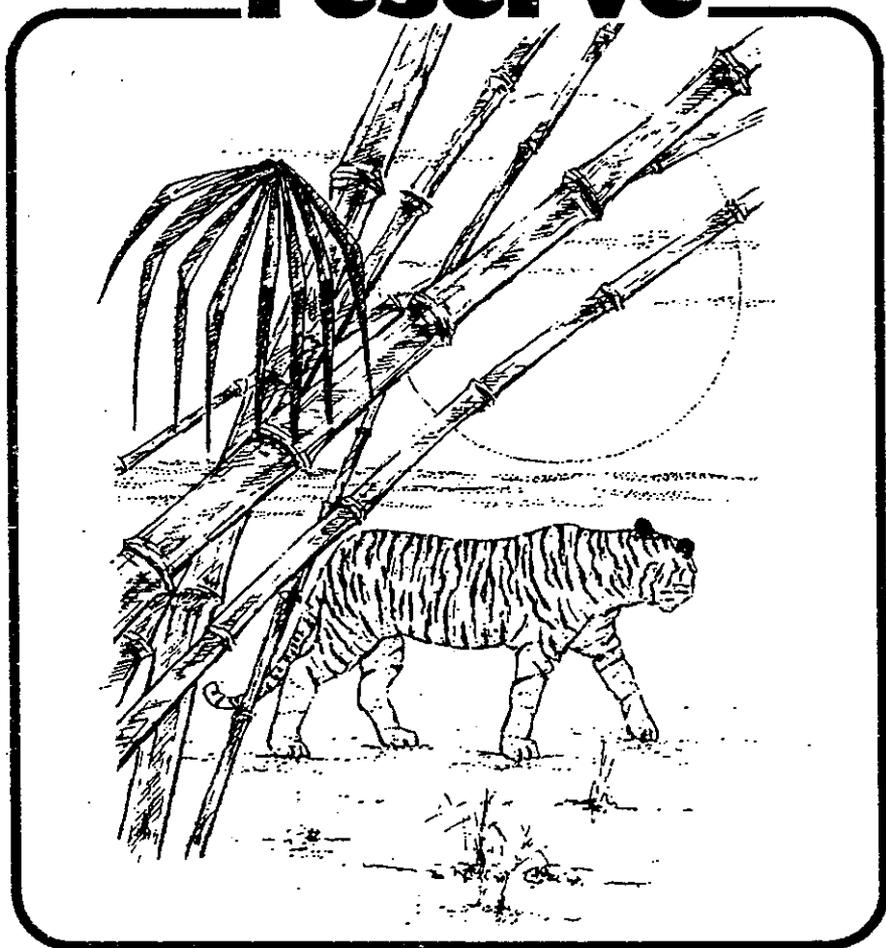


the javan tiger
and the
meru-betiri
reserve



a plan for management



**The Javan Tiger and the Meru-Betiri Reserve
A Plan for Management**

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**The beauty and genius of a work of art
may be reconceived . . . a vanished harmony
may yet inspire the composer;**

**but when the last individual of a race
of living things has breathed its last,
another heaven and earth must pass
'ere such a one can be again.**

William Beebe

THE JAVAN TIGER AND THE MERU-BETIRI RESERVE

A Plan for Management

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SYNOPSIS

The Javan tiger (Panthera tigris sondaica) is in imminent danger of extinction. There are no specimens in zoological gardens. The known wild population is no more than four or five individuals, all of which are living in the Meru-Betiri complex, a mountainous forest on the south coast of East Java. The best chance of preserving the Javan tiger in the wild lies in:

- a. Developing public awareness and sympathy for its plight;
- b. Strict protection from any further killing;
- c. Careful management of the Meru-Betiri Reserve, with provision for the tiger's needs as a primary management goal.

These three factors are equally important and interdependent.

This report summarizes information available on the socio-economic and ecological conditions in the Meru-Betiri area and presents a detailed five-year Management Plan for the Javan tiger and the Meru-Betiri Reserve.

MANAGEMENT PRESCRIPTIONS IN BRIEF

Goals of Management

Manage the Meru-Betiri Reserve in a way that its essential character and value remain intact - that the natural fauna, flora, and scenic features of the area are conserved. Promote regulated use of natural resources of the Reserve for educational, aesthetic, recreational and scientific purposes in such a manner that the natural character of the area will be preserved.

Management Plan

Manage the Reserve according to the work/operations plan (management plan), commencing in 1977.

Legal Status and Boundaries

Upgrade the legal status of the Reserve from Suaka Margasatwa (game reserve) to Cagar Alam (nature reserve); extend the borders to include:

- The production and protection forests north of Gn. Betiri and south of the Kali Sanen where Javan tigers sometimes range
- The offshore islets
- A 500 m zone extending from the shore into the sea.

Authority and Administration

Overall authority will be vested in P.P.A.; the Section Chief is responsible for supervision and planning; a Manager will be responsible for management operations and administration of the Reserve.

Staff Organization, Duties and Training

Total staff for the Reserve includes the Manager, 32 basic level, eleven mid-level, and eight advanced level personnel who are to be organized in five divisions:

- Management and Protection
- Administration and Service
- Research
- Interpretation and Public Relations
- Settlements

All staff are to be given permanent government appointments. The Manager will be assisted in implementation and development of certain

programmes by special teams from the Central Office of P.P.A.

Training of basic-level personnel is the responsibility of the senior Reserve staff; the Manager, advanced and medium-level personnel are to attend special training sessions conducted by the Central Office. All senior staff are to periodically visit other working reserves as part of their training.

Protection and Control of Exploitation

To maintain the ecological integrity of Meru-Betiri and to provide the degree of security needed to protect the last Javan tigers, P.P.A. must:

- Embark on an upgrading programme to systematically phase out exploitation from all areas of the Reserve within the period of the plan;
- Control the movement of people in the Reserve through the use of checkpoints and an active patrol system;
- Acquire control of the plantation enclaves, close down their operations and turn these into wildlife management areas;
- Prevent any further expansion of cultivated areas, effect control of all inholdings and move the people now living there from the Reserve;
- Establish and enforce a 20 km no-hunting zone around the Reserve.

Sea Turtle Conservation

The turtle conservation project must be brought under the full control of P.P.A. All nesting beaches are to be completely protected. The collection of eggs must be stopped.

Wildlife Management

Maintain the "feeding grounds" at Nanggeln, Pringtali, and Sukamade Barst and the plantation enclaves as habitat for large ungulates. No additional feeding grounds are to be cleared. Re-introduce rusa (Cervus timorensis) and banteng (Bos javanicus) to Sukamade Barst, and rusa to Nanggeln and Kali Sanen.

Research

Two research programmes should be undertaken:

- Management-oriented basic studies to be conducted by the Reserve

staff under the direction of the Resident Ecologist. These will consist mainly of completing lists of the natural resources of the Reserve and monitoring population trends of certain animals and plants;

- Detailed studies on selected topics, conducted in cooperation with Universities, visiting scientists, and government agencies. These will consist of special projects of importance to the future management of the Reserve. Other research will be encouraged if it does not interfere with ongoing programmes and is in keeping with the management goals.

All research in the Reserve is to be coordinated through the sub-directorate of Planning, P.P.A. and the Reserve Ecologist.

Education and Visitor Use

A programme of education and interpretation to explain the history, purpose and value of the Reserve and the significance of its unique flora and fauna will be initiated; facilities to assist visitors in enjoying the amenities of the Reserve are required, but these must be in keeping with the primary goal of conservation.

The Reserve staff, in cooperation with interested Universities, will provide an extension programme to encourage an understanding of the value and function of the Reserve and to assist in teaching sound conservation principles. The value and survival needs of the Javan tiger are to be emphasized in this programme.

Public Relations

The Reserve staff has the responsibility of integrating the existence of a viable nature reserve into the lives of local people through education and demonstration of conservation principles that will enhance their lives. A four-point programme is outlined in the plan.

Estate Management

All building construction and other developments within the Reserve boundaries are to be kept to the minimum necessary for management purposes; the design of all facilities will be in harmony with the natural surroundings. The location and construction schedule for all accommodation and facilities is detailed in the management plan.

All trails and roads, except those needed for control purposes, are to be closed; no new trails, except those absolutely necessary for the protection of the Reserve, are to be built.

Transport and Equipment

The Manager is to have a four-wheel drive vehicle; other senior staff and some mid-level staff will be provided with motorcycles. All other staff will be issued bicycles. A launch will be needed to patrol the coast.

The staff must be provided with adequate field equipment. No additional firearms will be required.

If the provisions of the Management Plan are met, Meru-Betiri Reserve will meet all criteria for inclusion in the United Nations List of National Parks and Equivalent Reserves.

INTRODUCTION

MERU-BETIRI AND THE PRESERVATION OF THE JAVAN TIGER

Through the 1800s and early 1900s, Java's largest carnivore, the tiger, was bountied, hunted and killed until, by the beginning of the Second World War, it survived only in a few scattered forested mountain areas and in a few nature reserves (Fig. 1).

Even before the Second World War, there was considerable international concern about the survival prospects of the Javan tiger (2); after the War there was little chance for the situation to improve (3). By the mid-1960s, it was apparent that even in many of the remotest regions of the island the tiger had not survived; it could no longer be found in the most famous and well-protected nature reserves in all of Indonesia, Ujung Kulon, an area set aside specifically for the conservation of the Javan tiger and Javan rhinoceros (Rhinoceros sondaicus) (4). With good reason, many conservationists thought that yet one more irreplaceable animal form was lost forever (5).

There have been continuing scattered reports of tigers living in some of Java's wilder regions - reports of a large cat seen at night in the headlights of a car or a large cat track seen on an isolated beach or beside a mountain stream. Subsequent examinations have shown the animal to be a leopard (Panthera pardus) (5, 6). In the late 1960s, however, there were particularly persistent reports of tigers still living in the Gunung (Mount) Betiri area, a rugged mountain complex on Java's south coast, 60 km southwest of the town of Banyuwangi.

In 1961 a Danish hunter killed a tiger and a melanistic leopard in these mountains; knowledgeable observers insisted a few tigers could still be found living there.

Dr. R. van der Veen, a botanist long familiar with East Java, visited the area in 1971 and reported that a population of tigers probably did exist (7). Later that year the eminent naturalist, A. Hoogerwerf, surveyed the region and established with certainty that there was a small population of tigers (8). If there was to be any chance of preserving the Javan tiger, this is where it would be (9-11).

The survival of the Javan tiger in the wild is dependent upon strict protection and the preservation of its habitat. When the presence of a small population was established with certainty, nature conservation authorities moved quickly. The blocks of protection forests, known collectively as Meru-Betiri, were declared Suska Margasatwa (game reserve) by decree of the Minister of Agriculture in June 1972. To

assist the government of Indonesia in protecting the last Javan tigers, the World Wildlife Fund and the International Union for Conservation of Nature and Natural Resources began providing financial support for the Meru-Betiri Reserve, through WWF/IUCN Project No. 1015 in 1973 (12).

The legal establishment of the Meru-Betiri Reserve and the provision of financial support for its maintenance were the first steps in providing protection for the tiger and its habitat. In the last four years, a number of surveys have been made to determine the tiger's status and to establish management priorities (13-18). These surveys have provided useful observations on the tiger's status and important information on the other fauna and flora of the Reserve. The report by Bartels and van der Veen (17), for example, identified the value of Meru-Betiri as one of the last remaining lowland rain forests in Java, with such rare plants as Rafflesia zollingeriana and Balanophora fungosa. Special emphasis has been given to the need for protecting the sea turtle nesting beach in the Reserve. Since the establishment of Meru-Betiri as Suaka Margasatwa, a small guard force has been established, some staff accommodation constructed and four habitat management projects initiated.

Yet for all this, neither the future of the Javan tiger, nor the future of the Reserve, was secure. The principal problems so far identified were:

- No reproduction had been reported in the tiger population since 1971 when an older female was shot at Sukamade Plantation;
- Protection of the area was far from adequate;
- The ecological integrity of the Reserve was seriously disrupted by the two large plantation enclaves that cover the lower reaches of the major river valleys, appropriating the most suitable habitat for the tiger and its prey (16).

At the request of P.P.A. Director Ir. Prijono, the authors conducted a survey of the Meru-Betiri complex from June to September, 1976 to assess the survival needs of the tiger and to identify the physical and biological features and processes that have implications for future management.

THE MANAGEMENT PLAN

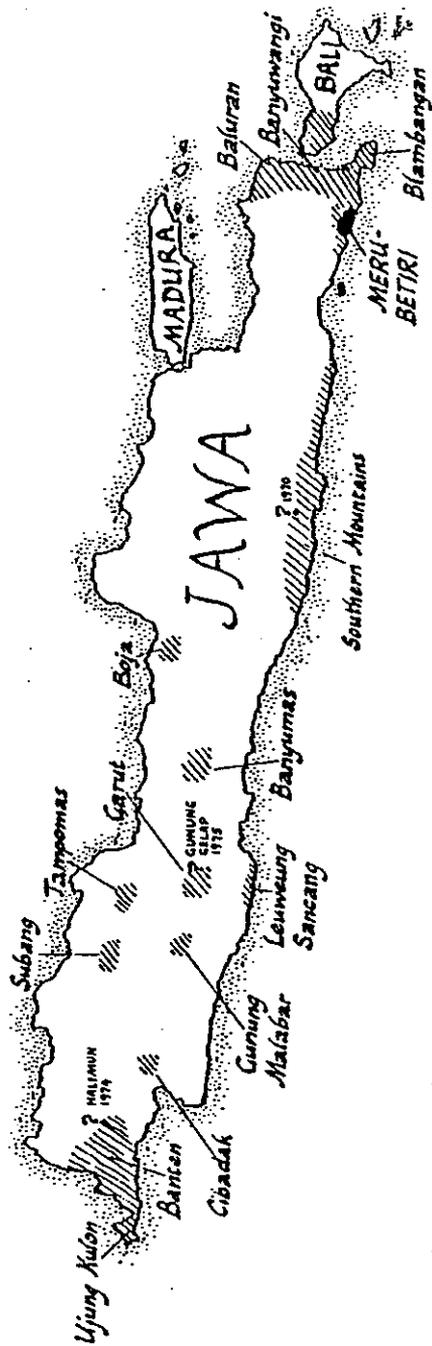
We found Meru-Betiri to be a magnificent area, and we also found that the programme for the management of the Reserve had reached an important juncture. In our judgement, Meru-Betiri can become a fine reserve if appropriate management action is taken, and taken soon. If action is not taken, the Javan tiger will surely disappear and the chance to conserve an extensive selection of Java's natural vegetation types,

Figure 1 The Reduced Range of the Javan Tiger

One hundred and fifty years ago the tiger ranged over most of the island of Java, and was considered a nuisance in some populated areas. By 1940 it was found only in the most remote mountain and forested areas (after Tremp, 9).

By 1970, the only known population was in the Gunung Betiri complex on the eastern south coast. This is an isolated region of the Southern Mountains, protected in the past from extensive habitat alteration by its precipitous and dissected topography. While the last Javan tigers have managed to survive in this rugged area, it is not prime tiger habitat. Careful planning and management are required to ensure that the tiger's ecological needs are met in the future.

TEMPAT HIDUP HARIMAU LORENG TERACHIR
THE TIGER'S DECLINE



Distribution of the tiger ca. 1940

Distribution of the tiger ca. 1970

Unconfirmed reports ? Laporan, belum tentu

a range of vegetation extending from the sea to 1200 m will be lost.

The management programme for Meru-Betiri, or any reserve or national park, will not succeed in the long-run if policy and programmes are formulated on a day-to-day ad hoc basis. Accordingly, the Director General of Forestry is requiring that every designated reserve and park in Indonesia be managed according to a work/operations or management plan. The management plan provides guidelines for the conservation and development of the Reserve over a number of years; it is the control document which guides the preparation of more detailed plans as they are needed.

We have prepared the Meru-Betiri management plan in two parts (19):

The first identifies the Reserve's values, its resources, its relationship to surrounding areas, and the human needs that can be met in keeping with conservation principles;

The second part is a management document which details management goals and guidelines and provides a plan for the protection, interpretation, use, and administration of the Reserve.

Emphasized throughout the plan are the conservation measures necessary if there is to be any possibility for preserving the last remaining Javan tigers.

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Figure 2 The Landscape of East Java:

- a. Lines of commerce and forest areas (including teak plantations);
- b. Underlying geology, Sukamade Beach to Raung Volcano (after van Gemmen, 20);
- c. The intensity of the dry season (after van Steenis, 27).

The Gunung Setiri complex is a distinct physiographic region. The older geological formations underlying this region contrast with the young volcanic complexes that dominate the East Javan scene. The dry southeast winds (June - September) give off rain as the air masses rise over the volcanoes and higher ridges. Pockets of rain forest occur in these wetter areas in a region that is otherwise dominated by monsoon vegetation. The higher areas in the Meku-Betiri Reserve are blanketed with rain forest. The lower areas are transitional forest.

Unfortunately, and to the detriment of the tiger, the critical wildlife habitat in the major river valleys of the Reserve has been converted to plantations of coffee and rubber.

THE MERU-BETIRI RESERVE

NATURAL FEATURES AND PROCESSES

THE SETTING

Travelling southeast from Banyuwangi, you drive along canals and pass by small towns. The land is flat, a mosaic of paddy fields dotted with palms and scattered clumps of bamboo. This is a countryside where man has completely altered the natural vegetation in order to produce food and fibre for his needs. Travelling further, the mountains surrounding Gn. Betiri loom in the distance, at first just a dusty green in the haze; closer, the details begin to emerge on the steep slopes. There is good forest with great emergent trees; the forest and the mountains stand in vivid contrast to the flat, densely populated agricultural land you are travelling through.

The Meru-Betiri Reserve is an area of about 50,000 ha lying on the south coast of East Java (Fig. 2a). Its extent is reflected by its name: from Meru Bay to the top of Gn. Betiri (1223 m). This is a remote region and access is limited. During World War II the Japanese attempted to build a road along this coast, but fortunately for its natural features, they failed. From Jember through Ambulu, it takes more than one hour to reach the plantation enclave of Sandialit, a distance of 30 km. The Sukamade plantation enclave in the east is three to four hours' drive from Banyuwangi by turning off the Banyuwangi-Jember highway either at Genteng (70 km) or Glenmore (100 km). The northeast corner of the Reserve can be reached from the plantation Malangasri, about one hour's drive from Glenmore. For the most part, the roads are unimproved. Travel by jeep or truck is recommended. There is a telephone line from the Sukamade estate to Banyuwangi.

