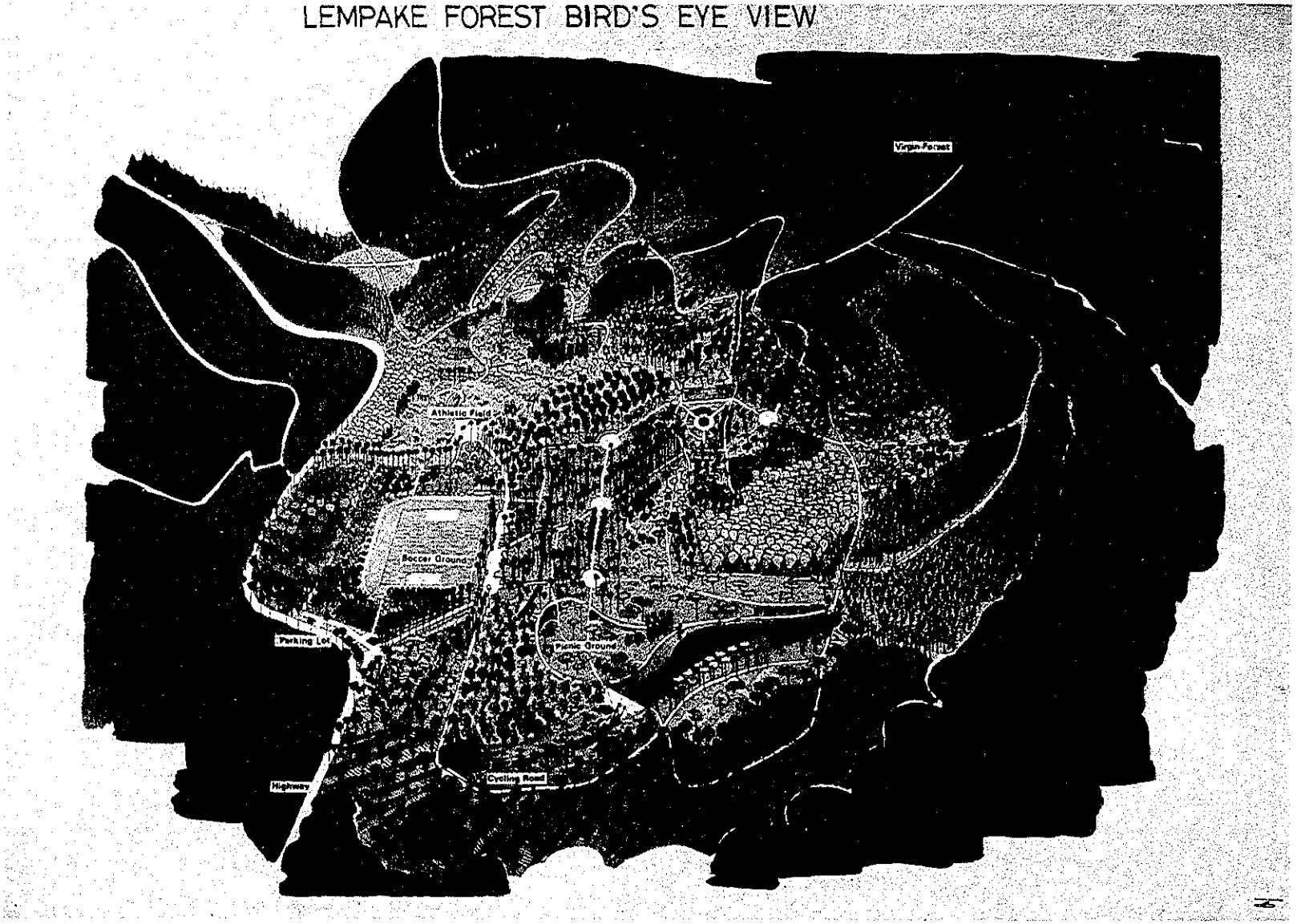


Shinsaku Hogen

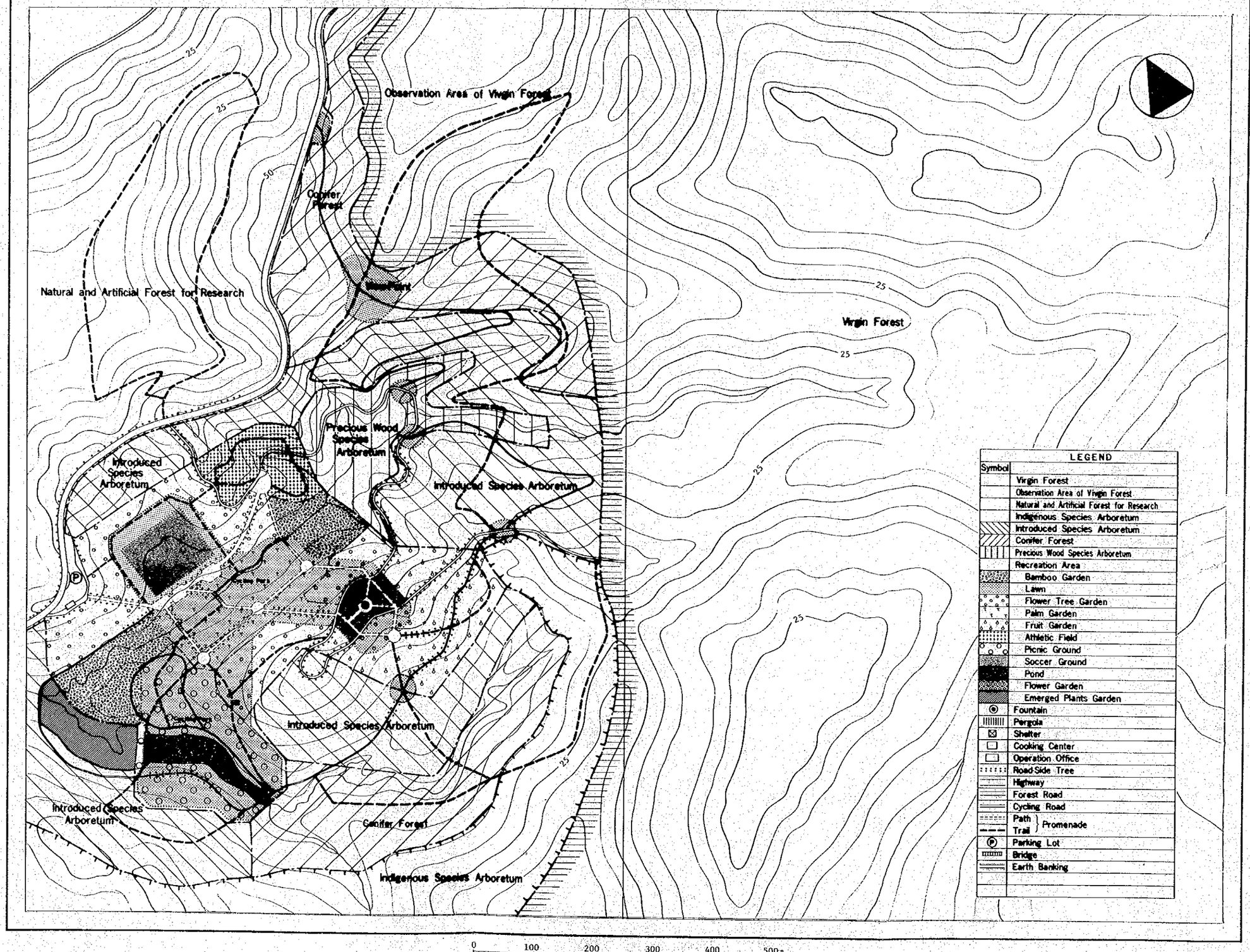
President

Japan International Cooperation Agency

LEMPAKE FOREST BIRD'S EYE VIEW



LEMPAKE FOREST LAND-USE PLANNING MAP



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1. PURPOSE AND OUTLINE OF THE SURVEY

1.1 Purpose and Details

(1) Purpose

The tropical rain forests in East Kalimantan are one of important forests in the world having large trees of over 60m in height, several thousands valuable species and other abundant plants which constitute important supplying source of timber. The Government of Indonesia, considering Java, being over-populated, is now undertaking development of other islands than Java, particularly emigration to East Kalimantan. As a result, the population of East Kalimantan is recently on rapid increase. Especially the urban population of Samarinda and Balikpapan is greatly increased.

Lempake university forest of Mulawarman University at Samarinda City, East Kalimantan which is the object of this survey is a part of 60,000ha of the concession established 1970 under C.V. KAJU MAHKAM and in 1973, 300ha of the above has been transferred to Mulawarman University.

In cooperation with Japanese Government, the university has planned to establish the Center for Reforestation Studies in the Tropical Rain Forest in its new campus in Samarinda City and in parallel with Lempake University forest, the protection forest covering 19,000ha in the middle of highway between Samarinda - Balikpapan has been transferred as Sanboja University forest. For this reason, the initial plan of Lempake University forest was to divide the forest into research forest, demonstration forest, recreation forest and reserve forest (See Fig. 1-3), but of the research forest, its function is to be transfered to the new university forest and this university forest is needed to plan a new Lempake University forest providing with functions of demonstration forest, recreation forest and reserve forest.

With these details and bankgrounds, this survey was conducted as a part of "Survey on basic design of the Center for Reforestation Studies in the Tropical Rain Forest of Mulawarman University, Indonesia" which is undertaken, at the request of the Government of Indonesia, the preparation of utilization plan of Lempake University forest and the design of required facilities as route of road and needed structures in the university forest for the consolidation work of university forest which is to be done by Indonesian side.

(2) Field Survey and Details of Consolidation Plan

This survey is roughly divided into a grasp of current situation and survey for design of forests and facilities which are materialized in future. If various surveys are further sub-divided, they include measurements of forest roads and sidewalks, water system and topography, sampling of forest conditions and regeneration.
Assistants and students of Mulawarman University cooperated in the survey.

(3) Organization of Survey Team

Name	Duty	Attached to
Akira KAWANA	General (Chief)	Prof. Faculty of Agriculture, Tokyo University of Agricultural and Technology
Masaru HAYASHI	Cooperation Planning	Chief, planning section, Management Div. Tokyo Regional Forestry Office
Hiroshi MINAGAWA	University Forest Planning	Chief Researcher, Forestry Civil Engineering Consultants
Kozo OHIRA	Forest Road Planning	Deputy, Forest road section, Forestry Civil Engineering Consultants
Chuichi YAMAKAWA	Construction Planning	Azusa Sekkei Co., Ltd.
Keiji SHIMURA	Construction Planning	Azusa Sekkei Co., Ltd.
(Following staff cooperated in this project in Japan)		
Masayuki HORI	University Forest Planning & Management	Standing Director, Japan Forestry Technical Association
Katsuhisa TAKAGI	University Forest Planning	Japan Forestry Technical Association
Tadao OHARA	University Forest Planning	Japan Forestry Technical Association
Shunji KUDO	Forest Road Planning	Chief, 1st Technical Section, Forestry Civil Engineering Consultants

(4) Survey Schedule (University forest planning and forest road planning)

29th Oct.	Tokyo - Jakarta
30th, 31st	Arrangements with organizations concerned
1st Nov.	Jakarta - Samarinda
2nd	Arrangement with the university
3rd-19th Nov.	Field survey
20th	Arrangements with the university
21st	Samarinda - Jakarta
22nd-23rd	Report to the organizations concerned
24th	Leave Jakarta
25th	Arrive Tokyo

1.2 Summary

Lempake University forest covering 300ha was considered at first to be used as the research forest of Mulawarman University.
Since the request of reforestation research institute under grant-aid system to Japanese Government was made centering Ir. Sanbas, Reactor of the university, the university forest shares a part of the responsibilities. Notwithstanding, needless to say in detail, it was too small for research of tropical reforestation and it was proposed that the facilities for training and experiments are established separately. Then it was decided that the university forest covering 19,000ha was established along the road between Balikpapan and Samarinda.
Assuming the above situation, Lempake university forest, attaching importance to conservation of tropical rain forest, extension of science of forestry in the university, education of local people and function of recreation, was to be re-examined.
In this area, the primeval forest is left as it is and partly the second growth occupies the cut-over area of Urin, and the surroundings are reclaimed by transimigration. In developing this program, the planned national highway from Samarinda to the north was realized and the road is under construction penetrating one block of this area.
According to the preliminary plan (Fig.1-3) the area was diveded into protection area, experimental area, demonstration arboretum and recreation forest. But after the discussion with the rector, the are was to be divided into Virgin forest, Natural and artificial forest for research, Indigeneous species arboretum, Introduced species arboretum, Conifer forests, Precious wood species Arboretum and Recreation area on which surveying and design were made.