Several physiographic and geological considerations are pertinent to an understanding of the Meru-Betiri ecosystem and its historical development. The Reserve lies in a disjunct section of the Southern Mountains, a belt that extends all along Java's south coast. These mountains are the south flank of the Javan geanticline. The belt is severed in several places by wide valleys, which are depressions where the geanticline disappears below sea level. The Southern Mountains consist of volcanic deposits of the Miocene. Later in the Miocene, the ridge sank below sea level and was covered by a thick layer of limestone. Some time later a regression of the sea took place and the region remained slightly above sea level until the Pleistocene. The upper and middle Pleistocene was a time of great geological turmoil in Java. The arching up of the Javan geanticline elevated and tilted southward the belt which we see as the Southern Mountains today. The top of this geanticline sank in relation to its southern flank, forming a depression called the Solo Zone, covering the Miocene deposits with new material. Today, these young volcano complexes, some of which rise to more than 3000 m, are the dominant physiographic feature of the East Javan landscape (Fig. 2, 20).

The physiographic distinctness of the mountain complex of which Meru-Betiri is a part is reflected in present land-use and by the routing of railroads and highways. The main lines of commerce between Jember and Banyuwangi pass through the low-lying juncture between the Raung Volcano and this section of the Southern Mountains (Merawan, Fig. 2b). Agricultural development and settlements are concentrated on the floors of the wide, adjacent valleys. Forest areas, both natural and plantations of teak (Tectona grandis), are found on the steeper slopes (Fig. 2a).

Within the Betiri complex, the most suitable river ("kali") valleys, the Sanen, Curah Nongko, Bendialit, Sukamade and Karangtambak, were cleared and converted to plantations, primarily of coffee and rubber, by the Dutch early in this century. Since World War II parts of these areas have been used for growing rice (Oryza sativa), corn (Zea mays) and cassava (Manihot utilisima). On the eastern and western flanks of this complex, where slope and climate are conducive, the natural forest has been replaced with extensive plantations of teak. Many of these vegetation alterations are comparatively recent. It has only been since World War II that the natural connection between Meru-Betiri and the South Banyuwangi Wildlife Reserve (Blambangan) to the east has been severed (11).

The Meru-Betiri Reserve lies in the core of this isolated region of the Southern Mountains, protected in the past from extensive habitat alteration by the ruggedness of the topography; and it is only in this rugged area that the last Javan tigers have managed to survive.

THE LAND AND WATER

The superficial expression of the Meru-Betiri landscape is the result of dynamic natural processes. Climatic and mechanical processes over the area have modified the underlying geological formations, which accounts for the current physiography, drainage system and distribution of soils. These, in turn, influence the distribution of plant associations which, in turn, influence the distribution of the wildlife species.

The landscape is precipitous and dissected (Fig. 3a; 23). In 16 km the elevation rises from sea level to 1223 m at the top of Gn. Betiri. From this highest point, a ridge extends east to Gn. Mandilia (843 m) and west to Gn. Tajen (1036 m). To the north, the land drops away to the Kali Sanen, which forms a magnificent canyon in the upper reaches. At the headwaters of the Sanen, Baru and Karangtambak, just north of Gn. Tajen, is a high rolling landscape at 500 to 800 m, known as Malangsari, most of which has now been converted into a plantation of coffee and cocoa. The western end of Gn. Mandilia

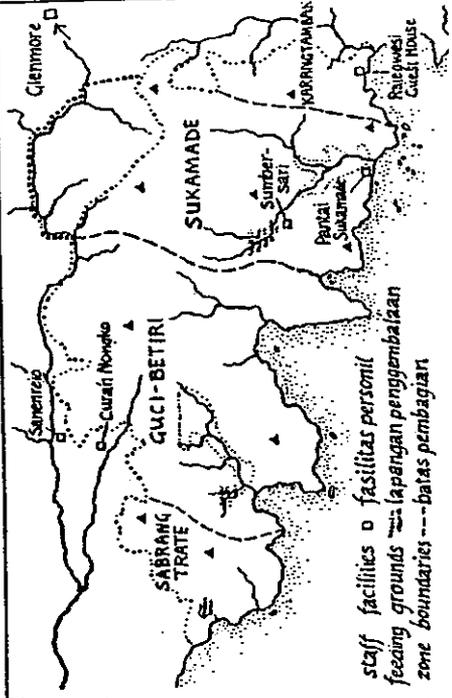
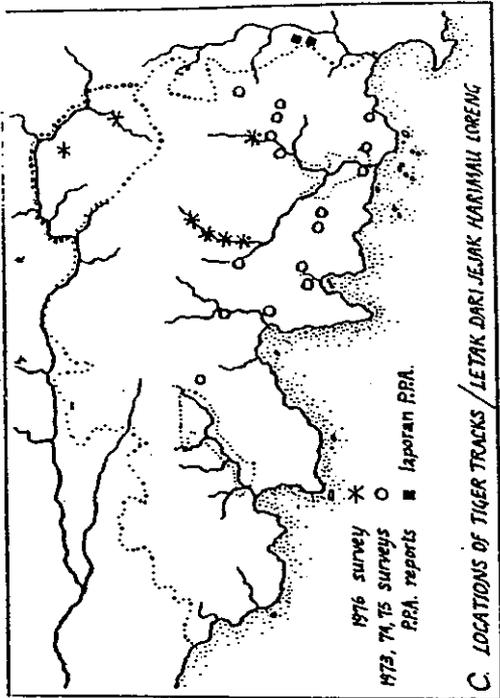
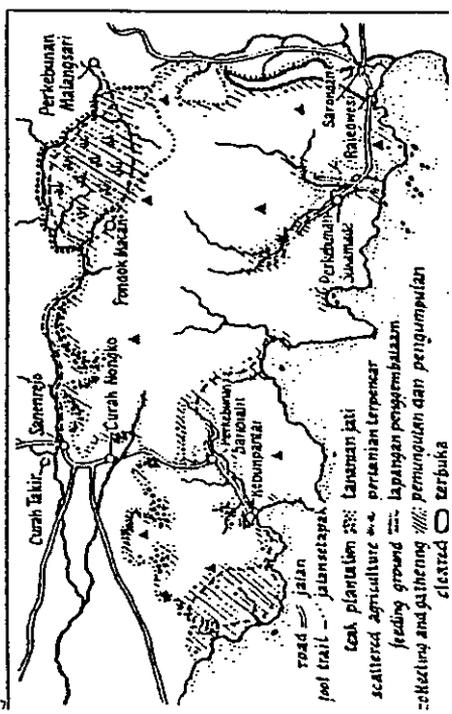
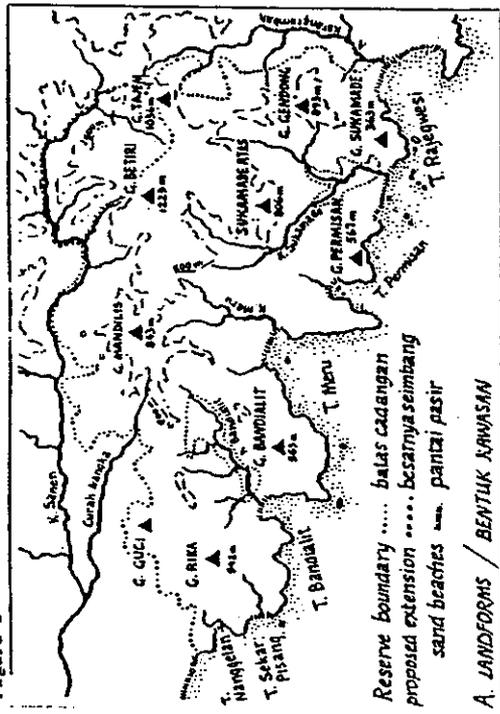
Figure 3 The Meru-Betiri Reserve 1976:

Protection and management of Meru-Betiri can only be achieved through an ecosystem approach, employing sound conservation principles. Some of the first steps in planning for the future management of the Reserve include:

- Assessing the natural features and processes of the region;
- Determining physiographic and regional relationships;
- Locating the threatening and disruptive influences that disrupt the completeness and integrity of the ecosystem;
- Identifying where boundaries must be set to include the seasonal and life-cycle needs of the flora and fauna;
- Establishing where careful guidance of the complex natural processes is required to sustain the extinction-prone species.

This information is compared with the present management and protection programme to determine what further actions are required.

Figure 5



is also cut by a deep canyon drained by the Curah Nongko. Extending south from the high ridge are a number of fingers that eventually meet the sea. The downward slope of these ridges is gradual until the last few kilometers, producing a rugged and picturesque coastline dominated by the high points, Gn. Rika, Bandialit, Permisan and Gendong, all more than 500 m.

The major drainages between these ridges are the rivers Sandielit, Meru and Sukamade. The east edge of the Reserve is drained by the Kali Karangtambak. Where these major rivers enter the sea, there are extensive sand beaches, along with smaller sand beaches at Nanggalan, Sekar Pisang and Permisan. Most of the coast is steep and rocky.

Underlying the Setiri complex is an enormous hornblende granite batholith (Fig. 2; 20), but with the exception of a few dikes and eroded areas, the batholith is covered by material from volcanic activity of the Miocene. The limestone deposits, which were laid down over the andesite in the upper Miocene, have mostly been eroded away and can be seen now only in a few places on the higher ridges. The most commonly encountered surface materials are what van Bemmelen (20) terms hydrothermally-altered old andesite. Specifically, this material seems to be volcanic breccia and conglomerates consisting of pyroxene and hornblende andesite (22, 23). In the major river valleys, alluvium has collected.

The exploratory soil map of Java (22) lists the soils in the Reserve area as a complex of red-yellow mediterranean and litbosoil. The soils in the Reserve are poor, but in the north they have been enriched by material from the volcanoes, Raung and Ijau (17). Our survey revealed at least three major soil types - alluvial, regosols and latosols (24) - but no detailed soil analysis has yet been carried out. The alluvial soils are confined to the lower valleys and the areas behind the sand beaches. These are the most attractive sites for agriculture. The regosols and latosols are found on the steep slopes. Regosols are young soils, almost without profile development. They generally occur as almost unweathered volcanic material near active volcanoes (25). Regosols are most apparent in the north where we found small-scale agricultural development. Through the south, the soils are older. Laterization appears to have been more extensive. Latosols quickly lose their fertility under cultivation because leaching has removed the nutrients in all but the surface layer, but they can support a luxuriant growth of broadleaf evergreen rain forest. Unlike the western and northern parts of the Reserve, the southeastern area does not have the extensive stands of bamboo on the hillside that suggest the occurrence of past agriculture.

There is a subtle, but important influence of parent material on the distribution of ungulates that has scarcely been recognized, much less studied intensively in tropical areas. This is the phenomenon of

mineral deficiencies and how this affects carrying-capacity and movements (26). We did not locate a single salt-lick in our survey and we question if any occur in the Reserve. The wild swine (*Sus* spp.) appear not to be dependent upon the mineral in licks, but this is not true for the cervids and bovids. Van Steenis (27) relates how in the past there were at regular intervals spectacular migrations of rusa from the Jang plateau (3000 m) to the coast to drink sea water. Halder (28) noted that there are no mineral licks in the Ujung Kulon or the Baluran reserves and that the banteng covered their need for salt by occasionally drinking sea water. We do not know how this factor would influence distribution and movement of larger ungulates in Meru-Betiri, but it is certainly a factor that must have attention in future detailed studies.

East Java characteristically has a long distinct dry period during the southeasterly monsoon from June to September, and a rainy period during the northwest monsoon from November to March. The mountains, however, modify this general pattern. The dry southeast winds give off rain against the south-facing slopes as condensation occurs through cooling at higher altitudes (27). This results in isolated "wet islands" situated on the south slopes of mountains in the east (Fig. 2c). These "wet islands" support areas of rain forest in a region that is dominated by monsoon climate vegetation (27).

Gn. Betiri and Gn. Tajen markedly influence the climate of Meru-Betiri, resulting in both an increase in total yearly rainfall and a reduction of the severity of the dry periods that so strongly influence the surrounding area (Fig. 2c). In Table 1, we present rainfall data recorded at the plantation enclaves at Sukamade and Bandialit and from the Malangseri plantation in the north. These figures can most readily be compared using the Schmidt and Ferguson ratio of wet and dry periods (24). Both Sukamade and Malangseri have a value of A; Bandialit is classed as C. In both total amount and yearly distribution of rainfall, the belt from Sukmade northward to Malangseri is similar to the climate which supports the magnificent rain forests in West Java. The western side of the Reserve, as evidenced from the rainfall data at Bandialit, is subject to a severe dry season, which has a marked effect on the vegetation, as we discuss later. This region is much more typical of the dry monsoon climate of East Java.

There is considerable variation in total rainfall from year to year (Table 1h). At Sukamade, for example, the total rainfall in the last five years has varied from 1219 to 6574 mm, by a factor of more than five. During the driest year there was a period of five months without rain. Van Steenis (27) points out that rain forest trees react to spells of excessive drought by dropping more leaves than normal to keep evapo-transpiration in balance. Yet these extensive drought

TABLE 1
DAFTAR 1

RAINFALL DATA FOR MERU-BETTIRI 1971-1975
CURAH HUJAN DI MERU-BETTIRI 1971-1975

A) Jumlah : Hujan rata2

Bulan	Malangsari		Sukamade		Bandialic	
	mm	hh	mm	hh	mm	hh
J	491	19	420	15	324	12
F	483	19	481	17	348	16
M	492	20	363	15	339	17
A	253	14	203	8	133	8
M	318	15	215	11	190	10
J	208	9	86	5	31	2
J	155	8	55	5	21	2
A	80	7	61	3	42	2
S	286	10	379	11	168	6
O	291	13	521	15	186	10
N	279	16	612	15	356	11
D	412	17	585	16	404	15
Jumlah	3748	167	3981	136	2544	117

B) Jumlah : hujan rata2

Tahun	Malangsari		Sukamade		Bandialic	
	mm	hh	mm	hh	mm	hh
1971	3342	165	2863	127	2764	122
1972	2367	109	1219	68	1083	73
1973	6046	199	4616	171	2602	141
1974	3296	157	4634	139	2535	120
1975	3690	193	6574	177	3725	133
V.	3748	167	3981	136	2542	117

C)

	Termasuk Type Schmid Ferruson	
	Q(%)	
Malangsari	9.09	A
Sukamade	11.10	A
Bandialic	33.30	C

Notes

Bulan = Month
Tahun = Year
Rata2 = Average

years have a more marked effect on the flora of Meru-Betiri and the forest contains a greater number of drought-resistant tree species than is typical for a rain forest in the western part of the island.

During a "normal" year, water flows in the small streams all through the periods of reduced rainfall (11). During a drought year, many of the small streams and the lower reaches of the bigger rivers are dry.

It is hard to judge what effect these drought years have on the carrying-capacity of the Reserve and the distribution of the larger mammals, but the effect of drought cannot be discounted. We would not expect the drought to affect the large mobile mammals as much as it would the smaller less mobile forms, for example, chevrotain (Tragulus javanicus) and muntjac (Muntiacus muntjak) (29). What is important is that care is taken when discussing what is "normal". What is "normal" even in this "wet island" of East Java is the regular occurrence of droughts.

VEGETATION

The Vegetation Types

Our broad examination of Meru-Betiri revealed five of the eleven vegetation types defined for Java by van Steenis and Schipper-Lammertse (30, 31). There are:

- a. Two formations of beach vegetation
- b. Mangroves
- c. Lowland swamp forest
- d. Rheophyte vegetation
- e. Mixed lowland and hill rain forest

It is possible that off the coast there is a limited extent of submerged littoral vegetation and at the very top of Gn. Betiri, there is mountain rain forest, although this is not in evidence at 1100 m. There is no true monsoon forest now, but this was once the most extensive forest type in the adjacent lowland areas (30).

The Pescaprae formation is a low, largely herbaceous plant fringe growing from the drift zone on to the dike behind sandy beaches. Most plants are creeping and rooting, producing runners. Dominants include Ipomoea pescaprae and Spinifex littoreus. This formation is only found on coasts where sand is being deposited; if sand is not deposited, the waves reach the beach dike on which grows the Barringtonia formation. In Meru-Betiri we found a well-developed Pescaprae formation on the beach at Sukamade and to a limited extent on the beaches at Meru and Bandialit.

There are some excellent Sarringtonia formations along the coast of Meru-Getiri. We noted Calophyllum inophyllum, Hibiscus, Terminalia, Pandanus, and a few other species (Table 2).

The mangrove type is limited to a few bays and estuaries, such as Sukamade and Permisian. This vegetation type is vulnerable to alteration. If cut off from the tides, the grove will die because a fluctuating water level is essential for respiration through the root system. The species composition of the type is simple. We noted Rhizophora, Avicennia marina, and Grugiera.

Behind the mangroves at Sukamade, Permisian and Manggelan, there are small stands of swamp forest that include Mangifera, Gluta renghaa, Alistonia anguaticolia and Sarringtonia spicata.

On the flood plains of the major rivers such as the Sukamade and, to a lesser extent, the Sanen and Gandielit, a Rheophytic vegetation type can be seen. According to van Steenis (30) "This is composed of plants which are not only riverine, but are restricted to the rocky, gravelly and sandy areas between the flood zones, which means the plants must be subjected to the overflow of swift-running water masses. Java is very poor in such plants" (p.10-11). In the Sukamade valley there are extensive stands of glagah (Saccharum spontaneum) in this zone. Important in this zone are the ephemeral herbs and grasses growing in the dry parts of riverbeds during the periods of low water. These are extensively fed upon by muntjac in some areas.

The fifth vegetation type, and most extensive, is the "mixed lowland and hill rain forest on dry land". Van Steenis reports this formation occurs below 1000-1500 m in areas which are over-wet or are subject to only a feeble dry monsoon with at least 30-40 rainy days during the four driest consecutive months of the year. It is of a highly mixed character with few dominants. It grows in a variety of soils. In these forests there are a large number of epiphytes, such as orchids and ferns. Bamboo groves occur, most species introduced from Southeast Asia (for example, Gigantochloa). The more extensive stands of bamboo are derived from former cultivation.

In the van Steenia vegetation map of Java (30), the Meru-Getiri area is shown as mixed monsoon forest, but Gartels and van der Veen (17) and van der Zon (32) state the principal vegetation type is, at least, "has the character of" (17) tropical rain forest. In Meru-Getiri this vegetation type is complex and confusing, largely because of the large elevational gradients and the variation of the rainfall regime.

To help clarify the situation we have listed this vegetation type under van Steenia's category of "mixed lowland and hill rain forest on dry land", but we feel that this type can be separated into at least three fairly distinct sub-types. Within these sub-types there are

distinct series (33, 34). Our purpose in making these distinctions is to fulfil present management and conservation needs and to group the vegetation into series of habitat types that reflect the distribution of the larger mammals. A precise delineation of the boundaries of these sub-types, and of all the vegetation types, must await the availability of aerial photographs accompanied by detailed field investigations.

In the dry season there is a noticeable leaf-shedding by many of the larger trees over much of the Reserve. This foliage reduction is mainly confined to the larger emergents and not the main canopy, which is primarily evergreen. This is most apparent in the western part of the Reserve, particularly in the forests under Gn. kika, Gn. Bandialit and Gn. Mandilis. An examination of Fig. 2c shows this is the driest zone of the Reserve with fewer than 20 rainy days in the four driest consecutive months of the year. To a lesser extent some of the emergent trees in the lower reaches of the Sukamade drainage lose their leaves, but this is restricted to a zone below 400-500 m. In this sub-type, there are many of the trees which van Steenis lists as species typical of a monsoon forest (Table 2; 34), but many of the indicator species are also absent. Apparently, this sub-type represents a transitional stage between semi-deciduous and evergreen rain forest, such as Jacobs (34) found occurring over much of Blambangan.

Above 400-500 m in the east and on the scattered high points in the west, the emergent trees are evergreen and their vegetation has the appearance of tropical rain forest in the classic sense. From the rainfall data at Malsngsari (at 700 m), there is an average of 35 rainy days during the four driest consecutive months. In observing weather patterns at Sukmade, it was apparent that 400-500 m was the elevation where clouds collected against the mountains during the southeast monsoon, giving rise to a more even distribution of rainfall in this area, as we have discussed previously. In the Sukmade drainage, there are many pockets of what have the appearance of good rain forest below the 400 m zone. At the plantations, there are an average of 25 rainy days during the four driest consecutive months (Table 1). On the hill in the lower Sukmade, drought-resistant trees are evident, as we have noted, but not in the high proportion seen in the west. The forest on the hills in the lower Sukmade drainage could be classed as one more intermediate step between rain forest and seasonal forest, but for our purpose here, we will include it with the rain forest formation.

What is distinct in the Sukmade drainage is the forest occupying the alluvial plain behind the beach formation. This has a strong component of drought-resistant trees, such as Kleinhovia hospita and Lagerstroemia spicata. In times past, much of the area now under cultivation within

TABLE 2
DAFTAR 2

SOME PREVALENT PLANTS IN MERU-BETIRI
BEBERAPA TUMBUHAN YANG BANYAK TERDAPAT

DI MERU-BETIRI
BEACH VEGETATION/HUTAN PANTAI

Pandanus tectorius

Nibiscus tiliaceus

Callophyllum inophyllum

Lantana camara

Terminalia catappa

Cycas sp.

Wedelia sp.

Sterculia foetida

Cerbera manghas

MANGROVES/NUTAN PANYAU

Avicenia marina

Bruguira sp.

Rhizophora sp.

Sonneratia ovata

Nipa fruticans

SWAMP FOREST/HUTAN RAWA

Barringtonia sp.

Gluta renghas

Mangifera sp.

Alstonia angustifolia

Mixed Lowland and Hill Rain Forest, Rheophytic Vegetation/Hutan Campur Dataran Rendah dan Hutan Hujan Pegunungan, Rheophytic

TREE AND TREE-LIKE PLANTS

Artocarpus elastica

Tetrameles nudiflora

Dracontomelon mangiferum

Anthecephalus cadamba

Kleinhovia hospita

Lagerstroemia sp.

Pterospermum javanicum

Adenanthera microsperma

Spondias pinnata

Durio zibethinus

TREE AND TREE-LIKE PLANTS (Continued)

Metrophora javanica

Aglaiia eusideroxyton

Albizia sp.

Ficus annulata

Pterospermum difersifolium

Aleuritas moluccana

Daemonorops elongata

Daemonorops melanochaetes

Daemonorops hygropilus

Tectona grandis

Corypha gebanga

Diospyros cauliflora

Arenga pinnata

Photinia notaniana

Lansium domesticum

Eugenia desiflora

Antidesma bunius

Evunines javanicum

Strochilus asper

Michelia sp.

Dioscorea hirsuta

Erythrina variegata

BAMBOOS/BAMBU

Gigantochloa sp.

Schizostachyum blumei

Dendrocalamus asper

Bambusa bambos

GRASSES/HUMPUT

Imperata cylindrica

Panicum distachyum

Saccharum spontaneum

Cynodon dactylon

Andropogon aciculatus

Panicum flavidum

Panicum pilipes

Panicum pertusum

Panicum muticum

Ageratum conyzoides

Prepared by Ir. Suyono

the plantation was probably under this vegetation type. The Director of Sukamade told us that this area was not cleared until the early 1950s.

From a management point of view, a distinction between these sub-types of rain forest is important; while the general structure of the mature forest is similar, each sub-type appears to respond to mechanical disturbances in a slightly different way. Fire, for example, is a threat to the dry forest type in the west. The response of the forests in the west to clearing by man is noticeably different from the seral vegetation produced in the wetter types. It is important, then, to discuss the impact of man on the vegetation from this basis.

The Influence of Man on the Vegetation

The vegetation surrounding the Reserve, except for small corridors in the north and northwest, has been completely altered by man. Within the present Reserve boundary and the proposed northern extension, the forests have been cleared from the plantation enclaves at Sandialit and Sukamade, up to about the 100-150 m contour in the Karangmbak drainage, and the area between the sea and the Sandialit plantation. About 100 ha, 25 ha and 50 ha have been recently cleared at Sukmadi, Pringtali and Manggelan respectively, as feeding grounds i.e., wildlife habitat improvement projects. Scattered along the western boundary under Gn. Guci and Gn. Mandilis are plantations of teak, dating from when the area was under the administration of Perhutani. There are 1100 ha of teak plantation within the present Reserve boundaries.

Aside from these comparatively recent vegetation alterations, there are signs throughout the Reserve of human disturbance of more ancient origins. The extent of these anthropogenic areas is difficult to assess, but extensive alterations are apparent on the hills above Sandialit Bay, on the lower slopes between Sekar Pisang and Manggelan and on the north slopes of Gn. Mandilis and Gn. Betiri.

The disturbed hillsides surrounding Sandialit Bay are covered with tall grasses and wild pisang (*Musa* spp.). Their origin is older than the memory of the plantation manager, but it is possible they date only from the period of Japanese occupation, cleared as part of the coastal fortification effort. This is only speculation; what is certain is that this is not primary vegetation, as present management personnel believe, and that even after more than 30 years, there is no sign that the original forest is recovering. It is doubtful that the present vegetation here is suitable as food for banteng, but it would have been more desirable to clear small scattered patches of this secondary growth than to clear the forest from the steep slopes at Pringtali, a few kilometers to the north, with the objective of creating a feeding

area for these wild cattle (18).

Large groves of bamboo occur between Sekar Pisang and Nanggalan, in the valley bottom above the Sukamade plantation, and scattered on the north slopes of Gn. Betiri and Gn. Mandilla. These are certainly the result of past cultivation. In the Nanggalan-Sekar Pisang area and the lower slopes above the Sanen River, these stands are open, with areas of alang-alang (Imperata cylindrica). In the Sukamade drainage, the bamboo grows in closed stands. The difference in stand structure is probably related to climate, specifically the soil-moisture regime. The drier sites with scattered alang-alang openings are the most suitable habitat for large ungulates, such as banteng and rusa. It is in these drier areas in the north and west that the banteng in the Reserve are found.

There is some question about the origin of the bamboo stands above the Sukamade plantation, which are being cleared as a habitat improvement project. Judging from the pattern of stumps and the remaining bamboo, this was a 150 ha area of bamboo with a few emergent Ficus, covering the valley bottom and extending up the lower slopes. The line between the bamboo and forest is distinct and does not seem to follow any observable land feature. Undoubtedly, this was cleared for cultivation in the past. One of the common bamboos is Gigantochloa; this species is not native to Java, but was introduced (34).

On the hills in the lower Sukamade drainage, the forest contains stands of bamboo, not as extensive and easily identifiable as seen in the west and north. The forest undergrowth here in this drier area is extremely thick. The forest canopy is more open than at higher elevations (11). In the past this region was probably subject to more disturbance than the forests at higher elevation, but it does not appear that these slopes were subject to agricultural development.

We are uncertain as to what percentage of the forest in the Reserve represents primary forest or, at least, a climax forest type. The published estimate is 50% (35, 36). Bartels and van der Veen (17) have remarked that the area is "almost wholly covered by dense primeval forest" and this is the chief impression one has upon viewing the forests from a distance. An accurate determination of the area of primary and climax forest within the Reserve will have to await a detailed vegetation analysis, but we would tentatively place the figure at 75%, using the definition in Mueller-Dombois and Ellenberg (33).

The exact percentage of the forest in a primary state is not the index of the value of Meru-Betiri as a nature reserve. More important is the diversity and extensiveness of the vegetation types. Meru-Betiri is a forested island surrounded by agricultural areas. Five of the major vegetation types occurring in Java are represented here. As such, this area is unique and unparalleled in Java today.

Figure 4

Rafflesia and Balanophora:

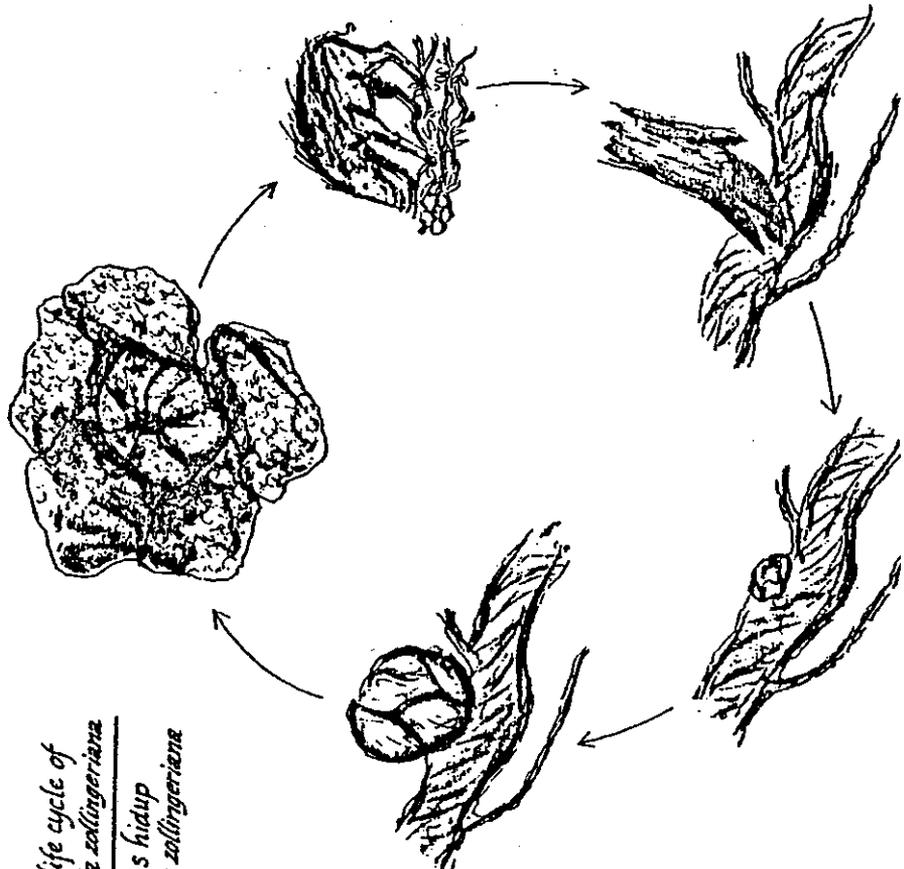
Meru-Setiri is the only known location of Rafflesia zollingeriana. Another rare root-parasite, Balanophora fungosa, is also found here.

The life cycle of Rafflesia is complex. It lives only on the Tetraatigma lianas; there are both male and female flowers, and pollination is apparently accomplished by carrion flies (Lacilia) attracted to the distinctive odour of the flowers; seeds are dispersed on the hooves of large mammals; the animal's hoof must injure the host liana for the infection to begin (after Jacobs, unpublished).

Balanophora is not as specific in its host plant as Rafflesia, but we do not know why these root parasites are so rare.

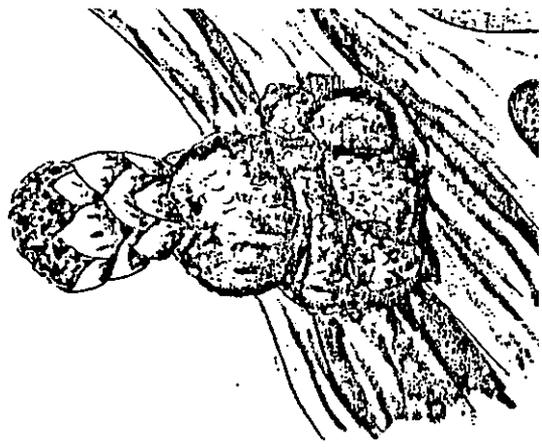
To preserve these and all the rare and extinction-prone species of the Reserve will require careful monitoring of population trends and research to understand their survival needs.

The life cycle of
Rafflesia zollingeriana
Siklus hidup
Rafflesia zollingeriana



Balanophora fungosa

ACTUAL SIZE
UKURAN BESAR



Rafflesia and Balanophora

There are three species of Rafflesia in Java; Meru-Betiri is the only known location for Rafflesia zollingeriana (17), although it was once found in a number of locations in the Southern Mountains (37). Rafflesia is protected by Indonesian law and its preservation, and the preservation of the rare root parasite, Balanophora fungosa, is a primary management concern for the Reserve.

These parasites are devoid of life-sustaining chlorophyll and are dependent on other plants for nutrients. The conservation program for Rafflesia will have to be based on understanding its life cycle, which has been summarized by van Steenis and van der Veen (38). Rafflesia lives in the tissue of the woody vitaceous liana, Tetrastigma. The lianas have limited life spans and it is necessary for new lianas to be infected regularly for the parasite to perpetuate. It has been determined from experiments that the Rafflesia's very minute seeds can only grow in wounded places where animals have trod on the basal parts of the lianas, injuring them with their hooves. In an early study, van Steenis (37) noted that a bud of 3 cm took an additional six months to open. It appears there is no distinct flowering season. Pollination is accomplished by carrion flies (Lucilia), which are apparently attracted to the distinctive odour of the flower.

The characteristics of both Rafflesia and Balanophora are shown in Fig. 4. An inventory of locations where these rare plants grow is a primary management need.

THE AVIAN FAUNA

The Forest and the Seashore

In the gathering dusk of July evenings, flight after flight of hornbills crossed the valley of the upper Sukamade River, returning to their roosting trees after a day of foraging. We frequently encountered the wreathed hornbills (Rhyticeros undulatus) on the higher ridges in Meru-Betiri; lower in the valley and along the streams we sometimes startled groups of smaller pied hornbills (Anthracoceros convexus). Depending on the fruits of the great trees for food, the hornbills are primarily birds of undisturbed rain forest. The sudden whiff of air through the stiff wing feathers of a hornbill startled in its feeding tree at a streamside and the laboured reverberating wing beats of family groups flying high above the valleys at dusk are familiar sounds in Meru-Betiri, a subtle reminder of the importance of maintaining large tracts of undisturbed rain forest to assure their survival and the survival of so many climax forest birds.

In the harsh glare of the midday sun, a little falcon (Falco moluccensis) swoops toward the low vegetation bordering the sandy beach; it checks its dive, detected by an alert prey animal, and continues down the narrow strip of vegetation with powerful strokes of pointed wings. Two reef egrets (Egretta sacra) dart after receding waves, searching for invertebrates. Out away from the land, a black-naped tern (Sterna sumatrana) plunges into the waves, disappears, then rises slowly with a small fish in its bill; it swallows its prey on the wing. In a tall dead snag, an osprey (Pandion haliaetus) sits looking over the open stretch of water at the river mouth behind the sand beach. It seems to be watching for fish moving into the brackish water with the incoming tide. At this hour there are no people on the Sukamade beach and it vibrates with life processes; it is a study of food webs and feeding niches, of hunting strategies and predator-avoidance behaviour.

What a contrast this is to the beach at Rajegwesi just around the point where man's presence dominates; motorcycles race along the sand; the shore and bay are sprinkled with fishing boats; and groups of people gather on the beach to talk, to work, or to walk. Rajegwesi is a quiet village inside the Reserve. The people there are dependent on the sea for food; the beach serves their needs as a work area and path. Yet some beaches should be left alone so that the lives of other animals can go on undisturbed. Man can visit here in an unobtrusive manner, sit and watch, and learn about the natural world upon which he is so ultimately dependent.

The Diversity of Birds

We did not attempt to conduct systematic studies of the birds during our brief survey, but an investigation of the avian fauna of the Reserve has been carried out by H. Bartels (39) and A. Hoogerwerf (8). More than 140 species have been recorded here, and there may be as many as 180 living in the Reserve (Table 3). This compares with 233 species of birds known to occur in the Ujung Kulon Reserve in West Java and 460 species for the island as a whole (1). The disparity between the numbers of birds found in Meru-Betiri and Ujung Kulon is probably due to habitat differences and the position of the Reserve in relation to major migration routes (40), although some migratory birds do pass through Meru-Betiri.