As in Lempake forest one family of Oran Hutan is living as an exceptional case, there is a reason to reserve the primeval forest to protect them though the surroundings are now developing.

In this plan two forests are to be reserved as primeval protection forests, the one is 150ha where human being is prohibited to enter and the other is 27ha where observation is allowed. Reservation of such forest near big city has a significant meaning.

As it is considered that authorities of the government and city have much expectation to use the rest of the area for recreation the arboretum is to be established centering this area. Though the population of Samarinda is on rapid increase, it is tentatively planned that 250,000 people can enjoy and utlize the area.

As the national highway penetrates the university forest as stated in the above, there appears an separated area is south west where natural and artificial forest for research is established. Of 27ha of primeval protection forest where observation is allowed, promenade is constructed inside the forest or vistavision is established on the ridge of boundary where we can enjoy the landscape of natural forest.

In flower season, color of crown of Meranti changes and we can see various crowns with flower.

Also we can see the composition of natural forest from above or inside.

At the entrance of the forest an office or visitor's center (operation center) is built where specimens, photographs and pamphlets are displayed.

In Indigenous species arboretum natural trees are reserved and they are gradually thinned and induced to isolated trees, and any tree which does not grow there but native to East Kalimantan is introduced. The introduced species arboretum is to introduce other species than those found in Kalimantan from in and out of Indonesia. Nursery practice and planting require further consideration. As conifer forests can not be found in this area, the beauty of man-made conifer forests will afford enjoyment to local people.

Pine forest, Agathis forest, Araucaria forest and Podocarpus forest are considered. Also Bamboo garden of domestic and exotic species will be set up.

Every tree in such arboretum and demonstration forest is given name plates for scientific observation.

Recreation area centering lawn with scattered trees is provided with soccer-court, athletic field, cycling road, walking race road, vista-vision, flower tree garden, fountain, picnic-cooking table etc. Thus, this forest

is designed to enjoy green shade under equator.
In the swampy land in dale, pond and low flower bed are built which is a facility to prevent flood.
Scientific green land of 300ha where we can reach in ten odd minutes by car from the center of the city or 30 minutes by bicycle is a plaza for rest and recreation for the people of East Kalimantan, centering Samarinda as well as a place of education on importance of green. This is not only a place of research and education but a stop point for visitors of natural forest or arboretum in tropical area.
The university will do its efforts to accomplish the work for this University Forest and we wish this basic planning by Japanese side will facilitate those efforts for coming many years by Indonesian side.

2. OUTLINE OF LEMPAKE UNIVERSITY FOREST

2.1 Location

This university forests is located in the southern-most of the above concession at the basin of Karamgmumus River which flows into Mahakam River and 12Km to the north from the campus of Murawaruman University. The area covers about 300ha with the size of 1.5km S-N and 2km E-W (See Fig. 1-2, 1-3).

The forest consists of a virgin forest of typical low land tropical rain type in the east half and a forest of second growths after harvested mainly of Ulin in the west half. They are very convenient for study and in good environment.

2.2 Climate

According to the survey of the meterological agency (1930-1960), Balikpapan weather station reports as under.

Table 1-1 Mean monthly temperature (C°)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
26.1	25.9	26.2	26.5	26.9	26.6	26.6	27.0	27.4	26.4	27.4	26.9

Table 1-2 Mean monthly humidity (%)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
84	85	85	84	84	85	84	81	81	85	84	82

According to the survey of Samarinda weather station (1930-1960) published in 1970, mean monthly precipitation and rainfall days are as follows.

Table 1-3

	Jan.	Feb.	Mar.	Apr.	May	Jun.	
Rainfall (mm)	181	149	189	205	181	142	
	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
	111	97	123	151	200	206	1,935
	Jan.	Feb.	Mar.	Apr.	May	Jun.	
Rainy day (day)	13.8	11.6	13.4	15.3	14.6	13.4	
	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
	10.0	9.3	10.0	12.3	14.5	15.4	153.6

Fig 1-1 MAP OF INDONESIA

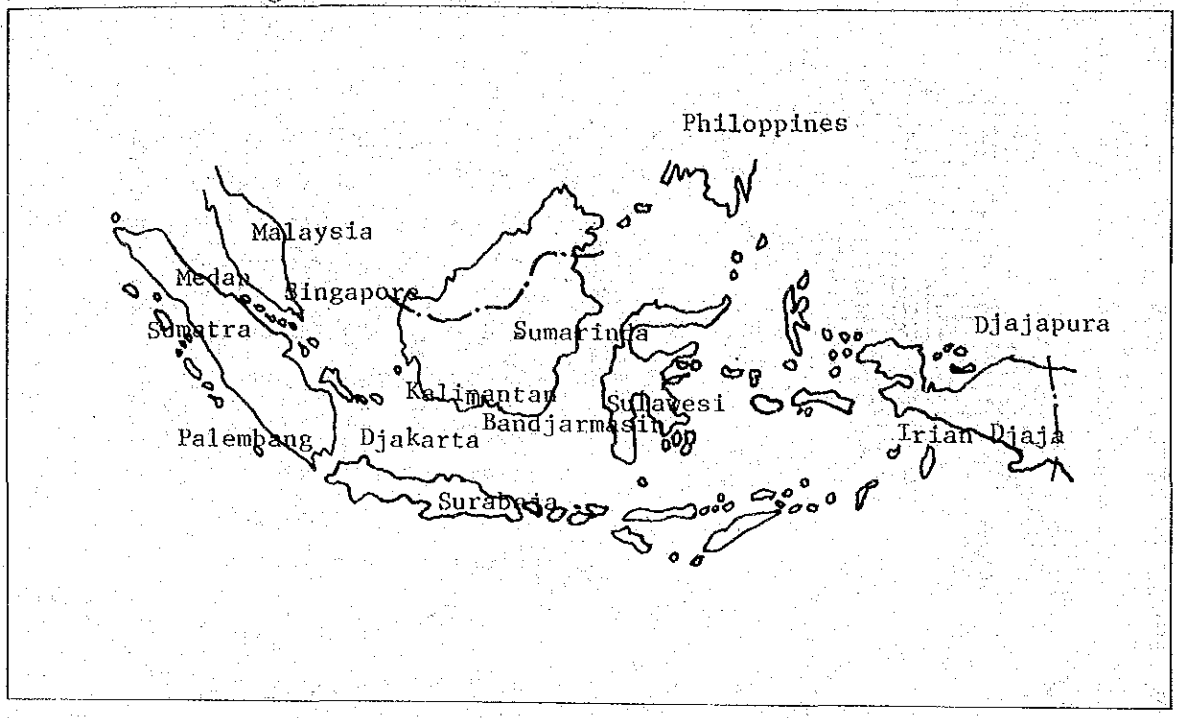


Fig 1-2 LOCATION MAP OF LEMPAKE UNIVERSITY FOREST

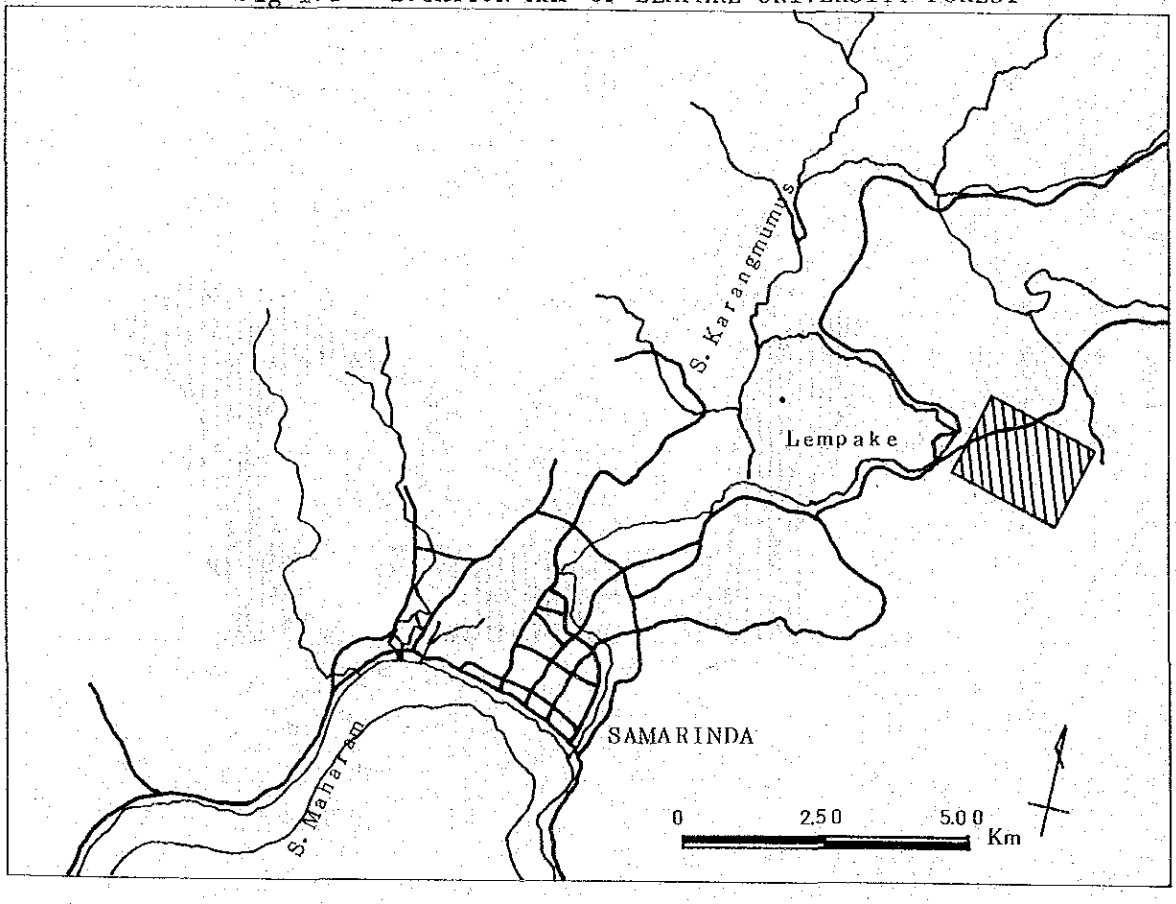
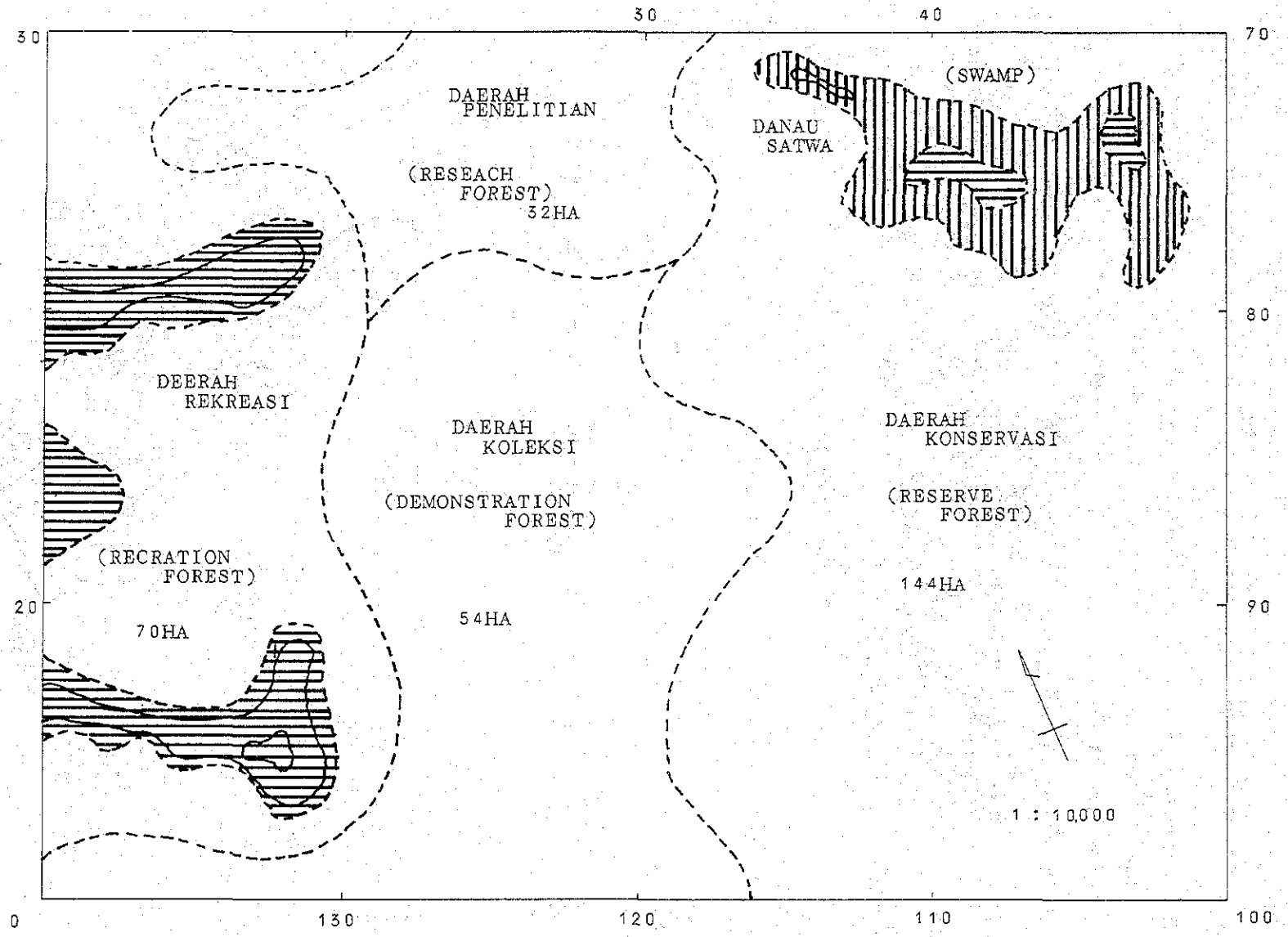