The Problem of Extinction-Prone Birds in Rain Forest Reserves (41)

The tropical forests of the world contain a rich assemblage of birds, characterized not by the number of any one species, but by the multitude of different species present. The tropical forest birds have been the subject of intensive scientific study, yet out of this research have come few specific guidelines to help the manager in his custodian role of maintaining the ecological integrity of natural areas.

TABLE 3

BIRDS OF MERU-BETIRI

- + Indicates species which are characteristic of lowland rain forest
 ++ Indicates rain forest birds found at moderate elevations in Java based on the experience of H. Bartels
 () Page in ref. 43

Hydrobatidae: Storm petrels (31)

Oceanodroma monorhina

Sulidae: Boobies (37)

Sula leucogaster

Ardeidae: Herons (40)

Ardea purpurea

Ardea sumatrana

Ardeola speciosa

Butorides striatus

Egretta alba

Egretta sacra

Ixobrycnus cinnamomeus

Ciconiidae: Storks (50)

Ciconia episcopus

Pandionidae: Osprey (69)

Pandion halliaetus

Accipitridae: Hawks (70)

Haliaeetus leucogaster

Accipiter trivirgatus

Spizaetus nipalensis ++

Spizaetus cirrhatus

Hieraetus kieneri +

Ictinaetus maiayensis ++

Spilornis cheela

Falconidae: Falcons (93)

Falco moluccensis

Phasianidae: Pheasants (99)

Arborophila sp. ++

Gallus gallus

Gallus varius

Pavo muticus

Turnicidae: Button quail (110)

Turnix suscitator

Rallidae: Rails (115)

Amauornis phoenicurus

Scolopacidae: Sandpipers (126)

Crocethia alba

Actitis hypoleucos

Burhinidae: Thick-knee (151)

Esacus magnirostris

Laridae: Terns (153)

Sterna dougalli

Sterna anaethetus

Sterna sumatrana

Columbidae: Pigeons (167)

Ptilinopus melanospila

Ducula sp.

Macropygia phasianella +

Geopelia striata (introduced)

Streptopella chinensis

Treron pompadora

Psittacidae: Parrots (178)

Psittacula alexandri

Loriculus vernalis

Cuculidae: Cuckoos (180)

Cacomantis sonnerstii

Cacomantis merulinus

Cacomantis variolosus

Chrysococcyx xanthorhynchus +

Surniculus lugubris

Eudynamis scolopacea

Phaenicophaeus curvirostris +

Phaenicophaeus javanicus +

Centropus nigrorubus

Centropus sinensis

Centropus bengalensis

Strigiformes: Owls (189)

Otus bakkamoena

Glaucidium castanopterum ++

Strix sp.

Caprimulgidae: Nightjars (199)

Caprimulgus macrurus

Apodidae: Swifts (201)

Apus affinis

Phaphidura leucophygialis ++

Collocalia fuciphaga

./.

BIRDS OF MERU-BETIRI (Continued)

- Gallocalia gigas* ++
Collocalia esculenta
Cypsiurus batuslensis
Hemiprocnidae: Tree swifts (206)
Hemiproctne longipennis
Trogonidae: Trogons (206)
Harpactes oreskios ++
Alcedinidae: Kingfishers (210)
Lacedo pulchella +
Halcyon chloris
Halcyon cyanoventris
Alcedo euryzona ++
Meropidae: Bee-eaters (214)
Merops leschenaulti
Coraciidae: Rollers (216)
Eurystomus orientalis
Bucerotidae: Hornbills (216)
Rhyticeros undulatus ++
Anthracoseros convexus +
Buceros rhinoceros +
Picidae: Woodpeckers (227)
Dendrocopos macel
Hemicircus concretus ++
Dryocopus javensis +
Chrysocolaptes sp.
Eurylaimidae: Broadbills (235)
Eurylaimus javanicus ++
Pittidae: Pittas (238)
Pitta guajana
Hirundinidae: Swallows (248)
Hirundo thhtica
Capitonidae: Barbets (221)
Megalaima javensis + (+)
Megalaima australis +
Megalaima haemacephala
Metacillidae: Wagtails (398)
Anthus novaeseelandiae
Campephagidae: Cuckoo-shrikes (251)
Hemipus hirundinaceus
Lalage nigra
Pericrocotus cinnamomeus
Pericrocotus flammeus +
Lanidae: Shrikes (404)
Lanius schach
Nectarinidae: Sunbirds (412)
Anthreptes malacensis
Anthreptes singalensis +
Hectarinia jagularis
Arachnothera longirostra
Arachnothera affinis
Sturnidae: Stralings; Mynas (406)
Aplonis panayensis
Aplonis minor
Sturnus melanopterus
Sturnus javanicus
Gracula religiosa +
- Artamidae: Wood-swallows (403)
Artamus leucorhynchos
Chloropseidae: Leafbirds (260)
Aegithina tiphia
Chloropsis sonnerati +
Chloropsis cochinchinensis ++
Pycnonotidae: Bulbuls (261)
Pycnonotus atriceps +
Pycnonotus melanicterus
Pycnonotus aurigaster
Pycnonotus goiavier
Pycnonotus simplex +
Criniger bres +
Turdidae: Thrushes (331)
Copsychus saularis
Copsychus amoenus
Copsychus malabaricus +
Enicurus leschenaulti
Saxicola caprata
Myophonus coerules
Timaliidae: Babblers (293)
Trichastoma sepium
Napothera macrodactyla
Macronous kelleyi
Stachyris melanothorax
Sylviidae: Old World warblers (350)
Megalurus palustris
Cisticola exilis
Prinia familiaris
Abroropus superciliaris
Orthotomus ruficeps
Muscicapidae: Old World flycatchers
Rhipidura javanica
Cyornis banyumas
Philentoma velatum +
Hypothymis azurea +
Trepsiphone paradisi +
Paridae: Tits (282)
Parus major
Dicaeidae: Flowerpeckers (420)
Dicaeum chrysorrheum +
Dicaeum trochilcum
Dicaeum trigonostigma

BIRDS OF MERU-BETIRI (Continued)

Ploceidae: Weavers (424)

Passer montanus

Ploceus manyar

Padda onyzivora

Lonchura leucogastra

Lonchura malacca

Lonchura major

Dicruridae: Drongos (269)

Dicrurus paradiseus

Dicrurus macrocercus

Oriolidae: Orioles (270)

Oriolus chinensis

Oriolus xanthonotus +

Corvidae: Jays, Crows (275)

Platylophus glericulatus +

Corvus enca

Based on the research of H. Bartels with additional records from R. van der Veen,
A. Hoogerwerf (8) and the authors, nomenclature after King et al. (43).

The work of Dr. E. Willis in the Nature Reserve of Barro Colorado Island in Panama has demonstrated the real problem that management personnel face in regard to preserving tropical forest avifauna. For 53 years, the Barro Colorado Nature Reserve has been carefully protected, but by 1970, 45 of the 208 breeding bird species present 50 years before had disappeared from the island. Several more species were down to a single or a few individuals. At that rate of decline, 20% of the original forest bird community will have disappeared before the first 100 years of the Reserve's existence. That is clearly a failure of the original management goal of maintaining ecological integrity. The Barro Colorado Reserve is not unique; the ecological phenomena observed here are relevant to all tropical forest reserves. Why have so many forest bird populations died out?

The species which have disappeared from the Barro Colorado Reserve fall into two discreet ecological groups: those that inhabit open fields, edges, and early secondary growth, and those that are found exclusively or most abundantly in mature forests. The problem of maintaining ecological integrity in reserves does not lie with the first group. These are the birds that often associate with man and usually are relatively abundant outside the reserve area. More important are the birds that have disappeared from mature forests. The Barro Colorado Reserve was created primarily to protect mature rain forests and their fauna. In 50 years, plant succession has been moving toward maturity, yet 18 species of mature rain forest birds have disappeared. Among these are the most picturesque and unique species. The reasons for their disappearance are not completely understood, but it has been possible to identify five categories of species that are particularly prone to extinction. By separating species into these categories, it is possible to identify which are in most critical need of management action:

- Species at the top of the food pyramids and the largest members of guilds
These species have a dispersed food supply, high metabolism, and require large amounts of living space. Usually they have low reproductive rates and consequently cannot withstand hunting pressure.
- Widespread species with poor dispersal and colonizing ability
This category represents the major portion of the species that inhabit the pristine landscape. They are vulnerable to extinction through habitat destruction.
- Endemics
These are species which usually have restricted distribution because of historical conditions associated with their evolution. Endemics are usually common in their specific region, but have restricted habitat requirements. Preservation depends upon identifying

these species and their centres of distribution.

- Species with colonial nesting habits

These are the birds that lay eggs and rear young in restricted communal sites. Nesting colonies are frequently located on small off-shore islets, sometimes on mainland beaches, promontories and coasts. The total reproductive effort is located in a very small area. Consequently, the species is particularly vulnerable to disturbance of these areas.

- Migratory species

Migratory species are exposed to decimating pressures at both ends of their migration routes, as well as all along the sometimes thousands of kilometers in between. When the nature reserve is only one end of the route or a resting stop along the flyway, there is little the manager can do to offer protection. The conservation of migratory species usually requires international cooperation.

Maintaining Natural Diversity

Maintaining the natural diversity of the birds of Meru-Betiri is a major problem for the manager. The published literature on Javan birds is not sufficient to recommend specific guidelines. A preliminary appraisal of the status and ecological needs of the Indonesian avifauna to the species level is in preparation by Ir. J. Wind (42). For Meru-Betiri, because of its island-like character, it will be important to identify and review the ecological needs of the extinction-prone forms to the sub-species level. From this basis, management needs can be identified, but this will have to be done by a competent specialist on Javan birds working in the Reserve for at least one year. H. Bartels has made an assessment of which forest birds should be closely monitored, based on his long experience in Java. These are indicated in Table 3 (43).

MAMMALS

It is imperative to have accurate data on habitat utilization, biomass, trophic roles, and the long-term dynamics of survival of mammalian species for any effort to conserve them in their natural habitats. Only with such data is it possible to predict the minimal size of populations consistent with wise conservation practices and, thereby, establish the minimal size of reserves needed for maintaining diversity (44, 45). In Meru-Betiri such data are difficult to obtain. For some groups, such as the primates, direct observation is possible, but most species are rarely seen in the dense forests.

Figure 5

A Guide to Mammal Tracks:

Walking along the sand beach at Sukamade in the first light of dawn, one can read the happenings of the night just past. At the end of the beach a porcupine shuffled along the dry stream bed. A Javan civit crossed the wide sand beach near the river's mouth. Where the sea has eroded the beach, a palm civit skirted the edge of the Barringtonia formation. Sometime yesterday a monitor travelled here. A sea turtle coming from the sea in the night to nest haa crawled over the track. Three sea turtles nested last night, but all the eggs were taken by people. At the east end of the beach, a leopard came down a dry wash, rounded the big cliff, and walked along the river bank. At the edge of the mangroves, we see where a troupe of macaques have recently passed. They have visited the shore and left again, even at this early hour. So much has happened last night while we slept. We can never know all that went on, but tracks tell a great deal if one takes the time to read them.



LANDAK

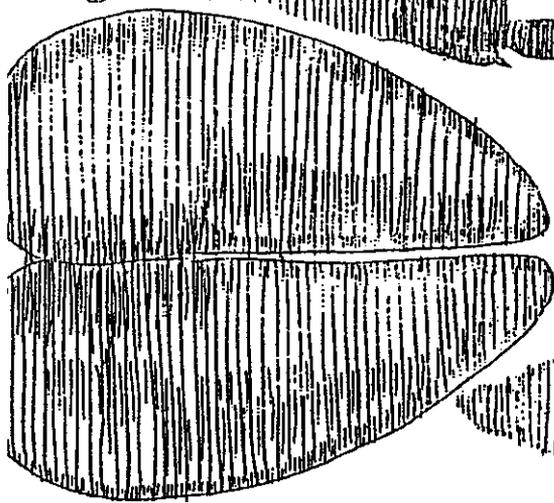
SANGKARANGAN



BANTENG



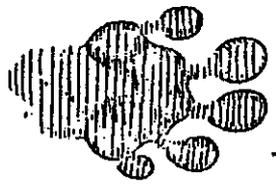
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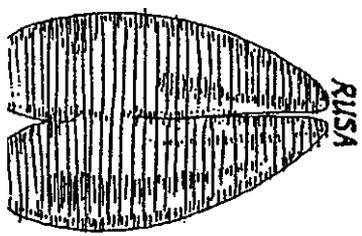
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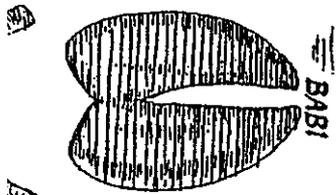
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SERO



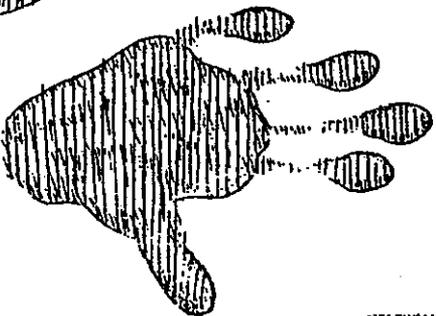
RUSA



BABI



KERA



MUNCIAK

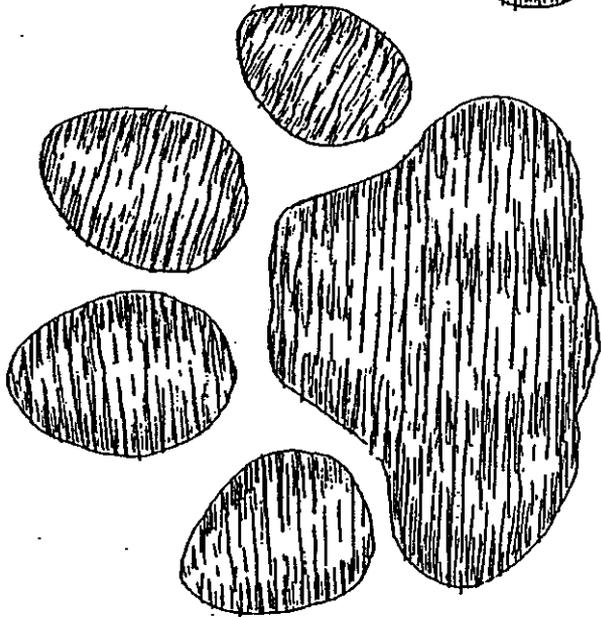


KANCIL

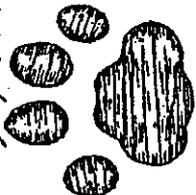


Figure 5 (Continued)

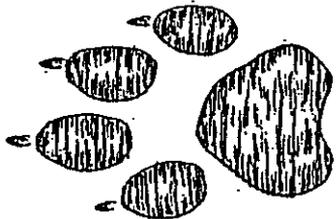
HARIMAU LORENG



KUCING BAKAU



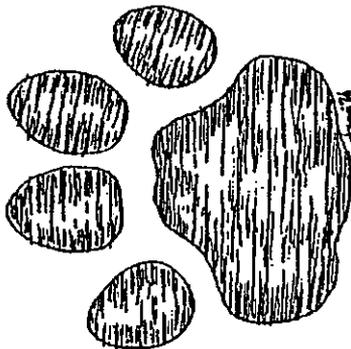
AJAK



KUCING BATU



MACAN TUTUL



The investigator must rely on indirect sign, such as tracks, feces, and feeding sites (Fig. 5). Collected in a systematic manner, such information can provide useful insights into trends in numbers, habitat utilization, and other ecological relationships. We relied heavily on indirect sign in our short survey of Meru-Betiri. Taken together with the scientific literature available on Javan mammals (1), we have pieced together an ecological perspective for the most conspicuous forms.

Diversity and Vulnerability

In the three months we surveyed Meru-Betiri, we were able to learn something about 29 species of mammals living there. These are listed in Table 4, together with the information we obtained on their status. The list is far from complete. Aside from the flying foxes (Pteropus vampyrus), we were not able to identify by species, the many bats. We learned nothing about the insectivores, but a number of species may live in the Reserve. Of rodents, we only identified the most common rat, some of the more visible squirrels and the porcupine (Hystrix javanica). There are about 65 species of mammals living on Java today, excluding the Chiroptera (46). This is a low figure when compared with an Asian mainland area, such as the Mekong Basin where 146 species of mammals, excluding the bats, are known to occur (47). A low species diversity on islands is a rule; and the forms that live on islands frequently occupy slightly different, usually expanded, niches from their mainland counterparts. This is expressed in terms of the habitats they occupy, in their position in food webs, and in competitive and symbiotic relationships (48). In many instances, we are concerned with the same species from a taxonomic viewpoint, but its ecological position, and thus its management needs, on the islands may differ from the mainland.

The Meru-Betiri complex is physiographically distinct from the surrounding area. The mountain mass of Gn. Betiri deflects the southeast monsoon winds, resulting in scattered showers throughout the dry season when the surrounding areas are without rain. We have described how this rainfall pattern has led to the development of tropical evergreen forest enclaves in the predominately deciduous monsoon vegetation of East Java.

Not all the species occurring in the rain forests of West Java are found in the island-like patches of rain forest in the East. Rain forest forms, such as the Javan rhino, the surili (Presbytis aygula) and the Javan or grey gibbon (Hyllobates moloch) do not occur and may never have (1). We do not know if these forms are so specific in their habitat requirements that they could not cross extensive barriers of seasonal forest or if in past millennia they did occur here, but

TABLE 4

COMMENTS ON THE MAMMALIAN FAUNA OF MERU-BETIRI

Species	Comments
CHIROPTERA	
<u>Pteropus vampyrus</u> - Flying fox; Kalong	Locally abundant; 1100 counted at Sumber Sari on July 4, 1976
DERMOPTERA	
<u>Cynocephalus variegatus</u> - Flying lemur; Walang topo	One observed near Tk Meru; two specimens recovered from leopard feces
PRIMATES	
<u>Nycticebus coucang</u> - Slow loris; Kukang	Not observed; reliably reported
<u>Presbytis cristata</u> - Silver leaf monkey; Lutung	Common at all elevations
<u>Macaca fascicularis</u> (= <u>iris</u>) - Long-tailed macaque; Kera	Common, especially at lower elevations
PHOLIDOTA	
<u>Manis javanica</u> - Pangolin; Trenggiling	Not observed; remains identified in leopard feces; probably thinly distributed
RODENTIA	
<u>Hystrix javanica</u> - Porcupine; Landak	Moderate distribution
<u>Hylotetes spadiceus</u> - Red-checked flying squirrel; Bajing terbang	Reported, but not observed; may be present
<u>Lariscus insignis</u> - Three-striped ground squirrel; Bajing	Probably observed near Bandialit
<u>Callosciurus notatus</u> - Plantation squirrel; Bajing	Probably common in plantation and secondary growth

COMMENTS ON THE MAMMALIAN FAUNA OF MERU-BETIRI (Continued)

Species	Comments
<u>Petaurista elegans</u> - Spotted flying squirrel, Bajing	Observed once
<u>Ratufa bicolor</u> - Giant squirrel, Jelarang	Observed; remains recovered from leopard feces; moderate distribution in the forest
<u>Rattus exulans</u> (= concolor) - Burmese rat, Tikus	Remains recovered in small carnivore feces; probably locally abundant
CARNIVORA	
<u>Cuon alpinus</u> - Red dog, Ajak	Thinly distributed
<u>Aonyx cinerea</u> - Clawless otter, Sero	Two observed in Sukamade Kali
<u>Melogale orientalis</u> - Ferret badger, Biul	Reported from Sukamade; tracks not observed
<u>Arctictis binturong</u> - Binturong, Binturong	Not observed; remains found in leopard feces
<u>Viverricula zibethica</u> - Javan civet, Rase	Locally abundant, especially near water
<u>Paradoxurus hermaphroditus</u> - Palm civet, Luwak	Locally abundant, especially near water
<u>Herpestes javanicus</u> - Javan mongoose, Gangarangan	Tracks observed in Sukamade
<u>Felis bengalensis</u> - Leopard cat, Kucing batu	Reported; probably present, but not observed
<u>Felis viverrina</u> - Fishing cat, Kucing bakau	Tracks, probably of this cat, seen near Kali Sukamade and Kali Sanen
<u>Panthera pardus</u> - Leopard, Macan tutul, Kumbang	Thinly distributed; perhaps 15-25 adult residents in Meru-Betiri; melanistic animals reported
<u>Panthera tigris</u> - Javan tiger, Harimau loreng	No more than four - five individuals living in the eastern part of the sanctuary

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COMMENTS ON THE MAMMALIAN FAUNA OF MERU-BETIRI (Continued)

Species	Comments
ARTIODACTYLA	
<u>Sus scrofa</u> ; <u>S. verrucosus</u> - Wild swine; Babi hutan	Both species may be present, but not confirmed; locally abundant
<u>Traquulus javanicus</u> - Lesser mouse deer; Kancil	Rare; remains in leopard feces
<u>Muntiacus muntjak</u> - Muntjac; Kijang	Locally abundant
<u>Cervus timorensis</u> - Rusa deer; Rusa	Not found in Meru-Betiri, but found in the Ponco Moyo area a few kilometres to the east.
<u>Bos javanicus</u> - Banteng; Banteng	Thinly distributed in Nanggelan, Gn. Rika and lower Kali Sanen; also found in Ponco Moyo area; total population ± 30

Species seen or reliably reported; no systematic collecting was undertaken in this survey; many additional species at Rodentia and Chiroptera were seen, but not identified.

became extinct through the multitude of factors that plague the fauna of islands and island-like habitats (41, 49).

It does appear, however, that the Meru-Betiri Reserve has a remarkably complete mammalian fauna, considering its zoogeographic position and regional relationships. Of the large mammals, the most obvious missing species is the rusa. Historically, the rusa was the principal prey species of the tiger and, for completeness, we have included it in our discussion (Table 4).

As a rain forest enclave in the East Java landscape, Meru-Betiri is an island on an island. It is an island twice removed from the mainstream of dispersal (50); at the same time, it is subject to conditions that tend to accelerate rates of extinction. In the past, the area was cut off from the rain forests of West Java by the extensive monsoon forests; today an even more impenetrable barrier for many species has developed in the form of the extensive agricultural area that has replaced the forest. For many of the species found living in the Reserve, this means that if their competitive ability is somehow impaired through man's activities or if their numbers are reduced or wiped out, they cannot re-establish from sources outside. The factors that accelerate rates of extinction on islands and in island-like habitats have been discussed in detail in the excellent article by Dr. Terborgh (41). Important for the manager to understand is that the mammalian fauna of Meru-Betiri is exceedingly vulnerable to environmental disruption.

Habitat Utilization and Ecological Needs of the Larger Mammals

Vegetation Structure - the Habitat Types:

To examine the relationships between vegetation and the larger mammals, we identified nine habitat types and ordered them in an ecological series along a hypothetical north-south transect between the Sanan River and the sand beach at Sukemad (Fig. 6). These include:

1. Open sand
2. Barringtonia, mangrove and tropical swamp forest
3. Alluvial forest
4. Plantations of coffee and rubber
5. Rheophyte vegetation
6. Bamboo/Ficus
7. Tropical rain forest
8. Transitional forest
9. Bamboo/grass

The bamboo/Ficus, bamboo/grass and the plantations are anthropogenic seres; the other types are vegetation types, as we have used the concept

here. In making the vegetation type distinctions, we followed the precedent set by van Steenis and his associates (30), including criteria outside the vegetation, itself, such as historical/geographic position, distribution of rainfall and temperature, water relations, soil characteristics, and topographic conditions (see 33). Such a division is important in identifying broad climax vegetation types and their seres.

Habitat types are based on physiognomy or structure of the vegetation, which has proven to be an extremely useful distinction in the studies of large mammals in South Asia (29, 49, 51). Basically, this classification groups vegetation by the presence of grasses and forbs, shrubs or trees and the relative degree of cover between the dominant plant forms. Hence, at one extreme are the sand beaches, followed by open grass and ephemeral vegetation on the banks of streams, and on the other, mature tropical rain forest.

The primary reason for making these distinctions is that the degree of forest cover profoundly affects the biomass of large mammals which can be supported (49). As a generalization for ungulates in South Asia, when proceeding from a dry thorn forest to a moist deciduous forest, the biomass of large herbivores increases, along with an increase in the rainfall gradient. Yet if the forest cover becomes continuous and there is little or no grassland area, the forest will tend to support a very low density of large terrestrial herbivores; at the extreme wet end of the vegetation gradient, the biomass of these forms will decrease again. In South Asia, the highest ungulate biomasses are attained where forest and meadow or alluvial plain interdigitate to create a maximum interdispersion of cover types (49). In general, the abundance of large predators will parallel that of the large herbivores (29).

We can predict a low diversity and abundance of ungulates in mature tropical rain forests because in these forests the undergrowth is often sparse and, aside from fruit, leaves, and other litter which fall from the crowns of trees, most of the plant productivity is locked in the trunks and root system or stored in the crowns of the trees. For this reason, while the diversity and biomass of terrestrial herbivorous mammals is low, the folivorous primates can be relatively abundant (44).

With this known, we can examine the distribution and abundance of the larger mammals living in the Meru-Betiri Reserve. Figure 6 presents our estimates of animal activity in various habitat types.

Banteng:

From an ecological and behavioural perspective, banteng are the best-studied large mammal living on Java. We have the excellent reports

Figure 6

Habitat Utilization by the Larger Mammals:

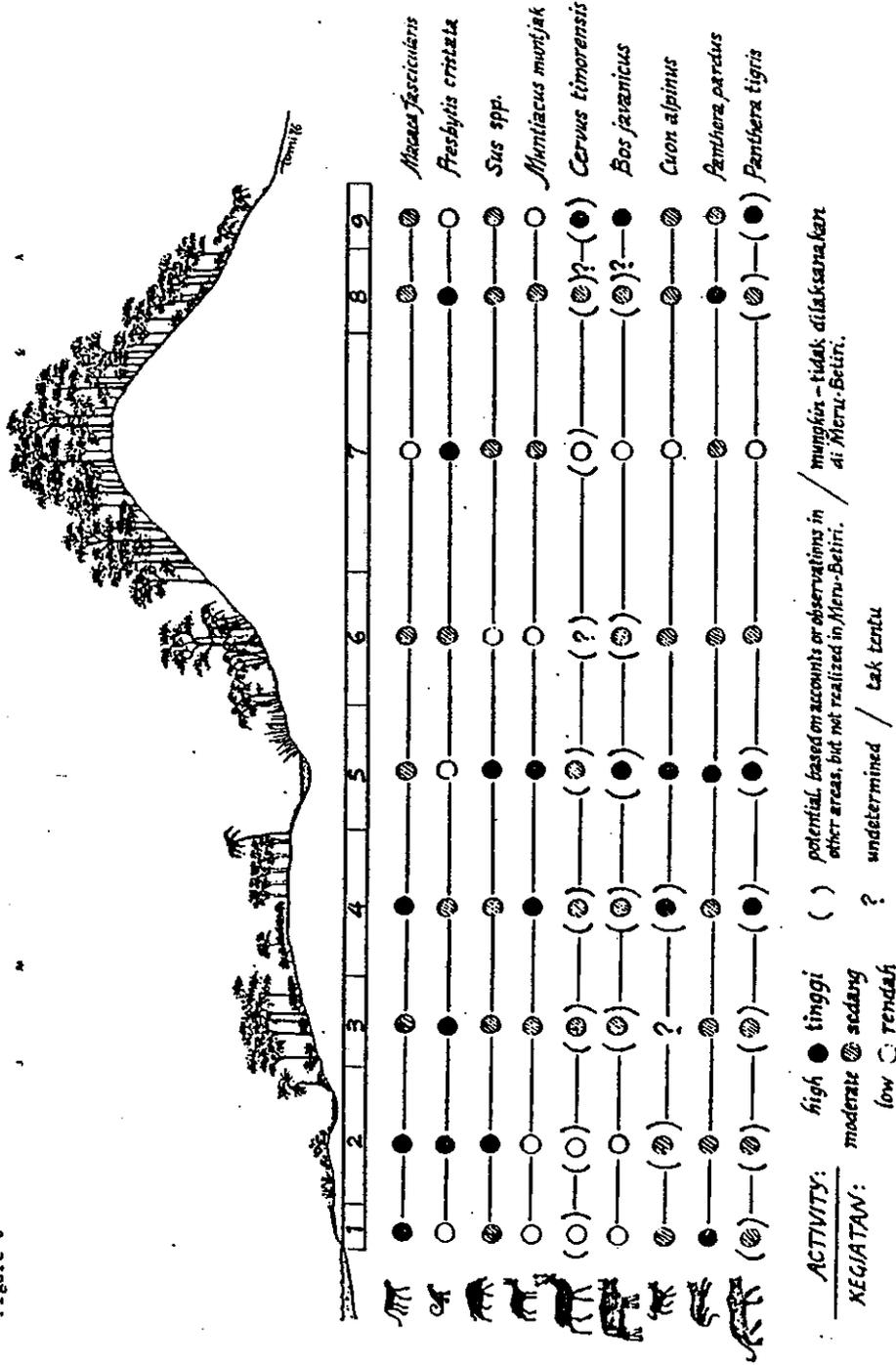
The first step in determining the conservation needs of the larger mammals living in the Reserve is to determine in which habitat types the animals are living. These can be related to the probable conditions forming the optimal habitat for which they are adapted. The next step is to determine if the species is exploiting all areas of available habitat.

In making our preliminary assessment of habitat utilization trends in Meru-Betiri, we have divided the vegetation into types, defined according to physiognomic or structural classes. Our estimate of animal activity in these types is based on direct observation and the relative intensity of the sign we encountered. In some instances, we were unable to make determinations. Our assessment of potential is based on observations made in nearby areas and from the published literature.

The four species which do not seem to occupy all the habitat available in Meru-Betiri are the tiger, Asian wild dog, banteng and rusa.

The heterogeneous nature of the vegetation of Meru-Betiri creates a favorable home for many of Java's large mammals, making the Reserve a valuable area in the National programme to conserve wildlife.

Figure 6



of Halder (28), Hoogerwerf (1) and Wharton (52).

Halder did not include the Meru-Betiri complex in his distribution map for banteng nor does the IUCN Red Data Book (10) discuss their occurrence here. Hoogerwerf (11) was unable to confirm their presence during his 1971 survey. Later W.W.F. surveys, however, have mentioned their presence in Meru-Betiri.

We found banteng tracks in the bamboo/grass vegetation in the west and near the Sanen River north of Go. Mandilis. Kepale Rayon Sarkan estimated about ten animals live in the north and about thirty in the Nanggelan area, and we feel this is a reasonable estimate. He has observed calves in both groups. We also found tracks of one or two individuals on the beach at Meru and behind the beach at Permisian. Banteng are not seen at Sukamade and only rarely at the Bandialit plantation. Sarkan told us the banteng live in the range of hills to the west of Nanggelan; we observed considerable sign on the Ponco Moyo ridge and behind the village at Pulau Merah, east of the Reserve. These two areas are under the control of Perhutani.

Banteng can live in habitats ranging from the dry savanna and monsoon forest of the Baluran Reserve to the rain forests of Ujung Kulon. According to Halder, their general ecological requirements include food, water, minerals, cover for protection, and a topography they can master. They prefer to feed on grass, but will eat leaves, fruit and bark. They usually drink daily, but probably can go without water for several days at a time during the dry season. They retreat into heavy vegetation while resting, in response to disturbance by man, and in response to heavy rains. They avoid deep water, swamps, and rocky ground (p. 117).

With such general habitat requirements, it is surprising that banteng are not more well-distributed in Meru-Betiri. Dr. Halder found that although adult bulls and cows without calves can live in rain forests at least part of the time, the female young units and subadults are particularly restricted to open grassy areas. This indicates that grass and forbs are of extreme importance in providing the extra energy needed in the reproductive effort and for growth. The rain forest banteng of Ujung Kulon are dependent on the artificially-created open areas or feeding grounds, as Hoogerwerf has repeatedly emphasized. Wharton (52) has summarized the strong symbiotic relationship between banteng and man in Southeast Asia and he points to the dependence of banteng upon grasslands that have resulted from peat agricultural activities and man's use of fire.

From the data available, we hypothesize that there is habitat separation between the cow calf units and subadults, and the bulls and females without calves. If the cows with calves and the subadults are dependent

upon grasslands, the amount of grassland available sets the carrying-capacity and reproductive rate. In habitats where grassy glades are in short supply, the separation may be more pronounced. Here, we would expect the bulls and cows without calves to be more frequently encountered in the forested areas. In extensive areas of mature closed rain forest devoid of grass, banteng cannot live and reproduce.

If this is the case, parts of Meru-Betiri are not suitable habitat for banteng. They occur in the drier areas that have been subject to past disturbance by man, such as the bamboo/grass fingers and the open fields of grass at the plantation edges (Nanggalan). The occasional observation of banteng at the Bandialit plantation and our observations of tracks at Meru and Permisan baya indicate that dispersing banteng do occasionally move through the forested regions. The absence of banteng observations at Sukamade may indicate that the high ridge between this drainage and Meru Bay acts as a barrier to dispersing animals. The artificial feeding ground being created at Sukamade probably will not be colonized by banteng already living in the Reserve. This will make it necessary to introduce a nuclear herd.

While it has been demonstrated in Ujung Kulon that it is possible to create a habitat situation in rain forest areas where banteng can live, it must be emphasized that the banteng living under these circumstances have an extremely low reproductive rate and high mortality in the younger age classes caused by the shortage of food. This is particularly critical in dry years. These animals also suffer from loads of parasites resulting from the intensive use of these limited feeding areas (28). The best conservation strategy for banteng lies in protecting them in a suitable habitat and Meru-Betiri has a considerable area of such suitable habitat.

Rusa:

What we have discussed about the food requirements of banteng seems to apply to rusa. While closely related to the sambar (Cervus unicolor), rusa appear to differ significantly in their ecological needs. Sambar occur in low numbers over a wide range of habitats; they are primarily browsers and are associated with late-intermediate successional species of plants (29, 49, 51, 53). Rusa appear to be much more dependent on early successional species. In Java rusa reach their highest densities in open areas. They appear to have low water requirements and seem to fare better in dry areas. Grass and forbs dominate their diet (1).

For this reason, the absence of rusa over most of Meru-Betiri is understandable, but why it does not occur in the border areas of the north and west is not clear; they may have been killed out by hunting

or disease in some earlier period. *Rusa* occur in the Ponco Moyo area, a drier region a few kilometers to the east of the Reserve. We found their sign there in the secondary forest and the open alluvial forest, which is interspersed with small grassy glades.

Muntjac and Chevrotain:

Little is known about the food requirements of these small solitary-living deer. From the Jarman-Bell principle (54), we can predict they are dependent on highly digestible forage, such as fruit, seeds, flowers, and sprouting shoots.

In Meru-Betiri we frequently encountered muntjac feeding on ephemeral forbs and grass shoots along the waterways. They live in the forest areas, but are most abundant in the rheophytic vegetation and the plantations (Fig. 6), which differs from mainland Asia (51). Muntjac are a potential food source for tigers and leopards, but even in optimal habitats, they are never found at the high densities reached by some of the other Asian cervids (49).

We have not included the chevrotain in Figure 6 because we were able to learn very little about it. We recorded their tracks in a few places; we never observed one. It was our impression that these small deer are very rare in the Reserve, but we did recover the remains of three in leopard feces.

Both the chevrotain and muntjac have limited mobility (29), which would restrict their distribution to areas where water is obtainable throughout the year and in dry years. This may render large areas of the Reserve unsuitable as habitat for them.

Wild Swine:

There are two species of wild swine (*Sus*) in Java (Table 4); both are reported to occur in the Reserve, but we were not able to confirm this. The swine are not ruminants; they do not have the capacity to digest cellulose. They are omnivorous in their feeding habits and depend on highly digestible foods, such as fruit and roots, especially those specialized for starch storage. They will eat carrion and animal matter when it is available.

We found wild swine widely distributed in the Reserve (Fig. 6). On the Indian subcontinent, wild swine reach their highest densities in alluvial habitats. Dr. A. Laurie (55) reports that in some limited areas of Ujung Kulon, they may reach even higher densities. Our impression in Meru-Betiri was that wild swine were extremely mobile and lived at low densities throughout most of the Reserve. Their

mobility gives the impression of much greater numbers than actually occur. They were most active in the plantation areas and the rheophytic vegetation types.