Fig. 1-3 PRELIMINARY ZONING PLAN OF LEMPAKE UNIVERSITY FOREST



2.3 Vegetation

2.3.1 Forest Composition

Forests near Lempake University Forest are low land tropical rain forest and occupied by Dipterocarpus spp. of high root swelling and its occupancy area is considered up to 60% partly.

Important species are as follows:

(1) Marsh Zone

Perupuk (Coccoceras sp.)
Bungur (Legerstrumia)
Bajur (Pterospermum sp.)
Benuang (Melanchoea sp.)
Arau (Elmerrilia sp.)
Pendjit buaja (Tremia sp.)

(2) Steep Slope Zone

Lempung (Shorea sp.)
Kapur (Dryobalanops sp.)
Merading (Dacrydium sp.)
Pulang (Shorea sp.)
Ulin (Eusideroxylon sp.)
Medang (Litsea sp.)
Kebantjang (Shorea sp.)
Merkabang (Shorea sp.)
Njatoh (Palaquium sp.)
Bankirai (Shorea sp.)

(3) Flat and Mild Slope Zone

Ulin (Eusideroxylon sp.)
Kelampajan (Anthocephalus sp.)
Markeladi (Polyalthia sp.)
Medang (Litsea sp.)
Sengkuan (Draconternlon sp.)
Merkabang (Shorea sp.)
Njatoh (Palaquium sp.)
Lempung (Shorea sp.)
Kenuar (Shorea sp.)
Kebantjang (Shorea sp.)

2.3.2 Undergrowth

Underplants are rattan and vines, and Selingsing and Rasan (Palmae) occupy marsh and river sides.

2.4 Topography and Geological Structure

(1) Dry Land Feature

Dry land features are found from north-west to north-east and to south-east of the university forest being hilly land less than 50m above sea at the highest.
Geology and soils are sandy soil or clay loam accompanied with limestone deposited in Miocene epoch and they are red podozolic or yellow podozolic.

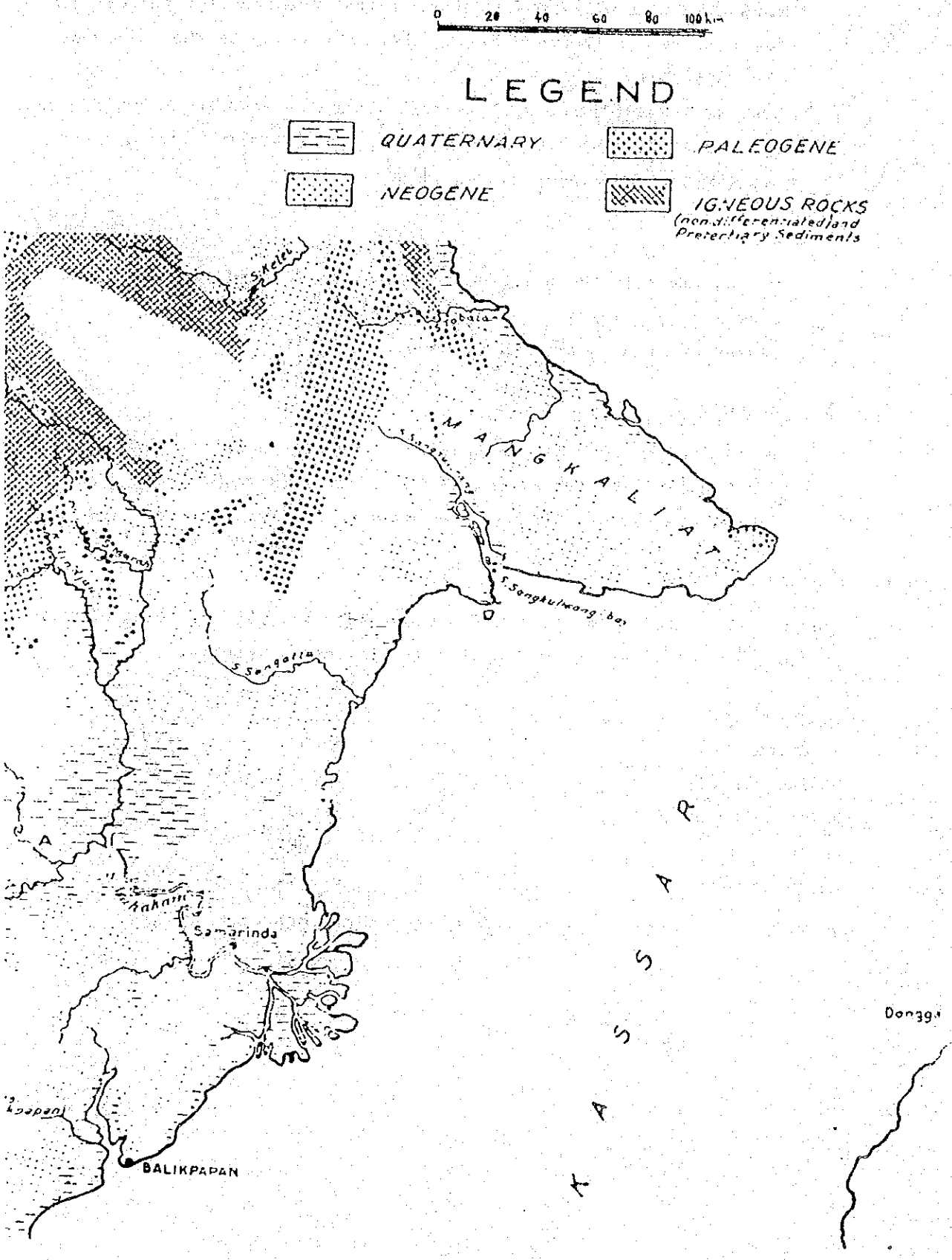
(2) Low Land Swamp

Rivers in the university forest are not influenced by ebb and flow. Low land swamps are found from south-west to north-east. Considering existence of plants having well developed aerial roots, scattered swamps are supposed to be permanent. Geology is alluvial pleposit of Quaternary period.

(3) Intermediate Topography

Between above two topographies, there are scattered intermediate topographies which dry up during dry season and become wet during rainy season.

GEOLOGICAL MAP
B O R N E O



2.5 Animals

(1) Manmals

We can find rare Oran Hutan (Pongo pygmaeus) in the University Forest, and it will need to protect that one couple together with two children of them are living there according to the survey of the University.

Deer are Rusa (Cerrus sp.), Kancil (Tragulus yavanicus) and Moncak (Muntiacus Muncak), and apes are Bakantan (Nasalis Larvatus) and Ova (Hylobates Noloch).

(2) Reptiles

In the river in the university forest, it is said that chrocodile 6-7m long is living.

Snakes are blue snake and pythons.

(3) Birds

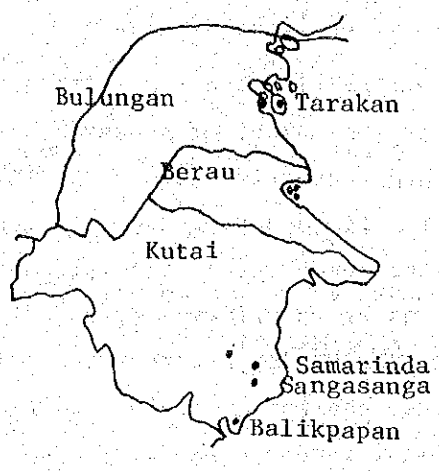
We find birds such as Bangan putih (Egretta Garzetta), Bluwok (Ibs Cinevrus), Black crane (Ibis Hitan), Merak (Ravo Muticus), Wasp (Burungsesep), Madr (Anthreptes Malacensis), etc.

2.6 Population

Population (dynamics) of East Kalimantan where Lempake University Forest Located is as follows. (See Map 5)

Samarinda City	(1969)	(1976)	(Increase - %)
Samarinda City	108,000	185,500	72
Balikpapan City	110,000	219,000	99
Bulungan Country	145,500	147,000	1
Berau Country	82,000	38,000	-54
Kutai Country	295,000	307,500	4
Total	740,500	897,000	12%

Fig. 2-2 East Kalimantan



Population dynamics of 3 complexes near Lempake University Forest in a sense of direct demand for recreation is as follows.

	(1969)	(1977)	(Increase - %)
Tenggarong complex	19,128	23,769	24
Angana complex	10,461	17,092	63
Muarabadak complex	6,892	18,259	165
Total	36,571	59,120	62 %

Rapid increase of population of above 3 complexes in recent years is due to the area designated to accept immigration.

The number of immigrant families was 737 in 1969. That in the second five year plan now underway is 5,000 families (25,000 people) and 1,000 (5,000 people) families in Lempake district only.

Their livelihoods were primitive farming, shifting cultivation, logging using human shoulder or splash dam and fisheries. In 1970's, because mechanical logging of Meranti has rapidly been introduced, East Kalimantan is focused as a center of timber extraction and export of Indonesian wood and particularly Samarinda is changing its situation as timber market of East Kalimantan.

3. UTILIZATION PLAN OF UNIVERSITY FOREST

3.1 Preliminary Idea of Utilization Plan

The university authorities had a preliminary idea to utilize the university forest through establishment of research forest, demonstration forest, reserve forest and recreation forest. (Fig.1-3)

As a result of the field survey taking the university's idea into consideration, the fundamental principle has been set up to utilize the forest through zoning as primeval reserve forest, nature observation forest, Indigeneous species arboretum, Precious wood arboretum, Introduced species arboretum, conifer arboretum and recreation.

(See Lempake Forest Land-use Map displayed at the beginning of this report)

Zoning based on the above fundamental principle is as follows:

	Utilization	Area (ha)
(1)	Primeval reserve forest	177
(2)	Natural and artificial forests for research	30
(3)	Indigeneous species arboretum	20
(4)	Precious wood arboretum	4
(5)	Introduced species arboretum	27
(6)	Coniferous forest	16
(7)	Recreation area (Including road)	26

Flower tree garden	6.1
Fruit garden	3.6
Palm garden	3.2
Bamboo garden	2.5
Soccer ground	2.5
Athletic Field	1.7
Parking lot	0.3
Road	2.1
Pond	0.4
Picnic	3.0

3.2 Primeval Reserve Forest

A block of the university forest covering 150ha and the north of B block covering 27ha totaling 177ha are the primeval reserve forest. Of these, the primeval reserve forest of A block prohibits human trespass and cutting whole area. But the primeval reserve forest of B block is

permitted to use for study, survey and ovservation for ecology, dendrology and forest science only.

This area is also the sanctuary of wildlife.

Although sidewalks are provided for survey and observation in B block, attention shall be paid for the construction not to disturb the vegetation.

3.3 Natural and Artificial Forests for Research

The district which is mainly composed of the second growth of 30ha to north-west of highway of B block is to be the natural and artificial forests for research.

The purpose of this natural and artifical forests for research are to observe and record the succession of plant and animal in natural condition. For this object, the observation and exploration roads are provided.

3.4 Indigeneous Species Arboretum

3.4.1 Species

The arboretum of indigeneous species which is growing in East Kalimantan is established on the hillside of 16ha from east side of B block to south side.

Some of family name and local name of species growing in East Kalimantan are as follows.

	Family Name	Local Name	
(1)	Anacardiaceae	Asam Pajai	Asam Putaran
		Rengas	Sumpung
(2)	Annonaceae	Banitan	
(3)	Apocynaceae	Jelutong	Pulantan
(4)	Bombacaceae	Durian anggang	
(5)	Celastraceae		
(6)	Combretaceae	Ketapan	
(7)	Datiscaceae	Bennang	
(8)	Dilleniaceae	Simpur	
(9)	Dipterocarpaceae	Bangkirai	Belangiran
		Damar	Kenuar
		Kay tahan	Keruing
		Kapur	Lempong nasi
		Lempung tambaya	Lempong Kumbang
		Merkabang	Putang Resak
		Tempudau	Tengkawang

(10) Ebenaceae	Kayu hitam	Kayu batu
(11) Fagaceae	Paning[2] (Pinanak)	
(12) Guttiferae	Bintangur	Gerunggang
	Marsimpa	Penaga
	Semangkap	
(13) Lauraceae	Medang	Kayu besi (Ulin)
(14) Leguminosae	Kompasia	Keranji Petai
	Sansanit	
(15) Lythraceae	Bungur	
(16) Moraceae	Bitawa	Keladang Tarap
(17) Myristicaceae	Mandara	
(18) Myrtaceae	Ubah	Palawan
(19) Olacaceae	Bawang	Nahung
(20) Polygalaceae	Kacapuri	
(21) Rubiaceae	Kelempayan	Jambu-jambu
(22) Sapindaceae	Rambutan	
(23) Sapotaceae	Kotian	Nyatoh
(24) Sterculiaceae	Dungun	Bayur
(25) Others		

3.4.2 Method of Establishment

Timber cruise will be made in the proposed area of arboretum and a list of species now existing as well as a location map of standing trees will be prepared. Of the existing species, at least one tree will be reserved through very light and frequent thinning, trees reserved and planted will be properly arranged not to bring about a large open space. In arrangement, consideration will be paid to the promenade. Trees to be left at the arboretum will be given name plates of family, genus and local name. It is considered that trees not found in this arboretum will be introduced and planted at the opened spot or line.

3.5 Precious Wood Arboretum

An arboretum of precious wood trees which are native or exotic species is established at the low land area of the foot of mountain covering 4ha in the center of B block.

3.5.1 Species

Some species of the purpose are as follows.

a) Special Wood

(1)	Rose wood	Dalberga latifolia	(Liguminosae)
(2)	Sissoo	Dalberga sisso	(")
(3)	Johar	Cassia siamea	(Liguminosae)
(4)	Narra	Pterocarpus indicus	(")
(5)	Pradoo	Pterocarpus macrocarpus	(")
(6)	Padauk	Pterocarpus dalbergioides	(")
(7)	Red narra	Pterocarpus vidalianao	(")
(8)	Kuku	Pericopis mooniana	(")
(9)	Kamagong	Diospyros discolor	(Ebenaceae)
(10)	Ebony	Diospyros ebenum	(")
(11)	Kayu hitam	Diospyros philosanthera	(")
(12)	Kayu malam	Diospyros discolor	(")
(13)	Cendana	Santalum album	(Santalaceae)

b) High Class Wood

(14)	Jeti	Tectona grandis	(Verkenaceae)
(15)	Sungkai	Peronema canescens	(")
(16)	Mahoni	Swietemia wacrophylla	(Melioceae)

3.5.2 Method of Establishment

Of the above 16 species, those which are planted on trial base in Indonesia, Philippines, Malaysia and Solomon are following 12 species.

Rose wood	Sisso	Johar
Narra	Pradoo	Padauk
Red narra	Kamagong	Cendana
Jeti	Sungkai	Mahoui

The arboretum covers 4ha. For planting, we can get data on trial planting of above mentioned 12 species but such data are not available on the rest of 4 dpecies. However collection of saplings, seeds, scions or cuttings of these 4 species are suposed to be relatively easy, as these are native to Indonesia.

3.6 Introduced Species Arboretum

The arboretum with Introduced species will occupy 27ha on the hillside slope in of the center and the south of B block. The introduced species of this section means trees growing in other area than East Kalimantan.

3.6.1 Species

Representative trees growing in other areas than East Kalimantan as Sulawesi and West Irian are as follows.

Merbau Ipil Bintangoer Matoa
Damar putih

Exotic species which are planted on trial base in tropical rain forest zone (Indonesia, Malaysia, Philippines, Solomon, Fiji and New Hebrides) are identified by family, genus and number of species in the following list.

	Family	Genus	No. of species
(1)	Anacardiaceae	Compnosperma	1
		Mangifera	1
(2)	Annonaceae	Xylopia	1
(3)	Apocynaceae	Alstonia	1
(4)	Bombacaceae	Ceiba	1
(5)	Boraginaceae	Cordia	2
(6)	Combretaceae	Trminaria	8
(7)	Elaeoscarpaceae	Elaeocarpus	1
(8)	Euphorbiaceae	Aleurites	2
		Endospemum	3
(9)	Guttiferae	Calophyllum	1
(10)	Hypericaceae	Colophyllum	1
(11)	Lauraceae	Cinnamomum	1
(12)	Leguminosae	Acacia	1
		Albizia	3
		Callothyrsus	1
		Castanospermum	1
		Leucaena	2
		Pahudia	1
		Xylia	1
(13)	Lythraceae	Lagerstroemia	1
(14)	Meliaceae	Cedrela	4
		Entandrophragma	4
		Flindersia	3
		Khaya	2
(15)	Moraceae	Chlorophora	1
(16)	Myristicaceae	Myristica	1
(17)	Myrtaceae	Eucalyptus	24

		Melaleuca	1
		Tristanic	1
(18)	Proteaceae	Cardwelia	1
		Grevilla	1
(19)	Rubiaceae	Autlocaphalus	1
		Nauclea	
(20)	Sapindaceae	Pometia	1
(21)	Ulmaceae	Celtis	3
(22)	Verbenaceae	Gmelina	2
		Vitex	3

3.6.2 Method of Establishment

As introduced species include fast growing or pioneer species. The planting method will be considered according to the nature of the species.

3.7 Coniferous Forests

Coniferous forests are established covering 16ha on the ridge line in the center of north east and at the bottom of hillside in south side of B block. Conifers to be selected are Araucariaceae, Pinaceae and Podocarpaceae of Indonesian and exotic origin.

3.7.1 Species

Species belonging to families of Araucariaceae, Pinaceae and Podocarpaceae which are planted or planted on trial base in tropical rain forest zone together with native to Indonesia are shown below.

a) Araucariaceae

(1) Agathis

Agathis alba
Agathis beccari
Agathis borneensis
Agathis celebica
Agathis labillardieri
Agathis loranthifolia
Agathis moorei
Agathis palmerstonii

(2) Araucaria

Araucaria bidwillii
Araucaria columnaris

Araucaria cunninghamii

Araucaria excelsa

Araucaria hunsteinii

b) Pinaceae

(1) Pinus

Pinus caribaea

Pinus merkusii

Pinus oocarpa

c) Podocarpaceae

(1) Dacrydium

Dacrydium elatum

(2) Podocarpus

Podocarpus spp.

3.7.2 Method of Establishment

The ridge line in the center of north east will be the arboretum of conifers of Agathis and Pinus.
This area covers about 9ha and on the basis of 1ha for one species the forest can be established by clear-cut reforestation system.
The bottom of hillside in south covering 7ha will be the arboretum of Araucaria, Dacydium and Podocarpus. The establishment by clear-cut reforestation are also possible here.

3.8 Establishment of Recreation Area

3.8.1 Basic Idea of Establishment

We will consider the recreation activity in the tropical rain forest.
In order to make use of forest as recreation space, it is necessary to reconstruct the forest to serve the recreation purpose.
The environment of natural forest shows some limitation for climatic condition, visual amenity and recreation activity.
For establishment of recreation area, according to allotment of recreation area by above zonging, secure of recreation space and establishment of landscape well balanced surrounding forests have to be carried.
Access roads to surrounding forests from recreation area which is the base of recreation activity are constructed and also the courses for explore and study in thr forests are built.

This exploration courses are provided with arboretums of introduced species, indigeneous spedies and conifers forests and also provided in observation area of virgin forest.

The location of the university forest is 12km from the town of Samarinda and it is supposed that the university forest has a nature of urban and suburban forests. In general, shortage of parks with athletic facilities are felt in towns. From such considerations, recreation facilities are considered to provide:

Parking lot, forest road
Cycling road, promenade
Soccer ground
Picnic ground
Athletic field
Lawn ground (together with palm farm and flower tree arboretum)
Flower tree garden
Fruit garden
Small garden
Operation office (visitors center)

Items of recreation activity in virgin tropical rain forest will be limitted. In this sense, in establidhing recreation area, a large scale change of forests will be made to create an independent world to compare with surrounding forests. Planting of trees is to be examined considering landscape composition, as well.
Since recreation area is directly on the equator, it is considered that many shade trees to redice the direct sun light are to be introduced and planted.