Primates:

The long-tailed macaque (Macaca fascicularis) and the silvered leaf monkey (Presbytis cristata) are the most abundant larger mammals found in Meru-Betiri. The leaf monkey is a folivore/browser/frugivore while the macaque is a frugivore/omnivore (56). Of the 62 monkey groups we observed, 39 (60%) were leaf monkeys. The leaf monkeys were rarely encountered on the ground (one observation), but nearly half of the macaque groups (14 of 25) were. Both species were seen in many of the habitat types (Fig. 6) but we saw only macaques in the rheophytic and bamboo/grass types; the leaf monkey was the only primate seen in the higher elevation rain forest.

Wilson and Wilson (57) found the silvered leaf monkey more frequently in disturbed lowland and swamp forests and it was especially abundant along the banks of the larger rivers in Sumatra. They never observed it above 600 m or deep in primary forest. Sumatra supports a diverse primate fauna of which the genus Presbytis is represented by five species (58). In Meru-Betiri the silvered leaf monkey is found in habitats it does not usually occupy in the presence of congeners.

Long-tailed macaques are found in a wide range of habitats. They were reported to be abundant in the rain forests of the Gn. Leuser Reserve, Sumatra, and in the primary and secondary forests of the Kutai Reserve, Kalimantan (60), but the highest densities were reported by the Wilsons (57) in the mangrove forests of Sumatra. In Meru-Betiri we found macaques in a number of habitats, but we did not observe them in the higher elevation rain forests. If they occur here, they do so at very low density.

The primates are the most important food of the large carnivores living in Meru-Betiri (Table 5); thus it is important to summarize the factors that affect primate distribution (61):

- As folivores, we would expect the leaf monkeys to reach higher densities than the omnivorous macaques in the forested areas of the Reserve.
- We would expect little resource competition between the two species; differences in feeding preferences should result in differential habitat utilization. Figure 6 bears this out.
- Forest succession will affect both diversity and carrying-capacity of primates. Our preliminary assessment (Fig. 6) showed that the macaques are more frequently associated with early successional types: both macaques and leaf monkeys are found in the mid-successional

forests, but leaf monkeys are more abundant. In the late successional and mature forests, leaf monkeys are more often found.

- We would expect the highest primate densities in a mosaic of vegetation types rather than in a homogeneous situation.

The Large Carnivores:

All three of Java's large carnivores, the tiger, the leopard and the Asian wild dog (Cuon alpinus) live in the Meru-Betiri Reserve. We estimate there are no more than four or five tigers, perhaps 15-25 adult leopards (including the area north of Gn. Ketiri), and a small population of wild dogs, whose numbers we could not accurately determine.

The tiger is in imminent danger of extinction; we discuss this survival problem in the following chapter. Both the wild dog and leopard are listed in the IUCN Red Data Book (10) as threatened species but the wild dog should be considered as endangered in Java (34). For all three of these predators, the protection provided by the Reserve is essential for their preservation.

Both the leopard and wild dog are primarily predators of medium- and large-sized mammals. They use different hunting methods and this is reflected in their social systems. The leopard is a stalking predator. It must approach, undetected, to within a critical distance from its prey before launching its solitary attack. It kills with a precise neck bite. The wild dogs are chasing predators; killing is accomplished through a series of unspecific bites on the prey's unprotected areas. In hunting larger prey, they hunt in packs, but they may often hunt small animals singly (62).

In the wild dog, cooperative hunting has led to the evolution of cohesive social units centered on the mated pair and its maturing offspring (12). Their land tenure system has not been studied in sufficient detail to provide even an elementary outline of its structure.

The social system of the leopard can be classed as solitary. Research with leopards and other large solitary felids has shown that home ranges of males overlap those of females. Female ranges may overlap, but the ranges of males do not overlap to any appreciable extent. The mating system is polygynous. Communication is maintained through olfactory, auditory and visual means. Newly independent young may roam through the home areas of adults, but they do not settle into their adult reproductive roles until they have a home area of their own (29, 62, 63, 64). The number of individual leopards that can live in an area is probably set through the abundance of prey and the habitat characteristics which influence the vulnerability of prey to their hunting method; the population level is maintained through social

interaction (see 65).

In Meru-Betiri, both the leopard and wild dog were active in a variety of habitat types (Fig. 6) and both were widely distributed. The estimate of leopard numbers is based on a consideration of distribution and size of tracks, and can only be considered a rough approximation. We found only one instance where two wild dogs were travelling together. We found three instances where tracks indicated a female leopard was accompanied by young. We did not observe the tracks of wild dogs in the plantations and we think this is because of disturbance factors. We observed wild dog tracks on the Meru beach. Dog tracks were seen on the beach at Sukamade and Gandialit, but these were domestic dogs running wild, a practice that must be controlled.

The Large Predators and Their Prey:

During our survey of the Meru-Betiri complex, we collected 51 leopard feces, three of tiger, and two of wild dog (Table 5). Distinguishing of the feces was based on size and shape (1,66), but the determination cannot be considered absolute. In addition, we found the remains of two kills; one muntjac and one palm civit (*Paradoxurus hermaphroditus*). Only skeletal material remained and it was not possible to identify the predator. All large predator feces encountered in the field were collected; identification of remains was made by comparing hair and other skeletal material with specimens in the Zoological Museum, Bogor.

Conspicuously absent from the food items identified (Table 5) were the remains of wild swine. Hoogerwerf (1) reported that in Ujung Kulon all three predators fed on them. Both tigers and leopards fed on wild swine in the Royal Chitawan National Park in Nepal (64). Muntjac also occurred with less frequency than might be expected.

The predominant food of the large predators in Meru-Betiri, as revealed through our sampling of feces, was monkeys. Leaf monkeys exceeded macaques by a factor of more than two. This is a greater margin than would be expected, based on our observations on relative abundance, suggesting that some factors are operating to increase their vulnerability especially to leopard predation. A large number of the monkeys' teeth found in the remains were of old and young individuals.

An examination of the prey species' own food preferences gives a preliminary picture of the energy pathways through the mammalian community of the Reserve forests. The predominant trophic specificity of the prey is frugivore, with eight species; browser - four, vegetable matter - two, omnivore - two, insectivore - one, carnivore - one (Table 5). Eight species fed predominantly on plants, three on a mixed diet (plant and animal) and one fed on insects. There were no obligate

TABLE 5

FOOD REGIME OF THE LARGE CARNIVORES IN MERU-BETIRI

Food Item	Trophic Speciality	Remains in feces			Skeleton	Total
		<u>P. pardus</u>	<u>P. tigris</u>	<u>C. alpinus</u>		
<u>Presbytis cristata</u>	F/B	23	-	1	-	24
<u>Neogae feecigleris</u>	F/O	10	2	-	-	12
<u>Hyerrix javanica</u>	V	2	2	-	-	4
<u>Manis javanicus</u>	I	3	-	1	-	4
Birds		3	1	-	-	4
<u>Pardoxurus hermephtoditus</u>	F/O	1	1	-	1	3
<u>Taeguinus levanicus</u>	B/F	3	-	-	-	3
<u>Pteropus vampyrus</u>	F	2	-	-	-	2
<u>Cynocephalus variegatus</u>	B	2	-	-	-	2
<u>Ratufa bicolor</u>	F	2	-	-	-	2
<u>Muntiacus muntjak</u>	B/F	1	-	-	1	2
<u>Acetlicis binureous</u>	F/C	1	-	-	-	1
<u>Rattus exulans</u>	V	1	-	-	-	1
Rodent, unidentified		3	-	-	-	3
Undenctified remains		-	-	1	-	1
Grass		-	-	1	-	1

Notes

Discrimination of feces between predators was based on size and shape (see text)

Total feces: P. tigris = 3, P. pardus = 51, C. alpinus = 2

F = fruit; B = browser; O = omnivore; V = vegetable matter; I = insects, etc.; C = carnivore

carnivores in the diet. In terms of forest level, all but the two ungulates spend at least part of their time in trees. The macaque, palm civit, pangolin (Manis javanica) and porcupine probably spend a fair percentage of their time on the ground where they would be vulnerable to terrestrial predators, such as the tiger and wild dog. The leopard frequently climbs trees and often pulls large prey into trees to feed, but in Nepal, an intensive radio-telemetry study indicated they too were primarily terrestrial predators (64). That so large a proportion of the prey species taken are arboreal or spend a substantial percentage of their time in trees may indicate that when they do come to the ground, they are exceedingly vulnerable. Yet it may also be that terrestrial predators have hunting techniques for capturing arboreal forms.

We once watched three domestic dogs pursue a group of macaques through the bamboo/Ficus near Pulau Merah. The dogs followed the troupe, barking. When one young monkey lagged behind, the dogs immediately turned and ran beneath it, barking, driving it further and further from the main group. Away from the group, the young monkey became more and more distressed and called with increased intensity. As it was driven, we saw it actually come closer and closer to the ground in its confusion. We were not able to observe if a kill was made and are not implying this is a usual hunting method of the wild predators, but this observation does indicate a means whereby a terrestrial predator can pursue an arboreal prey animal.

It was our impression that there were more leopards in the area north of Gn. Betiri than in the south. Portions of this area are disturbed forest and there are some extensive stands of bamboo. Nonkeys were more abundant here than in the south, as would be expected from our summary.

Of interest is why the large predators frequent the sand beaches with such regularity. Our impression is that these were hunting areas. A number of prey or potential prey species, such as wild swine, palm civit, Javan civit (Veverricula malacensis) and macaques, frequent the beaches searching for intertidal invertebrates. When these mammals are on the exposed stretches of sand they are easily detectable for a considerable distance and are vulnerable to attack. One Javan civit we encountered in such a situation plunged into the surf rather than retreat back across the sand.

Survival Needs

For analytical purposes we divided the great forest into types and talked of energy pathways, competition and niches. A leopard kills a macaque; the macaque lives on forest fruits; the trees depend on sun, soil and rain. We analysed a community by looking at its parts,

but it is the wholeness that functions. In the forest, there is dependence, interdependence, and coexistence. Relationships are established through natural selection. Competition directs selection; selection gives rise to specialization; specialization facilitates coexistence. Sun and soil, rain and seasons, plants and animals - together they form a dynamic ecosystem. However, the vital relationships are easily shattered by thoughtless and unknowing men.

Man has affected the Maru-Betiri ecosystem, and this is reflected in the abundance and distribution of the mammals. Careful management action will be required to offset man's disruptive effects. We recommend the following preliminary measures:

- Effect adequate protection of the Reserve
 - Expand the Reserve area so that the range of habitats north of the Gn. Setiri - Gn. Mandilis ridge and south of the Kali Sanen fall within its boundaries;
 - Eliminate the disruptive influences on Reserve ecosystems; this includes elimination of the human exploitation of coastal and forest products and the removal of human habitations and agriculture from the Reserve;
 - Make limited introduction of rusa and hanteng into areas where there is suitable habitat, but where they do not presently occur and where it is unlikely that they will colonize naturally;
 - Initiate a monitoring and research programme to continually assess population trends so that the effectiveness of the Reserve management programme in providing for the ecological needs of endangered and extinction-prone species can be assessed from an adequate data base.
- The details for implementing these recommendations are given in the management plan.

SEA TURTLES

A giant turtle emerging from the pounding sea in the moonlight to nest on a sandy beach is one of the most dramatic natural features of the Maru-Betiri Reserve. Dr. A. Carr (67) once wrote:

"They go ashore to nest - some singly, some in aggregations - and after nesting they disperse into places that are mostly unknown. For at least a year after hatching, the young disappear, and the developmental migrations of the five genera have never been traced. The tendency to spread the

life cycle through hundreds or even thousands of miles of ocean aggravates the biological and political problems of protection. When to these inherent difficulties is added the demand of a spreading market for a growing list of turtle products, the outlook for maintaining the resource grows dimmer. There even seems to be a clear likelihood that some of the sea turtles will disappear as natural species." (p.13)

Along the coast of Meru-Betiri are sandy beaches suitable for turtle nesting (Fig. 7). In the recent past, turtles have nested at Nanggelan, Meru and Rajegwesi. We saw fresh nests at Permisan and to the east of the Reserve at Pulau Merah, but all of these nests had been opened by people collecting eggs. The occasional turtle still nesting on these beaches leaves hope that with complete protection, recovery might be possible.

Now it is only at Sukamade that turtles nest in any number. Of the seven species of sea turtles alive today, five reportedly come here to nest: the green turtle or penyu bantang (Chelonia mydas), the loggerhead or bromo (Caretta caretta), the hawksbill or sisik (Eretmochelys imbricata), the Pacific Ridley or kumbang (Lepidochelys olivacea) and the leatherback or blimbing (Dermochelys coriacea). All are endangered species (68).

The turtles nest all year long at Sukamade, but there is a seasonal fluctuation in numbers. Overall, the number coming yearly to the beach appears to be declining, which parallels the world trend in sea turtle populations (Fig. 7).

Sukamade is perhaps the most important turtle nesting beach left on the eastern south coast of Java (69) and has been the subject of a special turtle conservation project for a number of years. Between 1970 and 1975 more than half a million eggs were collected and sold. Official records show that 150,000 eggs were left to hatch (70). We are sorry to report that during the time we spent on the beach at Sukamade in June, July and August, all eggs were collected each night by the turtle conservation project officers. No nests were left undisturbed. We have no data for other times, but no nests are being marked to supply data on the hatching rates that are being reported. We believe that under the present management programme this important nesting beach will not survive.

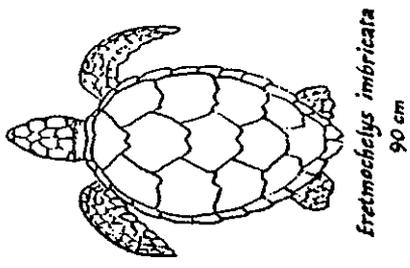
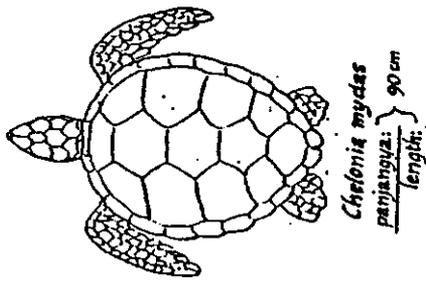
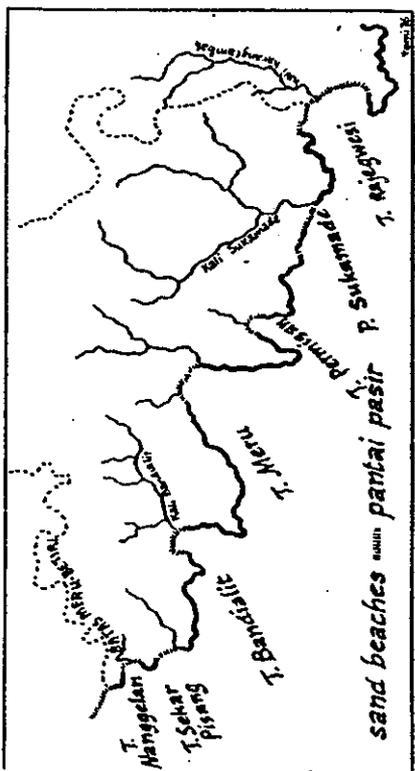
A fundamental consideration in any turtle conservation programme is

Figure 7

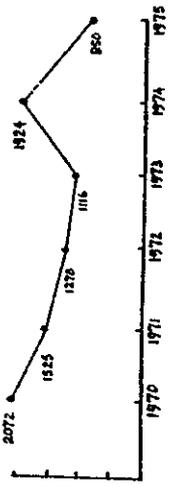
Sea Turtles:

The Sukamade beach is the best remaining turtle-nesting area on the south coast of East Java. Five species of sea turtles are reported to come here, but by far the most frequent nester is the green turtle (Chelonia mydas). A turtle conservation project has been in operation since 1969 and the project has been successful in controlling the illegal taking of eggs from the Sukamade beach, but the numbers of turtles coming to nest show a continual decline. In the period the turtle conservation project has been in operation, 500,000 eggs have been collected and sold by the project personnel to help cover project costs; it appears that no eggs are being left to hatch. It is essential that this practice be stopped. The Sukamade beach and all the sandy beaches in the Reserve must be totally protected or they will soon be barren of nesting sea turtles, as are so many other former nesting beaches on Java's south coast. The turtle conservation project should come under the full control of P.P.A. Expert assistance is required to initiate a programme for re-establishing depleted nesting populations.

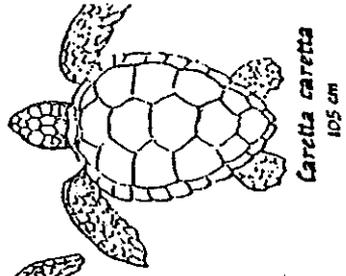
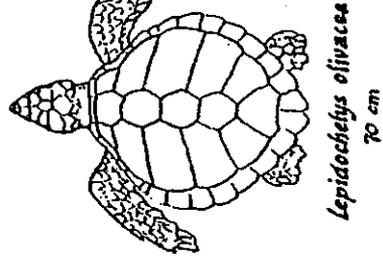
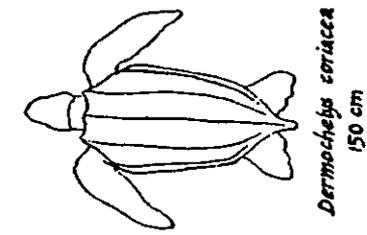
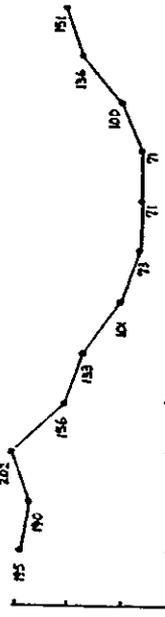
Figure 7



Banyaknya penyusuk ke pantai Sukamade
Number of turtles coming to Sukamade beach



Jumlah rata-rata tiap bulan (6-tahun)
Mean number per month (6-year period)



that hatchlings are probably imprinted with some "sensible essence" of the beach and the detection of this essence guides them back to the same beach to nest when they mature (71). Managers cannot expect depleted nesting beaches in the Reserve to be re-established by turtles from other beaches or other areas. The recovery of depleted beaches will require a restoration programme (68).