3.8.2 Technical Standards of Recreation Facilities

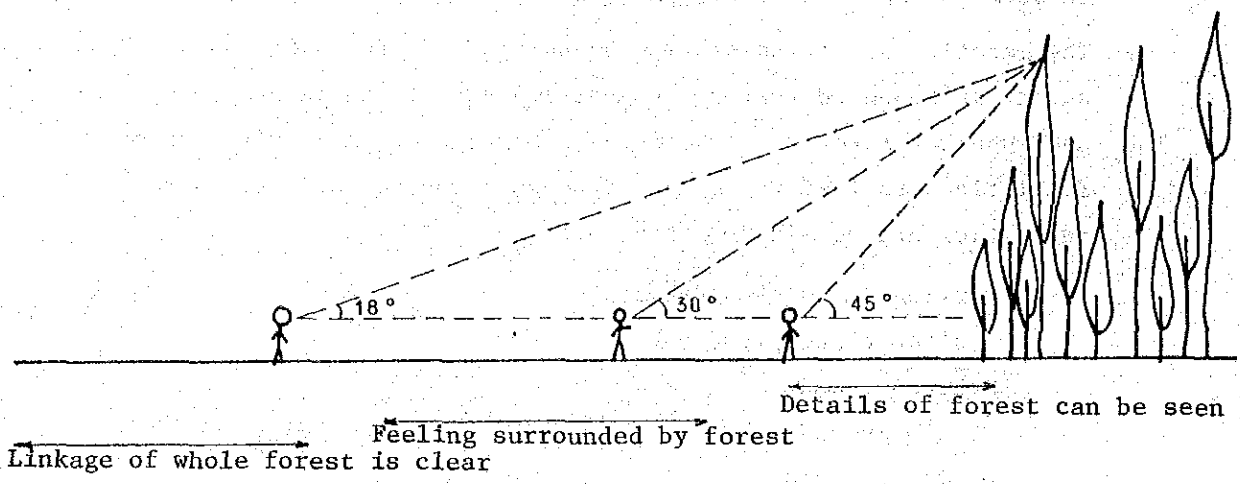
(1) Open Space

Forests in the proposed area are composed of virgin tropical rain forests and the second growth coming out on harvested area of Ulin. The virgin forests are mixed with Dipterocarpus family with the highest tree of 50-60m.

The second growth with remaining some high trees is, as a whole, 10-15m in height.

Here let us consider the extent of the open space based on the tree height in the planned area. The views of forest from several angles of view are summarize as Fig. 3-1.

(Fig. 3-1 Type specimen of view of forest)



Referring to Fig. 3-1, the technical standards are shown in Table 3-1 when an open space is built in the forest.

(Table 3-1 Technical standards when an open space is built in the forest)

Sense of space	an angle of elevation of human vision*	Minimum width in primeval forest	Minimum width of second growth	Minimum width of open space	Minimum width of second growth
When details of forest are objects	Over 45°	Under 50m	Under 15m	Under 100m	Under 30m
Feeling surrounded by forest Feeling in forest	30°-26°	86-102m	26-30m	170-200m	26-30m
Linkage of whole forest is clear	18°-14°	154-200m	46-60m	300-400m	92-120m
No feeling to be in the forest	Under 10°	Over 283m	Over 85m	Over 570m	Over 170m

Remarks: Calculation base - Tree height in primeval forest 30m
Tree height in the second growth 15m
* Kevin Lynch - Site planning MIT Press Cambridge U.S.A.

When details of forest are the object of vision, the open space will be under 100m wide in primeval forest and under 30m wide in the second growth.

In order to produce feeling to be surrounded by forest, the width of open space will be 170-200m in the primeval forest and 25-30m in the second growth.

To make clear linkage of whole forest the width of open space required 300-400m in primeval forest and 90-120m, in the second growth.

In order to create an independent world in open space where we feel not surrounded by forest, the width of open space requires over 570m in primeval forest and over 170m, in the second growth.

(2) Cycling Road

Plan of cycling road is to set up the route which combines recreational resources, recreational facilities and recreational view points.

The items required to present as technical standard in case of design of cycling road are; (a) distance traveled per day and designed speed, (b) surface slope of cycling road, (c) width and surface of road, (d) disposal of curve and shoulder of road, their details being as under.

(a) Distance traveled per day and designed speed

The distance which the beginners can travel by bicycle joyfully is 40-50km/day.

The distance from Samarinda to the planned site is 12km.

If its standard is 40km, the total length of cycling course established in the planned area is 15-16km at the most.

The travel speed of bicycle over 40km/h at down slope will bring about fear complex psychologically.

In general, the travel speed of cycling is shown in Table 3-2.

(Table 3-2 Travel speed of bicycle)

	Travel speed (km/h)	
	Ordinary travel 750 rev. per min.	Full speed travel 1000 rev. per min.
Practical bicycle (without change gear)	15	28
Light bicycle (without change gear)	16	32
Sports bicycle (with multistage change gear)	19	26

Source: Japanese Bicycle Industry Promotion Assn.

Ordinary travel speed is good for recreation.
Considering the future trend including popularization of bicycle in Kalimantan, 15-16km/h will be optimum design value.

(b) Surface slope of cycling road

Surface slope of cycling road should have suitable for bicycle travel.
It is natural that the steeper the slope, the shorter the distance gradients and distances of the slope are shown in Table 3-3.

(Table 3-3 Surface slope and limited distance of the slope for bicycle road)

Longitudinal slope (%)	Distance (m)
2.5	450
3	330
4	200
5	130
6	80
7	50
8	20

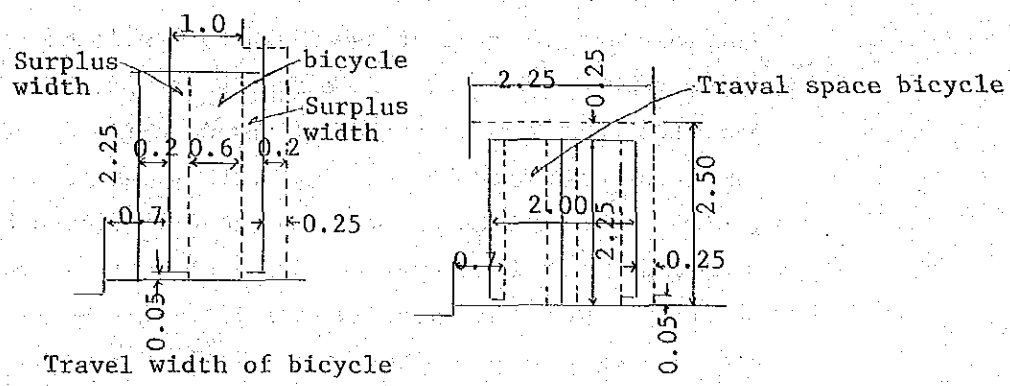
If up grade is over 4%, meandering is liable to be caused.
If down grade is 4%, speed may be 36km/h, we should consider lateral sway caused by brake. Therefore, where surface slope is 4%, the widening of road width should be

taken into consideration.

(c) Width and surface of road

The width of road needed for bicycle traffic is shown in Fig. 3-2.

(Fig. 3-2)



(Unit: m)

In most cases, cycling is done by more than two persons and opposing bicycle passes each other. Ordinary roads are more than 2 lanes. In the forest, open space over 1m wide is provided on both sides of the road.

Asphalt pavement is the most desirable for road surface.

Drainage in the rainy season should be taken into consideration.

(d) Disposal of curve and shoulder of road

Minimum radius of the curve of the road when the speed is 20km/h on flat land, is over 9m.

The curve under ramp, whose surface slope is over 5% and the distance thereof is over 100m, requires 35m radius.

Curve is provided with one-way grade as Table 3-3 and width of road is widened under ramp.

(Table 3-4 Size of curve radius and one way grade)

Curve radius (m)	Under 30	Under 60	Under 100	Under 250
One way grade (%)	5	4	3	2

(3) Promenade

Promenades are provided with rest points at every enjoyable distance for pedestrians, and thus giving them visual variation to avoid fatigue.

Walking distance of usual visitors who come by car is shorter than distance of those who come for hiking. The hiking course of one day may be 20km at the most.

The shortest distance of usual visitors will be 250-300m.

If we expect the effect of recreation on promenade, it is important that the promenade offers wide fields of vision. The promenade environed by the lawn open space, the center of recreation, the standard width of road is 5-6m and that of promenades in the forests are 1.5-2.0m. Steps are formed properly, where the slope is over 15°. If the road is clayey and in danger of becoming slippy, it is better to provide steps from 10°. The standard of slope of step work is as follows:

$$2h + b = \text{from } 60 \text{ to } 65$$

where hcm is height of step and bcm is width of step.

(4) Parking lot

The area of parking lot depends upon the number of visitors. Total population including that of in and around Samarinda is supposed to be 250,000. Assuming that visitors to the universuty forest in a year are 5% of the total population and the largest number of visitors per day in ordinary case is 5% of the former, the scale of facilities is 625 men/day. If visitors by bus occupy 70%, those by car, 20% and others, 10% and turn-over rate is 2, the required area of the parking lot is shown in Table 3-5.

(Table 3-5 Necessary Area of Parking)

Traffic Facilities	Expected visitors	Passenger per car	Parking car a day	Revolution	No. of car parking	Req. area per car (m^2)	Req. area (m^2)
Bus	437	50	9	2	4.5	100	450
Car	125	4	31	2	15	25	375
Others (bicycle)	63	-	-	-	-	-	-

Therefore, the required area of parking lot of 800m^2-900m^2 is quite enough in ordinary case.
When a soccer game is held, as we expect many people on that day, an ample space of parking lot is secured.

(5) Operation office

Based on 625 men/day of the largest number of visitors, if utilization rate of center is 30%, and turn-over rate is 20, the sojourner at the same time is 9 persons. Then, the capacity of office is to be 10 persons.

(6) Athletic field

The athletic field includes various facilities of exercises in the course of 1.5-2.0km and the people are moving and playing games, there. It is important to set up facilities of athletics making use of materials and topography in the forest.
Sport entries events, as shown in Fig. 3-7, running, vaulting horse, broad jump, stump jump, balance beam, balance bar, log jump, sky ladder, walking on net, green caterpillar, hanging down, jumping down from step, crossing valley, crossing like crab, lifting stone, walking on the wall etc. and a course is established with the combination of the above sports.
Facilities are to be so arranged that players can choose facilities of short course or of long course fitting to their physical strength. As athletic facilities are mainly made from timber and the region is highly humiduous, it is necessary to use woody materials hardy against rot and to examin the facilities frequently.

(7) Picnic ground

Three factors of picnic are "look", "rest" and "move".
The picnic ground is composed of grove which is used as green shade and open lawn where people can move around freely and enjoy landscape. The standard area need for one person is 15-20m^2.
Facilities include drinking water, cooking tables, trash boxes, out-door tables, benches, arbors etc. For management of these facilities, there is a need to set up management road.