MONITORS, CROCODILES AND PYTHONS

The three large reptilian predators found on Java are adapted for different niches: the monitors hunt along shores; the pythons in trees; and the crocodiles in water or at the water's edge. The python appears to be an obligate predator; the crocodiles and monitors are primarily hunters, but sometimes feed on carrion. All can use a lying-in-wait hunting strategy or hunt actively. While these large reptiles rarely appeal to man's aesthetic senses, they are, nevertheless, an integral part of the rain forest community.

Monitors (prob. Varanus salvator) abound along the riverbeds and sandy beaches of Meru-Betiri. We found their tracks wherever there was suitable habitat. We have no information on the clouded monitor (V. bengalensis nebulosus) reported for East Java (72). Little is known about this species and it deserves special study to determine whether it occurs in the Reserve and if its survival is in question.

We did not see pythons, but they are frequently reported for the Reserve. The pythons of Java (Python reticulatus, P. bivittatus) have been heavily exploited by the animal trade and have disappeared over most of the island (35). Meru-Betiri is an important area in their conservation.

The three Javan crocodiles (Crocodylus porosus, C. siamensis, C. palustris) are in serious danger of extinction (35). Today there are no crocodiles in the Reserve. The estuarine crocodile (C. porosus) and the mugger (C. palustris) may have lived here in times past, but their primary habitat is now totally disrupted by plantation operations. When the Reserve ecosystems are brought under the complete control of P.P.A., an introduction attempt for these two species should be made.

Of course, there are many other reptiles and many amphibians in the Reserve, and it is disturbing that we cannot even list their names, much less discuss their ecology and identify possible survival needs. That makes them no less important than the larger, more conspicuous forms, but, as with so many rain forest species, the complete protection of the Reserve is the first management need.

THE IMPORTANT NATURAL FEATURES AND PROCESSES

In the previous sections we have discussed sea turtles and tigers, Rafflesia and great trees. These are the dramatic features of this fine reserve, but not the only features or even the most important. They are the ones which readily catch the human imagination.

A rain forest is a study in diversity of flora and fauna. It is a study of complexity, coevolution of plants and animals, of interdependence. The ants and termites probably represent the largest animal biomass. The very existence of the forest is dependent on the role they play in nutrient recycling. The establishment of many of the great trees is dependent on seed dispersal by birds and mammals. Pollination of flowers is accomplished by wind and bats, birds and insects.

We regret that the information is not available to detail these many important and interesting processes and relationships. Yet we emphasize that the uniqueness of this Reserve lies not in dramatic events like the migrations of great herds of wildebeeste in the Serengeti or the periodic eruptions of geysers in Yellowstone; the beauty and value of Meru-Betiri lie in subtlety, in diversity and in wholeness.

THE JAVAN TIGER

The tiger lives in a world of sunlight and shadow
Always secretive - never devious
Always a killer - never a murderer
Solitary - never alone
For it is an irreplaceable link
To the process and the wholeness of life.

J.S.

Towards the end of the Pleistocene, the sea rose over the Sunda shelf, leaving the island configurations we know today and isolating many populations of widely-distributed species. For some, conditions on these island refugia were favorable and their numbers flourished. Conditions were not always suitable, and some populations did not survive. Of the Sundas, only conditions on Sumatra, Java and Bali were such that the great cat, the tiger, could live, if only for a time.

With the flow of genes broken, slight morphological differences began to emerge, variations in body size, in cranial character, and in the colour and marking of the coat (Table 6). In the 19th and early 20th centuries, when taxonomists began to examine the specimens of Sunda tigers accumulating in private collections and in the great museums, they found that these variations were sufficient to warrant sub-species designations; all tigers unmistakably, but each race was distinct (73). We can hypothesize that the morphological variations in these island populations represent adaptive response to local conditions, but we will probably never be able to establish their function with certainty. So it is with tigers; time is so short and we know so little.

TIGERS AND MAN

For thousands of years man and tiger lived together in the Sunda Islands (74). There were conflicts. At times tigers and man competed directly for food. Man killed tigers; tigers killed men. Yet both were bound together in an integral and fragile web on these island ecosystems. Both were molded and bound by the nature of their resource base and the forces of their environment.

However, the tiger has not fared well with man's expanding sphere of influence. The development of powerful technology, and world marketing

TABLE 6

CHARACTERISTICS OF THE SUNDA TIGERS, PANTHERA TIGRIS

	Sumatras	Sondiac	Balica
Size	normal *	normal *	smaller
Ground colour of the skin	lightest	darker	darker
Colour of inner side of forelegs	whitish	a lighter shade of the ground colour	a lighter shade of the ground colour
Nasals	short and wide	long and narrow	long and narrow
Occipital plane	broad	narrow	narrow
Frontal line (fore-head)	most flat	more vaulted	still more vaulted
Bullae	normal	normal	somewhat flatter

From Sody (73)

* Smaller than Panthera tigris tigris, J.S.

systems, backed by inputs of energy from fossil fuels, have changed man's relationship with the land. For the many animals and plants which share with man the thin zone of life on this planet, the consequences have been disastrous. After so many thousands of years, the tiger's existence is in question throughout its range, especially on the Sunda Islands. The Bali tiger has not survived the onslaught of "modern man" and it is, in all probability, extinct. The Javan tiger is in imminent danger of extinction, and may follow soon if we do not act, and act correctly.

We have waited so long with the Javan tiger that it may not be possible to assure its survival. Conservationists are left with the task of somehow putting together a programme that will stop this march of extinction. It should be done in a way that provides a reasonable chance for the tiger to survive as a viable and dynamic component of its natural ecosystem.

THE STATUS OF THE TIGER IN MERU-BETIRI

Tropical forests and secretive, solitary-living carnivores are a challenging study combination, but not an impossible one. We conducted the fifth status survey for the Javan tiger in Meru-Betiri (11, 14, 15, 18), and we conducted it in the classic manner, developed over the years, for rapid status surveys. This included travelling extensively over the Reserve and adjacent areas, searching for sign, and questioning the people we met. In all, we spent three months in the field. We attempted to include the routes of the previous surveys, as far as practicable; we surveyed the central and eastern areas of the Reserve twice.

Rapid surveys to establish the status of large mammals for conservation purposes should not be confused with intensive research, investigating their behaviour and ecology. Their objectives and methods are different. The theoretical approach and field techniques for the latter have evolved rapidly in the last 15 years. The recent synthesis by Dr. E.O. Wilson (75) serves as an index of the "state of the art" and a guide to future work. Rapid surveys can only be expected to provide an overview of the ecological situation and conservation needs, and results should be interpreted in this light. Both kinds of investigations are essential in the conservation effort for extinction-prone species.

Survey Results

The results of our status survey of the tiger can be summed up as follows:

- We found hard evidence of the occurrence of only three tigers, and we believe there are no more than four or, at the most, five tigers living in the area;
- We found no evidence to suggest that "effective" reproduction is occurring, but there is reasonable evidence to suggest that there are both males and females in the population;
- The tigers are not confining their movements to the Reserve, nor are they using all of the Reserve area;
- We found no evidence to suggest that a tiger has been killed recently by man, but we also found most people living in the area badly misinformed about the plight of the Javan tiger and its survival needs.

Distribution;

The location of the tiger tracks we found and those recorded during previous surveys are shown in Figure 3c. Not all the previous reports are included, but we have indicated the extent of movements which we term the tiger's "ranging area". There is no hard evidence or reports of tigers in the western part of the Reserve, but we did find one set of tracks and two feces large enough to be from tigers in the area north of Gn. Setiri. The people living in this area report they occasionally encounter tigers.

The core of the tiger's ranging area is the lower Sukamade valley, which is an area disrupted by a large plantation of coffee and rubber and populated by 2000 people. It is here that we found evidence of the highest density of muntjac and wild swine, and there were good populations of leaf monkeys and macaques (Fig. 6). We surveyed the entire Sukamade drainage in early July and again later in August. Both times we found fresh tiger tracks in the upper reaches of the river valley, but not in the lower plantation areas. Tigers sometimes do come to the plantation, as has been recorded by earlier surveys, plantation personnel, and the Reserve staff, but tigers are not visiting the plantation areas as frequently as could be expected on the basis of available prey.

Numbers:

While the entire monitoring programme for the tiger conservation project in India is based on an assessment of track size (76), this technique for assessing numbers is far from ideal (see 11). Track size can be used with a reasonable degree of accuracy when a small number of individuals is involved, as has been shown by studies in India (53) and Nepal (77), but this method should be backed by direct observations.

Our assessment of numbers is based on the size of forepaw tracks (12.5-13, 14 and 16.5 cm) found at six locations. The size of the tracks we recorded compare with 12.5-13, 14.5 and 15-16.5 cm track sizes recorded during the 1975 survey (18). This would indicate there are at least three tigers. There is no reason to believe there are more than four or at the most, five individuals. Previous surveys have suggested the number may be as high as 12 (14), but this is unsupported by the data presented. Our results do not necessarily reflect a decline in numbers, but they certainly do not indicate an increase.

Reproduction:

Two facts suggest that both male and female tigers live in Meru-Betiri: the disparity in the size of tracks we observed (12.5-13 and 16.5 cm) and the fact that both tigers were utilizing the same area. Overlap in home area use by tigers is also shown in the previous surveys. If two males were present, we would expect the areas utilized to be more exclusive (53, 64, 77). A comparison of track sizes from Meru-Betiri with those from identified individuals from Nepal (76) is not so reassuring. The smaller track from Meru-Betiri falls in the range of adult male Indian tiger track sizes, but Hoogerwerf's (1) data on tiger track sizes from Ujung Kulon indicates that the Javan tiger has a larger track than the Indian tiger, despite a smaller body size.

The last reliable observation of a tiger cub in Meru-Betiri was in 1971 (41). In that year an older female was shot at Sukamade. We did not find tracks of a family group travelling together, nor did we find cub tracks. After a cub is six months of age and travelling with the female, its tracks are fairly easy to distinguish from those of leopards with young.

From the available data, we cannot say that no reproduction at all is occurring, but neither is there evidence to suggest that the population is increasing.

Food:

The three feces we found, which were large enough to certainly be from tigers, contained the remains of porcupines (2), macaques (2), an unidentified bird (1) and a palm civet (1). One feces analysed by J. Slower (16) in 1975 contained the remains of a porcupine. Unfortunately, the feces found during previous surveys were not analysed. This is a small sample, but the results indicate that in Meru-Betiri the tiger is subsisting on a small-sized prey base, which is not an ideal situation.

Survival Needs

How do the survival needs of the Javan tiger relate to the situation in Meru-Betiri? In attempting to identify the important factors amenable to management action, we developed a list of four questions, which arose out of our survey and a consideration of IUCN's model research programme for species threatened with extinction (45).

- How does Meru-Betiri compare with conditions forming the optimum habitat for the Javan tiger?
- What prevents tigers from inhabiting all of the Reserve?
- Why has effective reproduction ceased in the tiger population?
- What have been the major sources of mortality of tigers?

Each question is examined in the light of available information.

How does Meru-Betiri compare with conditions forming the optimum habitat for the Javan tiger?

Though the tiger can live in vegetation types ranging from mangrove swamps to thorn forests (79), these vegetation types are not equally suitable as habitat. Optimal habitat for the tiger has not been established through empirical study, but available data does enable us to rank broad habitat categories in terms of their suitability in providing for the tiger's needs. To do this, we must choose some currency or criteria. Such an assessment might logically begin with the factors that affect the rate at which food can be obtained:

- diversity and abundance of available prey;
- size and allocation of each size of class in relation to the total prey biomass present;
- dispersion of prey;
- activity patterns and anti-predator modes of each class of prey;
- energy available from each class of prey;
- environmental factors that affect the outcome of the hunt;
- diversity and density of competitors;
- the numbers of other tigers present.

The factors involved can be divided into two groups: those that determine the kind, abundance, and dispersion of prey; and those that constitute and define optimal diet, foraging space and foraging period (80, 54).

Consider some of the characteristics that limit the tiger's exploitation of resources and use of space. It is a big, solitary-living, stalking predator. The success of this hunt depends on the element of surprise. The opportunities to catch a prey animal are limited by the abundance and distribution of prey in relation to the number and distribution of environmental situations where the tiger can make a successful close-range stalk. The suitability of prey will depend on the energy derived versus the energy expended in catching it. The tiger can feed on a wide range of prey sizes, and indeed, by virtue of its large size, it can feed on a larger range than its close relative and competitor, the leopard. Yet clearly, the tiger can compete more efficiently with the leopard by exploiting larger-sized prey. Males have no direct nutritional responsibility for their offspring. A critical phase in the reproductive cycle of the large solitary-living cats results from the restricted mobility of the young for the first few months after birth, and their long dependency on the female. During this period, the female must kill frequently and with predictable regularity. In the first months after the young are born, the female is greatly restricted in her movements. At this stage she is most vulnerable to disturbance (53, 62, 64, 65).

Considerable numbers of ungulates, suitable as prey for the tiger, can be found living in drier regions which support open grasslands (49). The grass provides an abundant food resource for these herbivores (54), but the tiger is not adapted for hunting here. This prey resource has been exploited by the group-hunting lion (*Panthera leo*) and chasing predators, such as the cheetah (*Acinonyx jubatus*) and wild canids (62). At the other end of the habitat spectrum are the tropical rain forests. They provide seemingly unlimited opportunities to launch a successful attack, but the degree of forest cover limits the amount of food available to ungulates, and their number and diversity is greatly restricted.

In Asia, the greatest diversity and biomass of ungulates are found where forest and meadow interdigitate to create a maximum dispersion of cover types (49). This also provides optimal hunting opportunities for the tiger (64).

In assessing habitat suitability, it is useful to make a distinction between the factors which maintain the density of tigers living in an area and those which establish density (see 65). The former concerns social structure and the land-tenure system; the latter concerns the feedback from the food resources that results in the curtailment of population growth. These two factors are, obviously, closely related (81), yet they are distinct (65). For our purposes, we assume that the number of tigers living in an area reflects the rate at which food can be obtained. We can make a preliminary assessment of habitat suitability by considering known tiger density in different habitats.

We have reasonably accurate density estimates for tigers from only three areas: Kanha National Park in India, studied by Dr. G. Schaller in the mid-1960's (53); The Royal Chitawan National Park in Nepal, where studies are still in progress (64); and the Ujung Kulon Reserve in Java, studied by A. Hoogerwerf in the 1930s and 1950s, before the tiger became extinct there (1). The Ujung Kulon area is covered with tropical evergreen forest with a few scattered, artificially-created meadows. Hoogerwerf estimated there were no more than three or four resident tigers living there or about one per 75-100 km². The ungulate biomass in the Reserve was estimated at about 500 kg/km² (49). In the Royal Chitawan National Park, which is an area of 80% Shorea forest and 20% alluvial plain with forest and tall grass intermixed, the ungulate biomass was estimated to be about 1800 kg/km² (51). The total number of adult resident tigers in this 500 km² area was about 25 or one per 20 km² (66,78). Kanha National Park in India is also an area of about 80% forest and 20% short grass and tree, savanna. The ungulate biomass was estimated to be about 1700 kg/km². The number of adult tigers present was about 10-15 in 320 km² or one tiger per 20-30 km² (53).

With these considerations, we can develop a perspective on the suitability of the various habitat types in Meru-Betiri. We would expect the suitability of rain forest areas to be low, the transitional forest areas moderate and the alluvial plain and bamboo/grass areas good to excellent. In Meru-Betiri, it is important to make a distinction between potential and realized conditions. For historical reasons, those habitats with the greatest potential are now relatively unsuitable. Plantations disrupt the valley bottoms and the numbers and diversity of ungulates living in the valleys and bamboo/grass have been greatly reduced. Portions of Meru-Betiri have the potential to be reasonably good habitat for the tiger, but this potential will not be realized unless management action is taken.

What prevents tigers from inhabiting all of the Reserve?

At least three factors may be involved: habitat conditions, disturbance, and the tiger's social system.

Availability of food will determine where a tiger can live and we have discussed the difference between the potential and realized suitability of various habitats in the Reserve. This would explain why the tiger may not be using some of the areas in the north and west, but the present distribution is not directly correlated with food availability.

Earlier investigators have suggested that the distribution of tigers in the Reserve may be a response to competition from leopards and wild dogs (11) and disturbance by man (18). Exploitation competition from leopards

and wild dogs will effect the suitability of an area for the tiger (64), but the leopard and wild dog are found living throughout the Reserve and we see no direct correlation with tiger distribution.

Disturbance by man is great in the west, but it is also a predominant feature in the core of the tiger's ranging area, the lower Sukmade valley. Disturbance is an important factor influencing the way tigers utilize their ranging area. It is a detrimental factor, but it does not completely explain tiger distribution.

The tiger in Meru-Betiri may be restricted to certain areas through attachment to a site; that is, there are adults with established home ranges or territories and they rarely move beyond these areas. As in other large solitary-living cats, there are three relatively distinct behavioural phases in the tiger's life cycle (53, 77). Through most of the cub stage, the young animal is totally dependent upon its mother and is restricted in its movements to her home range. Once independent, the tiger roams about without attachment to a particular area or site. Dispersing females probably do not breed successfully and dispersing males breed only rarely (see 65). When an area adequate in size and resources and free of too many other resident tigers is located, the young tiger restricts itself more and more to that area. With attachment to this area or site, the tiger is ready to begin the reproductive phase of its life. Site attachment is not essential for survival, but it is a prerequisite for reproduction. It results in a predictable social environment. It confers an advantage in food resource acquisition because of familiarity with the area and, thus, gives a competitive advantage over other tigers for food resources. We also know that benefits are derived from community interdependence in terms of reproductive fitness (29, 54, 65).

It seems likely that the tigers in Meru-Betiri are older individuals and that both sexes are present. We believe that these animals are living on established home ranges (or territories) rather than simply living as transient individuals. Resident male tigers more frequently make short trips away from their home areas than do females (53, 77) and the tracks observed under Gn. Mendilis in 1975 and to the north of Gn. Betiri during our survey were large, probably those of a male.