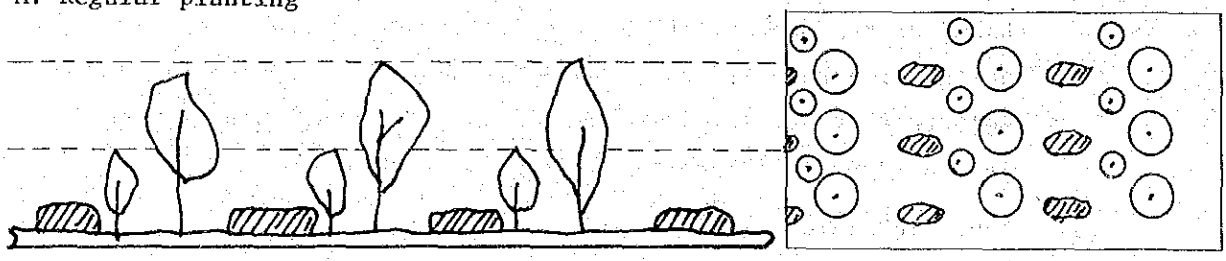
(8) Landscape planting

Planting in the recreation area is an important factor for

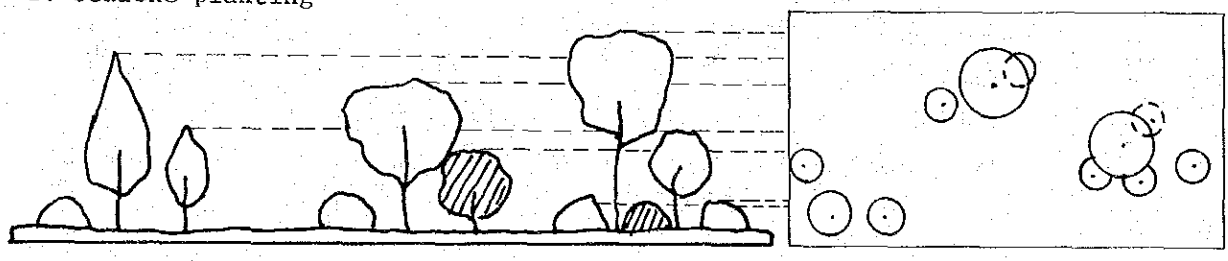
landscape composition. The method of planting in recreation area is as follows.

(Fig. 3-3 Planting types)

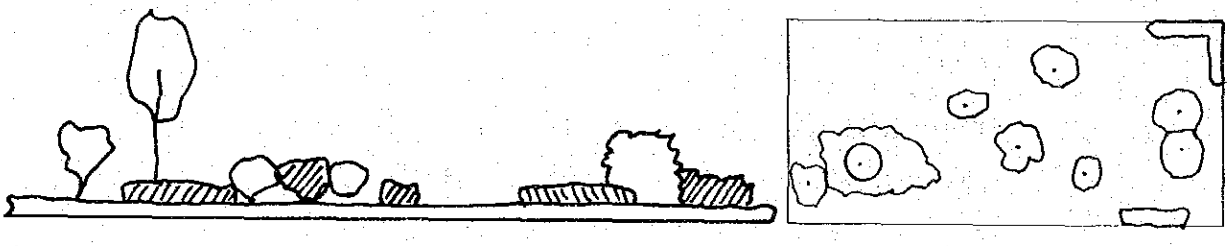
A. Regular planting



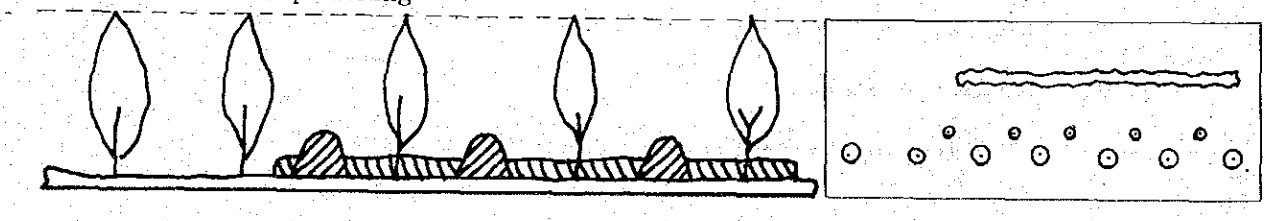
B. Scalene planting



C. Low trees planting



D. Row of trees planting



Planting types are shown in Fig. 3-3.

A: Regular planting (equal interval)

B: scalene planting (unequal interval)

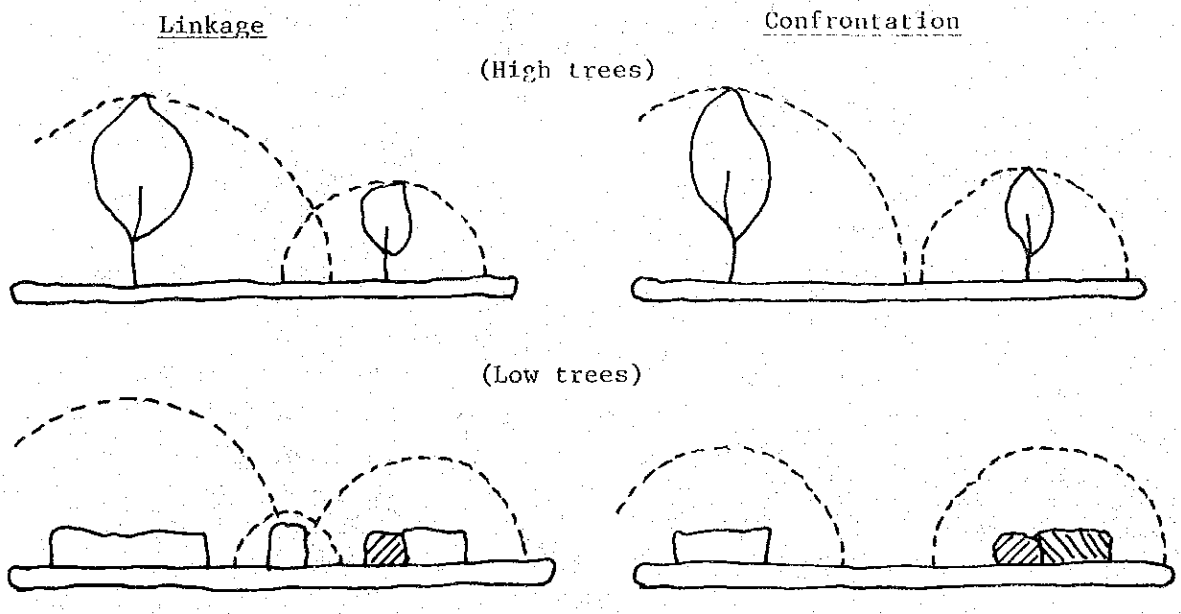
C: Shrubs planting

D: Row of trees planting

E: Single tree planting

Relationship between linkage and confrontation arising in the intervals of adjacent trees of similar forms, excepting the case where trees differ significantly in form or color, is that when the circles with radius of tree heights overlap, there is the linkage and when they do not overlap, there is the confrontation. In case of shrubs being planted in groups the, linkage is influenced by maximum widths of the planted groups rather than their heights. (See Fig. 3-4)

(Fig. 3-4 Linkage and confrontation of adjacent trees)

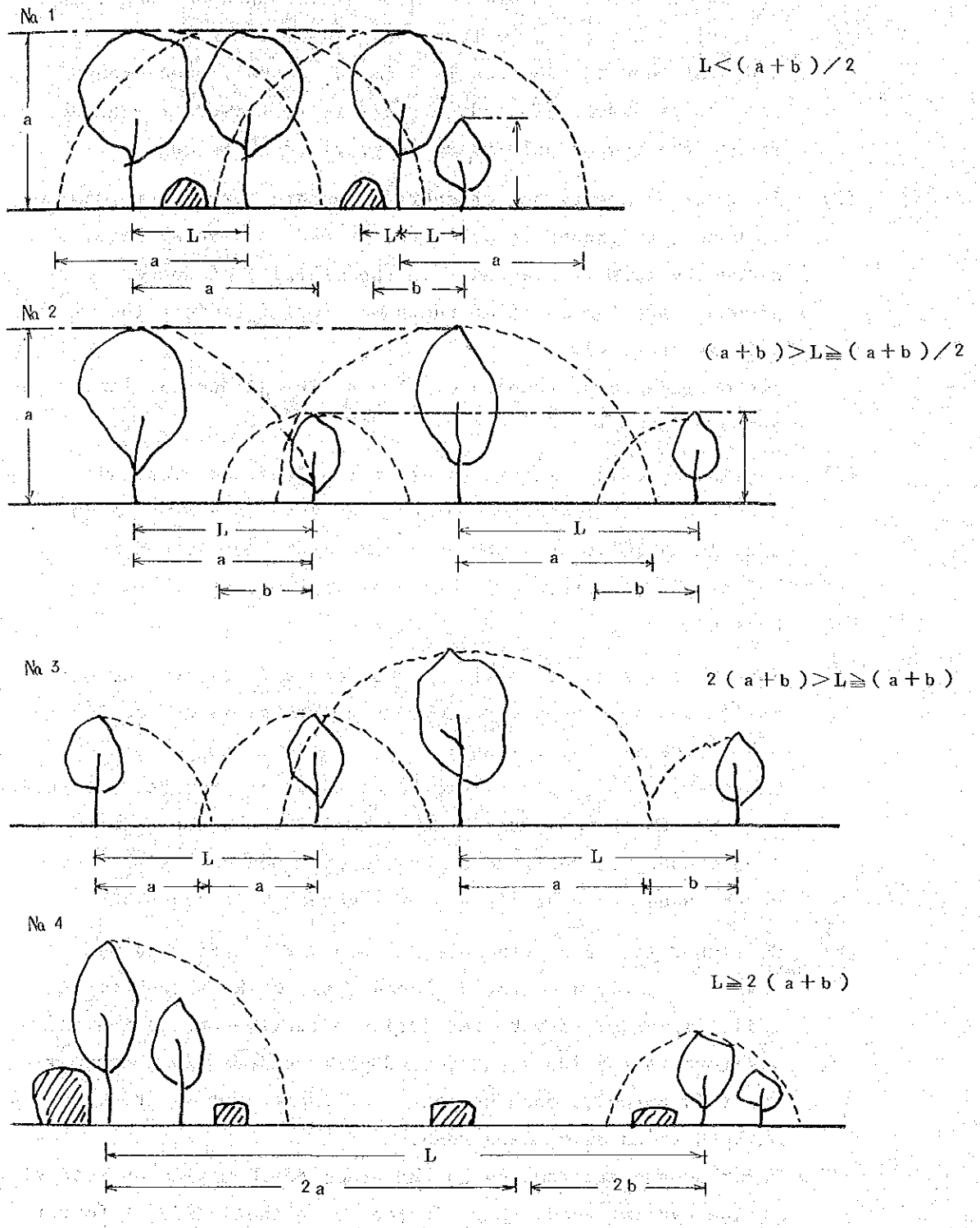


Based on the relation of linkage and confrontation, letting mutual distance between highest trees in a group be L and tree heights be a and b, the planting interval is arranged as shown in Fig. 3-5, type specimen in Table 3-6

(Table 3-6 Appearance by planting interval)

Relation of a, b and L	Appearance
1. (a + b)/2 L	Looks like a group
2. (a + b) L (a+b)/2	If same height, they continue
3. 2(a+b) L (a+b)	If middle and low trees are mixed they continue
4. L 2 (a+b)	In teneral, they are separate groups

(Fig. 3-5　Type specimen of planting interval)



4.8.3 Model Plan of Facilities

Descriptions by planned area are as follows.

(1) As a whole, in order to connect operation office, parking lot and flower trees garden with fountain visually, the ground over of lawn is made 200m wide on both sides and 300m long with sparsely scattered palm trees and flower trees.
Width of road in the area is 5-6m and a small open ground for rest is provided. To induce visitors to flower tree garden with fountain a row of palm trees is provided 100m long.

(2) In order to secure soccer court (standard form 70m x 105m) which is used play ground as well, the ground is leveled below 5% of slope and lawn is planted. In the vicinity of soccer court, lawn ground (used for stand at the same time) (gradient 10-15%) 20m wide is provided.
Its outside is surrounded by flower tree garden for landscape purpose.

(3) Cycling road is designed as 6% of longitudinal slope as standard. Total distance of cycling road is 4.6km. A shed for bicycle is built at south east side of soccer ground as starting point and the entrance is made carriage way for the purpose of control.

(4) The cycling road has 8 sites to afford a fine view, topographical variations such as river and ridges, crossings of traffic road and recreation facilities.
Moreover, where visitors are retained there provided with small open spaces of 400-600m^2. These small open spaces are not always lawn ground but designed to have wide range of vision. Here green shade trees are left over together with new plantations.

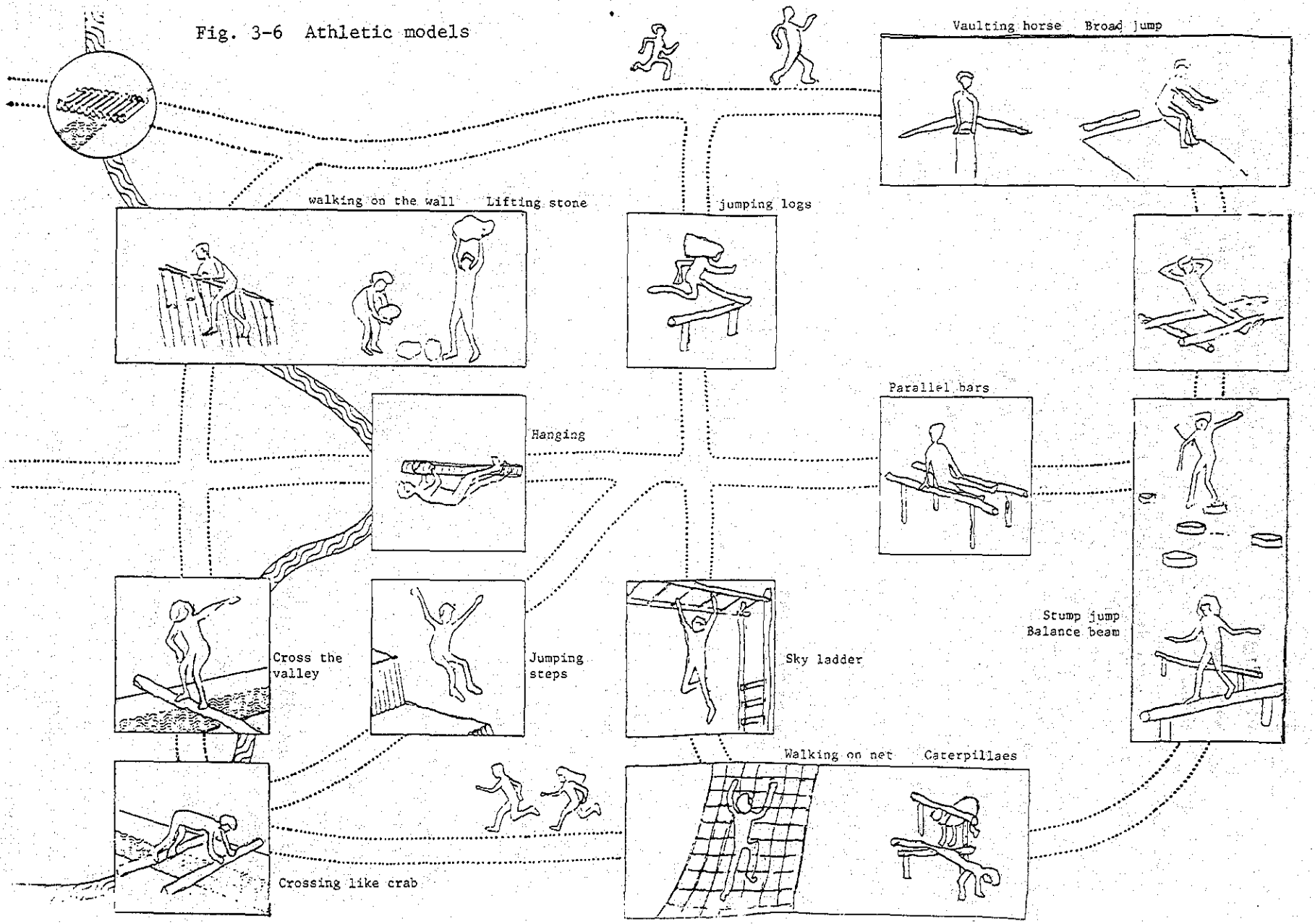
(5) Cycling road, as a principle, is one-way traffic and when the road is jointly used for promenade, sidewalk is secured without fail. In order to make recreation effective and to invite visitors to the inner part, good perspectives are necessary. For this purpose, open spaces of at least over 1m are provided on both sides of cycling road.
Undergrowths are removed in the areas 80-100m wide on both sides of the cycling road, thus lightening up the inside of forest.

(6) Picnic ground is lawn plot with green shade trees left over and

planted around a pond made by daming up stream. Any place offering a fine view is made observatory open space and on gentle slope downward cooking spot is made. Further drainage and water supply, out-door table, trash box, and toilet are provided.

(7) As regards athletic facilities, without providing full scale course, spart outfits are arranged in smaller area. Some sidewalks are used as substitutes for running courses. Model plan is shown in Fig. 3-6.

Fig. 3-6 Athletic models



(8) Flower garden has roads in radial directions centering around fountain, and is surrounded with flower bed of shade trees, flower trees, foliage plants etc. Apergola is built for shading.

(9) As there are many good walkers in Kalimantan, the promenade is extended to arboretums with indigenous and introduced species and conifer forest together with forest for research.
Trails are provided in some part of protection virgin forest which, being off limit for visitors, used for researches only.

(10) Pond is established by daming up stream. Lawn plots spaces are on both sides of pond connected to picnic ground and cycling road. In the lower ground below the bank, emerged plants are planted to protect flood as a storage basin.

3.8.4 Planting Materials

(1) Palm Garden

In lawn open space of recreation forest, several trees of every one species of palm tree are planted to establish demonstration forest of palm tree. Species of palm tree are as follows.

1)	Oil palm	Elaeis guineensis
2)	Sealing wax palm	Cyrtotochys lakke
3)	Rattan palm	Daemonorops mollis Syncalanus mollis
4)	Thorn palm	Oncosperma tigillarium
5)	Coconut tree	Cocos nucifera
6)	Queen palm	Arecastrum romanzoffianum Syscocos plumosa
7)	Date palm sp. Patiles	Phoenix doctylifera
8)	Talipot palm	Corypha umbraculifera
9)	Ivory nut palm	Metroxylon amicarum syn Coelococcus carolinensis
10)	Royal palm	Roystenea etata syn R regia
11)	Travellers palm	Pauenala madagascariensis

(2) Bamboo Garden

Bamboo garden is established to the east side of valley.

(3) Flower Tree Garden

A part of lawn open space is a flower tree garden inhere tropical flower trees are collected.
Species are as follows.

1)	Talisay (ph)	Terminalia catapa
2)	Amherstia	Amherstia nobilis
3)	Asoka	Saraca indica
4)	Sukun Timbul (celi)	Artocarpus incisus
5)	Brownea	Brownea grandiceps
6)	Pink casia	Casia javanica
7)	Tangi (Bali)	Lagerstroemia speciosa
8)	Kelor/Pala (Bali)	Moringa oleifera
9)	Poinciana	Delonix regia
10)	Jacaranda	Jacaranda acutifolia syn. J. mimosifolia

(4) Fruit Garden

Fruit garden is established in lawn open space where fruit trees native to Indonesia are collected. Species are as follows.

1. Durian	2. Rambutan	3. Nangka
4. Manggis	5. Mangga	6. Belinbing manis
7. Duku	8. Jambu	9. Salak
10. Sawo		

(5) Others

Roadside trees are planted along roads, cycling road, and promenade. Roadside trees are Kanari (Canrium commune) as general high trees and Calliandra (Callothyrsus meissn) as middle-low trees. Other fruits trees are used.

3.8.5 Planting Method

Stand improvement of arboretum, Fruit garden, Palm garden, Bamboo garden and roadside trees in recreation area will be subject to the aforementioned technical standard.

Planting of lower tree garden has four patterns of flower trees group planting for distant landscape, lawn planting, solitary tree planting, and roadside tree planting. Under the plantation, tolerant foliage plants are introduced.

Palm garden has three planting patterns of palm farm planting, clump planting of 3-5 trees, and roadside planting.

Bamboo garden is established by planting thinly in regular form which affords a fine view from a distance as well as accessibility into forest. Recreation facilities in tropical area require green shade trees. Some of green shade trees have larger width than height.

Shade trees are preferably planted as solitary trees or with over No.4 of planting space according to planting standard. Forest in athletic field is so treated with the removal of 70% of existing trees that open space is made with large trees being left in which facilities are provided.

Picnic ground is clear cut and then lawn and shade trees are planted. When the existing stand is composed of trees with widely extending branches, they are used as shade tree.

Summary of planting pattern is shown in Table 3-7.

(Table 3-7 Planting Pattern)

Planting Area		Planting type Fig. 3-3	Planting interval Table 3-6	Remarks
Flower tree garden	A	A	No. 1	
"	B	E	No. 3	If no flower tree, use green trees
"	C	B,C	No. 1	Introduction of foliage plants under trees
"	D	A	No. 2	No. 3 for roadside
"	E	B,C	No. 3	Introduction of foliage plants under trees
"	F	A	No. 2	
Flower garden		E	No. 3	Flower trees serving for shade trees
Palm garden	A	A	No. 2	
"	B	B	No.3-No.4	3-5 tress in clump
Bamboo garden	A	A	No.2-No.3	
"	B	A	"	Introduction of shade tree and flower tree into a part of the area
Athletic field		B	No. 3	Partly shade tree is introduced
Soccer ground		D	No. 1	Located below the sidewalk
Fruit garden		A	No. 2	
Row of flower tree		D	No.1-No.3	Two stages of row trees in the case of No. 1
Row of fruits trees		D	No. 2	Along the national way No. 3 is introduced
Row of palm trees		D	No. 2	
Picnic ground		E	No. 4	

4. DESIGN OF FOREST ROAD IN THE UNIVERSITY FOREST

4.1 Principle of Forest Road Plan

In construction of socalled general public road, the primary objective is to connect a city or the center of a town with another in the shortest time.

But the construction of forest road in the university forest is closely related to the size of forest area which is utilized by forest road. The forest road in the university forest now under plan is effectively used during construction of various facilities and after completion of facilities, it is used as a trunk road of branch lines such as promenade, path and cycling road. Such consolidated road network should be designed to provide the university forest with highest utility in learning, observation, and recreation. Through this plannig no topographical map of whole university forest was available but that of 1/50,000 in scale. Ror this reason, detailed topography could not be grapsed beforehand and we have planned to pass the most effective location in the facilities planning area of this university forest through reconnaissance. As a result, based on these topographical conditions as well as the request from the university, we have decided the most econimical and effective route considering the following points.

(1) Cutting and banking are to be carried out as little as possible and in removal of surplus soil it is spread out and its sloping surface is finished according to the attached "Standard of Earth Work".

(2) As the route near the river is susceptible to disasters, beside such route is located as for apart from the river as possible, it is made to pass ridges as much as possible, avoiding low and humid area.

(3) It is considered that the route will pass sunny places as much as possible and drainage facilities are also planned.

(4) Structures as bridges are as few as possible.

(5) From the viewpoint of recreation, ladscape consideration is taken.

(6) Standard and structures are determined as semipermanent type.

4.2 Outline and standard of Design

4.2.1 Outline of Design

(1) Survey

The forest road starts from the beginning point on the highway now under construction and reaches the ending point on the hill-

platan near center of this university.
About prearranged 3 calibration routes surveying and reconnaissance were made and after deliberate comparison of 3 routes the best scheduled route was decided.

(2) Reconnaissance

Tentative intersecting points (IP) for scheduled route decided by survey and center line by broken line were set.

(3) Actual Survey

a) Traverse survey

Tentative IP by reconnaissaice, after adjustment, were confirmed and IP peg was set up. The locations of IP were confirmed considering of curves, longitudinal slopes and structures. Measurements of intersecting angles (IA) were conducted by small-transit reading 1 minute; bending parts under 165° were provided with curves and pegs of beginning of curve, middle of curve and end of curve were also set up. Along the center line station pegs were established at the point of changing topography and of structure location. On the straight center line cumulative distance pegs were established at intervals of about 30m. The horizontal distances were measured by vinylon tape 50m long with the accuracy of 10cm unit.

b) Profile leveling

Profile leveling is done by small-transit and leveling rod in which benchmarks were established and ground height of each station peg was measured. Measurement of ground heights were done up to cm and bench marks were established one every 500m by using standing trees and stumps.

c) Cross sectioning

This survey was to measure lateral profiles perpendicular to the center line of the route being operated from station pegs to the necessary distances on bothsides.
The measuring was made on points of changing topography with pale and spirit level with the accuracy of 10cm unit.

d) Survey of hindering trees

This work was to survey trees within the planned extent along

the route by offsetting. Thus the number of hindering trees was obtained about each diameter class.

e) Survey of structures

In survey of bridge the following points were paid attention to:
Direction and angle of center line made with stream,
High water level, low water lenel and discharge, the bridge being wooden beam type to be designed by the system of Ministry of Construction of Indonesian Government. In survey of drainage facilities the following points were paid attention to:
Location of structure as will as angle and direction of drainage made with center line,
All of Materials are native timber.

f) Decision of Formation Level

In deciding formation level, based on the result of various surveys we paid attention to safety, smoothness and economy of traffic.

g) Materials for work

All structures such as bridge, box-culvert and intake box are made of Ulin which is obtained from the university forest.
As durability of Ulin is said to be 100 years, they are used for semi-permanent structure and the price is moderate and strength is high so that the wood may be best for structure.
Materials for upper and lower roadbeds and rubble stones for structures are gravel and boulders produced near the job site.

4.2.2 Design Standard

Most of this forest road are those concerned with the university and general citizens centering Samarinda City but the latter are prohibited to drive in the forest road for prevention of accident. Therefore, as the general citizens are obliged to walk in the forest road after parking their cars at parking lot, those who can drive in the forest road are only the people concerned with the university so that the car speed is designed to be 20km/hr. The effective width of 3m is sufficient enough and shoulders of 50cm are designed on both sides.

Since the heights of cutting and banking are below 5m and earth is soil or clay, the slopes of cutting and banking are to be 1:0.8 and 1:1.5 respectively. Considering traffic condition, the turnout is set up every 300m with standard width of 6m and length of over 20m and near Ending Point (EP), the turnaround is set up.

Because of soil or clay, the thickness of subbasement is 30-50cm to provide large solidness.

The upper subbasement is 10cm thick and crossfall is 4%. Curve radius is 15m at the minimum and width in curve section with radius less than 25m is to be widened.

Widened width by curve radius is shown below and smooth travel of car is considered.

Curve radius (R)	Widened Width (W)	Length of transition part (I)	Widening amount at BC & EC (W')
less than 15m	0.8m	5.0m	0.69m
16m	0.6m	5.0m	0.53m
18m	0.5m	5.0m	0.44m
20m	0.4m	5.0m	0.36m
22 - 25m	0.2m	5.0m	0.19m

Longitudinal slope is 11% at the steepest portion and where the change of slope is over 5%, longitudinal curve is set up.

4.3 Suggestions on Work Practice

(1) Preparatory Work

a) Road, side slope and the like are constructed according to the "Standard of Earth Work"

b) Confirmation of pegs and setting of check points

In starting work, the starting survey is undertaken and IP peg, station peg, B.M. and other pegs are confirmed.

Marking stakes necessary for the work and in danger of being lost during the work are transferred or check points are set up.

c) Finishing stakes, in accordance with attached "Standard of Earth Work" are set up intervals at need.

d) Tree cutting

Standing trees are cut down at the bases in the planned area and remove together with bushes and grasses out of the area. In portions where banking heights are over 50cm, stumps are allowed to be left.

The area of cutting and removal of stump is to cover the portion of over 2m outside of the top of cutting slope and the bottom of banking slope. Obstacles in the disposal area of surplus soil are removed.

e) Preparatory drainage

In starting the work, the dead water is drained out of the working area by excavation without timbering.

(2) Cutting Work

a) Cutting is excavation according to finishing stake.
In excavation, attention is paid not to excavate deeper than F.L.

b) The face of cut slope is to be finished as specified type without unevenness and bending.

c) The face of slope is to be worked without overcut.

d) Side-ditch is to be excavated according to "Standard of Earth Work".
The end of side-ditch is induced to proper spot where water does not flow in directly to banking or back of structure.

e) In order to prevent flow out of disposed surplus soil, protection facilities as log fence are set up.

f) If the face of slope is in danger of scouring or rupture caused by surface water or spring, intake and drainage facilities are provided at the top of slope, the bottom of slope and the face of slope.

(3) Banking Work

a) The face of slope, following finishing stake, is stamped in parallel from bottom to top.
Width of stamping is over 30cm.

b) Extra-banking is required to finish the specified F.L.

(4) Sodding Work

a) Materials are native Axonophus compresus and Cyperus sp., and

2-3 stumps are planted at intervals of 30cm.

b) Grasses for planting, after collected, are paid attention to prevent their roots from drying up and are planted as soon as possible.

(5) Wooden Pile Driving

a) Pile is to be without crack, large knot, dead knot and rotten knot.

b) When head of pile is crushed under driving, it is cut off at the minimum or repaired produced.
When piles are cracked or miss-driven, they are taken out, re-driven or additionally piled.

c) After completion of piling, the heads of piles are cut horizontal to the specified heights.

(6) Road Work

In spreading road materials, rutted or uneven surfaces are leveled and materials are spread. In filling holes, muds in large holes are removed and good materials are put in up to the original level. Local materials of moderate prices are to be used; the diameters of grains are to be under 20cm.

(7) Wooden Bridge

a) Material is native Ulin as a rule.

b) Bridge materials are to be free from defects affecting strength such as twist, bending decay, etc. and completely dried.

c) Lumbers are to be of specified sizes and forms.
Handrail or any other members requiring good appearances are to be planned.

d) Head of wooden sheet pile is to be cut accurately horizontal and chamferred.
In driving, iron cap is used as much as possible to prevent damage of head.

e) Metals for bridge are to be of even quality and free from insufficient welding and other defects.

(8) Ditches and Others

Intake box and box-culvert are subject to the attached diagram and materials are the same as those for bridges.

5. ROUGH COMPUTATION OF WORKING COST

5.1 Working Cost

The total cost of the work of university forest development is about 103,000,000 yen as shown in Table 5-1 and the cost of each work stage is given in Table 5-2.

The depriciation cost and the like of equipments used in this work are excluded.

(Table 5-1 Total Table of Working Cost by Items)

Item	Amount	Sum	Note
Formation of Arboretum	67ha	(One Million Yen) 16	Indigenous species arboretum, Conifer forest, Precious wood species arboretum, Introduced species arboretum
Equipments for Recreation	26ha	40	Soccer Ground, Athletic Field, Picnic Area, Flower Tree Garden, etc.
Path Trail Cycling Road	1,420m 6,030m 4,600m	34	
Forest Road	1,960m	13	
Total		103	

(Table 5-2) Total Table of Working Cost by Stage

Stage	Item of Work	(Unit 1,000 yen) Cost
	Forest Road	13,084
	Fence	575
1st	Cycling Road	9,906
	Pond, etc.	3,540
	Operation Office	
	Sub Total	27,105
	Soccer Ground	3,220
	Earth Work for Recreation Area	9,350
	Flower Tree Garden	2,135
2nd	Bamboo Garden	797
	Palm Garden	1,019
	Fruit Garden	1,366
	Path	8,546
	Trail	6,030
	Sub Total	29,261
	Spring	13,000
	Shelter	69
	Cooking Center	259
3rd	Pargola	80
	Small Garden	1,300
	Picnic Area	3,000
	Sub Total	17,708
	Indigenous Species Arboretum	4,762
	Precious Wood Species Arboretum	952
4th	Introduced Species Arboretum	6,429
	Conifer Forest	3,802
	Athletic Field	420
	Cycling Road	9,906
	Sub Total	26,271
	TOTAL	103,565

5.2 Basic Principle of Computation

5.2.1 Forest Road

As this forest road is used in preparatory works of this university forest such as cutting, reforestation and other various establishments of facilities, it is considered necessary to the work of this forest road before any work else. Thus, based on the results of varioud measurements, the more detailed computation of working cost was made in case of forest road than others according to the following.

(1) The construction of forest road was computed under the condition of the university direct management system.

(2) Of civil engineering equipments, bulldozer of 11tons is used and the proper value of work efficiency is adopted considering the actual conditions of the field.

(3) The progresses of works of earth work, ditches and bridge are computed with the standard value.

(4) In computation of wooden materials, only lumbering and manufacturing cost are counted but not the price of standing trees fitting the field situation, assuming that the standing trees in the university forest are used.

(5) About unscreened gravel and crushed stones of road materials the prices delivered at job site are used.

(6) Computation of cutting and banking in earth work is made as follows:
Cross-section is obtained by base-altitude method; volume of cutting and banking is obtained by the average area of both ends multiplied by the distance between of end sections.

(7) Cut surface is entirely sodded and the cost is calculated by the unit price of $1m^2$ multiplied by the whole area.

(8) Banking slope is to be sodded and the cost is calculated in the same way as above.
Slope of spreaded surplus soil is calculated in the same way as above.

(9) Stump-extraction is done with every stump diameter and the unit price is obtained from the work progress of m^3.

(10) Upper roadbed work is 10cm of spreading thickness and 3m of width and calculated the total length, and the cost is obtained from the unit price per m^3.

(11) Lower roadbed work is carried out with spreading 30-50cm thick according to the condition of roadbed. Rolling-fill by bulldozer is computed and the unit price per m^3 is also computed.

(12) Base excavation is done by man-power and its cost is calculated by work progress per m^3.

(13) Log fence is made with log of 12cm in diameter and board, its working and manufacturing cost being calculated from the unit price per m.

(14) Intake is a box made of board and its unit price per box is calculated from costs of lumbering and manufacturing.

(15) Wooden culvert for drainage facilities is calculated on the basis of 10m of lumbering and manufacturing costs and the unit price per 1m is determined.

(16) Computations of wooden bridge cost are made on the bridges of the lengths 7m and 6m and the price per one bridge is obtained from the prices of members and various work progresses.

5.2.2 Other Facilities

Because detailed topographical map is not available, consolidated and accurate basic figures can not be obtained and the precision of available date are low, the detailed calculation of various facileties other than forest road are impossible. We have to make rough estimation of work progress as under.

(1) In regard to path, cycling road and promenade, considering standard and structures, and also conditions of the field, the unit price was obtained from man-power per m.

(2) Preparation of soccer court and parking lot is done by bulldozer and the volume of earth necessary for ground readjustment is estimated considering that the area is relatively flat.

(3) Establishment of arboretum is done by raking off surface soil only and leaving present topography as much as possible and then the volume of earth and the work progress are counted.

(4) Shelter and kitchen are computed by standard work progress as

regards number of work and materials.

(5) Assuming that seedlings to be planted in arboretum and flower tree garden will be cultivated in the study center which is expected to be built newly in near future, the price of seedlings is not counted.

APPENDIX

THE PLAN OF FOREST ROAD

A Table Contens