While the tigers in Meru-Betiri may be restricting their movements to certain areas, this habitat cannot be considered optimal; it is simply the best that is available. Within the tiger's ranging area, the suitability of the habitat is further reduced through disturbance by man. There is little that a manager can do to alter the tiger's land-tenure system, but he can remove the disturbance element and improve the food situation in certain areas.

Why has effective reproduction ceased in the tiger population?

Behavioural, genetic and physiological problems are well-documented in captive breeding programmes for tigers.

With only four or five tigers remaining, we know that there has been a substantial loss in genetic variability. It is reasonable to assume that a population which has had so few individuals for some time is likely to result in the occurrence of individuals that are homozygous for rare recessive characters. Offspring produced with gross deleterious recessive characters probably have not survived to enter the breeding populations. Under captive breeding this is not the case, as can be seen in the rather extensive literature now available on the "white" tigers (86). However, we may see a decline in fertility or the survival of young as a result of "inbreeding depression" (Mayrin 45).

We know that fighting and dominance relations can be a problem in achieving successful mating between captive tigers (82), but this may not be manifest in wild situations. The tiger population in Meru-Betiri is not so thinly spread that individuals do not encounter each other frequently enough to mate, nor is there any reason to believe that some critical density is required to stimulate mating in tigers. Yet there may be a host of more subtle phenomena occurring, which the present state of our knowledge does not enable us to identify.

If there is a physiological problem preventing successful breeding, it may be possible to capture the animals, examine them, give treatment and release them back into the wild, but it would be a procedure involving great risk and of little use unless the ecological conditions in the Reserva are improved.

Adult tigers are capable of surviving in Meru-Betiri, but this does not mean that the food regime is adequate to support a reproductive effort. To reproduce successfully, a female tiger must have access to a considerable food resource beyond her maintenance needs. A shortage of food can be expressed at a number of points in the reproductive cycle: the number of eggs ovulated, the number and size of young brought to term, the number of young reared through the nursing period, and the number of young reared to independence. Although this has received considerable attention in the study of some species, we know relatively little about the nature of the feedback system from food resources that result in the curtailment of population growth in large carnivores. This makes it difficult to evaluate the situation in Meru-Betiri, but it is possible at this stage to make two generalizations that can guide management:

- Reproducing females are more sensitive to disturbance than other tigers. Disturbance must be kept to a minimum.
- Tigers have the potential to produce relatively large litters, but this requires an optimal hunting situation where the female has access to a prey resource of a size, abundance and dispersion in vegetation types that permit her to kill with predictable regularity, with little time and energy lost in hunting and travelling (see 63, 83). Such a situation does not currently exist in Meru-Betiri, but conditions can be improved through management action.

At this point, it is most important to concentrate on improving the availability of prey for the tiger in the Reserve.

What have been the major sources of mortality for the tiger in the Gn. Betiri complex?

We have reports of four tigers being killed in the Reserve area or the immediate vicinity in the 15-year period, 1957-1971: Bandialit (late 1950's), Meru Bay (1961), Sanen River (early 1960's), and Sukamada (1971). We have heard of no reports of tigers killed here after the area was declared Suska Mergasatwa (game reserve) in 1972, but this does not mean it has not occurred.

It is not possible to evaluate the degree of poaching of any of the wildlife species in the Reserve from the records being kept by guards. One indication of such activity could come from patrol records of the movements and activities of persons in the Reserve, but there have been no patrols. We asked scattered residents in the area north of Gn. Betiri if strangers ever came there to hunt, and they said no. This is not surprising, considering the rugged topography of the area, but hunting does occur in the more accessible border areas. At Malaegsari, one plantation official reported that people frequently came there to hunt wild swine and muntjac. We did not encounter anyone in the Reserve with firearms, but we did find evidence of military manouvres in the Permisian Bay areas.

One source of mortality could be people poisoning carcasses of kills. The insecticides are readily available in the area, and this technique is sometimes practiced in Java for killing leopards (84).

It is not possible to determine if infectious (contagious) diseases have been an important source of mortality. We know that infectious disease is a chronic problem in zoo maintenance of big cats and that certain diseases such as rinderpest, which has been a major cause of mortality for many of the large ungulates on Java, can infect and kill tigers (84).

Tigers occasionally die of wounds received in attempts to kill their prey and from wounds received while fighting. In older literature, the most oft-recorded incident of tigers found dead from wounds received while attempting to kill wild swine (53). Wild swine are the most numerous large prey animal available in Meru-Betiri. Fighting among tigers is rare, but occasionally deaths do result from territorial encounters (53, 85).

The extent to which these mortality factors may have affected the tiger population in the Meru-Betiri area is unknown, but management actions can be taken to reduce the potential threat from many of these agents.

Summary

Studying the biology of extinction is a particularly difficult endeavour; cause-and-effect relationships are nearly impossible to establish with certainty, simply because of the status of the subject. Correlation analyses have been used, but all too frequently the correlates considered are too coarse-grained and cloud the difference between causes and symptoms.

In this analysis, we have attempted to develop a conceptual framework of the tiger's behavioural ecology from an evolutionary perspective. Our assumptions could be stated in the form of hypotheses, which can be accepted, modified or rejected in the light of additional information. These hypotheses reflect our understanding of the present state of knowledge. It is from these assumptions and a clear statement of the goals of the conservation programme that management actions can be prescribed.

CONSERVATION PRIORITIES

The Javan tiger is in imminent danger of extinction. The three to five tigers living in the Meru-Betiri area constitute the entire known wild population of Panthera tigris sondaica. There are no known captives in zoological gardens.

In the Act on Protection and Conservation of Natural Resources, the President of the Republic of Indonesia declared "...that every creation of God, be it fauna, flora or rock formation, and natural beauty, etc., has its proper function and usefulness as an environmental component of life, for which no other substitute exists," and "...that in the interest of mankind, now and in the future, the preservation of the various creations of God is the absolute duty of every human generation, wherever and in whatever period it lives" (87). While there is nothing that can be done that will absolutely assure the survival of a race that has been reduced to so few individuals, it is our responsibility and duty to see that every possible effort is made

to take the management actions that will enhance the tiger's chances for survival.

The immediate conservation goal must be to establish the Javan tiger in such numbers and distribution as to provide a reasonable likelihood of its surviving in its native habitat. The long-term aim is to eventually restore the race to a productive status in the wild (45). The only chance for the survival of this irreplaceable predator lies in providing it with complete protection and in the careful guidance of the complex natural processes which sustain it. The conservation strategy we recommend hinges on two major points:

The Javan tiger must be protected from any further killing.

The removal or killing of one additional animal astronomically reduces the chances of survival and recovery of a race with so few individuals. The Javan tiger is completely protected by Indonesian law and the penalty for violation is severe. Strict enforcement of the law is absolutely essential. Any poacher must be quickly apprehended, but most important for the tiger is the prevention of any killing. This can be accomplished by an alert guarding force, but the guards will only succeed in their task with the support of the local citizens. Thus, a first management priority for the preservation of the Javan tiger is:

- To initiate a programme to develop public awareness and sympathy for the tiger's value and plight.

Three additional actions will help to avert any further killing of tigers by man:

- Extend the Reserve boundaries to include all the ranging area of the tiger;
- Establish a no-hunting zone around the Reserve;
- Initiate an active patrol system in the Reserve and in the no-hunting zone.

These measures will establish an environment free from the danger of further killing by man, but additional management action will be required to realize the primary conservation objective - to establish the Javan tiger in such numbers and distribution as to provide a reasonable likelihood of its surviving in its native habitat.

Before proceeding, however, it is important to pose the question, "Can tigers from Meru-Betiri be used for establishing a captive breeding programme for the race?" In terms of our stated goal, the answer is, "No!"

From a population perspective, removing a pair of tigers from the Reserve is the same as killing a pair of tigers in the Reserve; the status is such that if a pair of tigers is taken for captive breeding, it will destroy any chance for this population to recover. In addition, there is no assurance that a pair of tigers can be captured, transported, and kept in captivity without suffering mortality. There is no assurance that under captive conditions the pair will be more successful in producing offspring than in the wild. Even if it is possible to perpetuate the race in captivity, we do not have the knowledge it takes to make a successful introduction back into the wild.

Captive breeding programmes in zoological gardens are of value in some conservation efforts. There have been some spectacular successes in snatching animals from the brink of extinction, breeding them in captivity until stocks have been built up, and successfully reintroducing them into the wild (88). However, in this case, we are dealing with biological problems of a different order of complexity from that experienced with some of the avian or ungulate species.

Here we are dealing with a large carnivore which must make a living by killing with predictable regularity animals frequently as large as itself. In the large felids, the young learn to hunt and kill from their mothers. Captive animals never learn this, and we currently do not have the knowledge to be able to teach them. To re-establish a population of tigers in an area requires re-establishing a social structure and we do not know how to do this. It is possible to carry out the research required to develop the techniques needed, but no such research is in progress now. We do not think that the Javan tiger is the best animal with which to start. To our knowledge, no accurate figures have ever been compiled, but we believe that more endangered species have been saved from extinction by giving them adequate protection in a large area of suitable habitat than from captive breeding programmes. It seems to us that this is where the emphasis should be placed in the conservation effort for the Javan tiger.

The second thrust of the survival strategy for the Javan tiger can be stated thus:

The Meru-Betiri Reserve will have to be managed in a way that optimizes habitat suitability for the Javan tiger, making reproduction and population recovery possible.

There are two limiting factors amenable to management action at our present level of technical ability:

- Eliminate man's disruptive influences on the Reserve's ecosystem;
- Improve the food situation for the tiger.

The Reserve will have to be declared Cagar Alam (strict nature reserve) to give P.P.A. the legal authority to take the action necessary to regulate human impact on the Reserve. Most importantly, the disruptive influences within the tiger's present ranging area and potential habitat (see "Man and Meru-Betiri") will have to be removed.

Hoogerwerf (11) has emphasized that competitive pressure from the leopard and the wild dog can have an adverse effect on the carrying-capacity of the Reserve for the tiger, and this is in accordance with detailed studies in other areas of the tiger's ranga (84). The solution to this problem, however, is not reducing numbers of leopards or wild dogs. It lies in providing the tiger with a food base that it can exploit more efficiently than these smaller carnivores.

Groups of rusa deer and hanteng will have to be reintroduced into the Sukamade drainage and rusa will have to be introduced in the west and north where there is already sufficient habitat for these species. No additional "habitat improvement" projects will have to be undertaken.

The details for implementing this management strategy are outlined in the management plan.

THE FUTURE

There is something compelling about tigers that invokes visions and strong feelings in nearly everyone. In the forests and grasslands of Asia - living, killing, giving birth, dying - the tiger is an integral part of the ecosystem. In its natural home, the tiger is a jewel in Indonesia's natural crown, its rich natural heritage. If the tiger is lost from the wild, a certain sparkle in the crown will be extinguished and, we think, felt by all reflective people. There is nothing we can do that will absolutely assure the survival of this race in the wild, but that is never a reason not to try. We think a great deal of valuable time has been lost, and this cannot be made up with hasty action or quickly conceived plans. Nothing can bring back that time; we can only proceed with a thoughtful and dedicated effort.

MAN AND MERU-BETIRI

EARLY HUMAN INFLUENCE

Early man was a part of the Javan landscape even before many of the present land configurations appeared. Javan Man (Homo erectus) was contemporary with the mid-Pleistocene volcanic episodes (400,000 years B.C. From fossil remains, it appears that early man occupied a hunting and gathering niche along the larger rivers, especially in the drier habitats which support more large mammals (49). They used fire as a hunting tool and for cooking. Modern man (Homo sapiens) first appeared in Java about 40,000 years ago. These men were consummate big game hunters. They used an advanced hunting technology and they too employed fire as a hunting tool (47).

Thus, man has long been an important component of the Javan fauna, especially in the drier areas of the east. His influence on the vegetation, particularly through the use of fire, is a matter of great antiquity. While it is reasonable to identify and categorize the impact of early man as one environmental factor that has influenced the development and configuration of the vegetation of East Java (30), it is misleading to label these actions as an "unnatural influence", disjunct from the "natural scheme of things".

Writing of Java in his landmark book "The Malay Archipelago" in 1869, the naturalist Alfred Russel Wallace (B9), tells of the beauty of the landscape and the monuments of civilizations now forgotten that stand "buried in lofty forest... the remains of extensive cities where the tiger, the rhinoceros and the wild bull now roam undisturbed" (p. 74). He was referring, in part, to the great temples, such as Borobudur, Prambanan and Penataran, which were built during the Buddhist and Hindu period, c. 7th - 12th century A.D. These empires were centered in Central and Eastern Java. One of the principal centres of activity was the Hindu Kingdom of S(l)ambangan or Balambuang, which, after about 950 A.D., extended over the greater part of Besuki and Probolinggo and included the Blambangan Peninsula (Fig. 2). This Kingdom existed up until 1639 when it was subjugated by the Sultan of the Kingdom of Mataram of Central Java. In 1695 the Balinese invaded Blambangan and made it a colony. In 1767 the Dutch East India Company conquered Blambangan, except for the area surrounding Grajagan, which was brought under their control by 177B (34).

That these empires developed in the seasonally dry areas of East and Central Java is no coincidence; it was in the seasonally dry vegetation types that they could employ their most efficient land-reclamation tool: fire. Fire, together with the use of irrigation technology,

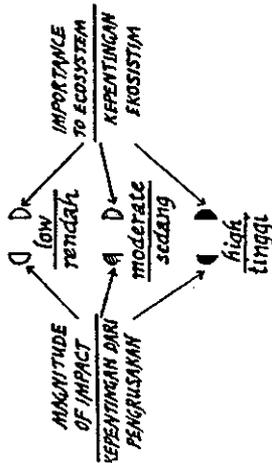
Figure 8

Human Impact on the Meru-Betiri Ecosystem

If no power of authority is granted to curb the exploitation and disruption of the Meru-Betiri ecosystem, it can be expected that the ecological integrity of the Reserve will be destroyed, its unique character will be lost, and the extinction-prone species will disappear. Seemingly minor and unimportant influences can lead to irreversible changes. The rate of change can be overwhelmingly rapid.

THE IMPACT OF MAN'S ACTIVITY ON THE MERU-BETIR ECOSYSTEM
KERUSAKAN YANG DISEBABKAN OLEH KEGIATAN ORANG TERHADAP EKOSISTEM MERU-BETIR

KEY:
KUNCI:
 severity of impact
 besarnya kerusakan



A. BESARNYA KERUSAKAN SEVERITY OF IMPACT

KESTAHAN EKOSISTEM / ECO-UNIT:
 • pembagian daerah pesisir / coastal zone
 • lembah sungai / river valleys
 • hutan peralihan / transitional forest
 • hutan hujan / rain forest

ACTIVITY / KEGIATAN	perusakan / harvesting	gangguan / disturbance	tidak dapat memamerkan / pollution	perubahan tempat / perubahan lokasi / habitat alteration
●	●	●	●	●
●	●	●	●	●
●	●	●	○	●
●	●	●	○	○

B. SUMBER KERUSAKAN SOURCE OF IMPACT

SUMBER / SOURCE:
 • turis / tourists
 • desa diluar / desa outside
 • desa didalam / desa inside
 • desa perkebunan / plantation desa
 • kegiatan pekerjaan / plantation operations
 • perkebunan

ACTIVITY / KEGIATAN	perusakan / harvesting	gangguan / disturbance	tidak dapat memamerkan / pollution	perubahan tempat / perubahan lokasi / habitat alteration
-	-	+	-	-
+	+	+	-	-
+	+	+	+	+
+	+	+	+	-
+	+	+	+	+

C. DAERAH KERUSAKAN AREA OF IMPACT

SUMBER / SOURCE:
 • turis / tourists
 • desa diluar / desa outside
 • desa didalam / desa inside
 • desa perkebunan / plantation desa
 • kegiatan pekerjaan / plantation operations
 • perkebunan

ECO-UNIT / KESTAHAN EKOSISTEM	perusakan daerah pesisir / coastal zone	lembah sungai / river valleys	hutan peralihan / transitional forest	hutan hujan / rain forest
●	●	○	○	○
●	●	●	●	○
●	●	●	●	○
●	●	●	●	○
●	●	●	●	○

made possible the growing of wet rice over large areas. A similar trend in land utilization, contemporary with that of Java, can be seen in the Khmer civilization of Cambodia (47).

Today the Blambangan Peninsula is a nature reserve. The forests there have extensive stands of bamboo, the only evidence that great empires once flourished (34). It seems reasonable to assume that these same people had some impact on the Gn. Betiri complex, especially in the areas along the major river valleys. There is no documentation for this, but the extensive stands of bamboo in some of the river valleys could date from this period.

While man and his influences are not new to the Javan scene, it is important to make the distinction between these former influences and the destructive consequences of modern development patterns. In the Gn. Betiri area, these can be traced to the early plantations that surround and violate the Meru-Betiri Reserve today. With the plantations came the tens of thousands of people needed to work them, and the impact these people have on the ecological integrity of the Reserve and adjacent forests is clearly of a greater magnitude than all the past influences of man on Java combined. It is these recent developments, rather than the historic influences, that are of primary concern for the welfare of the Reserve.

POPULATION AND LAND USE

We estimate there are more than 100,000 people living in the river valleys immediately adjoining the Meru-Betiri Reserve; nearly 90,000 people are associated with the towns Curah Nongko, Sananrejo, Curahtakir, Sumberejo, Sabrang and Sarongan (Table 7). Large numbers of people are employed or live on the large coffee and rubber estates of Malanghari (1500 ha), Sumber Jambu (1344 ha), Sumber Dadi (323 ha), Kali Sanen (<1000 ha) and Koto Slater (1000+ ha). We have no official estimate for the estate populations, but the manager of Malanghari told us that 6000 people, of whom 2000 were regularly employed, lived there. Surely, on all the estates combined there are in excess of 20,000 people.

The 1971 census showed an average of 539 persons per km² in East Java, with a population growth rate of 1.6%, which is below the average of Java as a whole (with 565 persons/km² and a 1.9% growth rate) (90).

Agriculture and forestry are the principal land uses in this region. Two rather distinct agricultural systems and, thus, economic systems, are operating: plantation agriculture and traditional agriculture. The second major land use is forestry, especially production forests of teak. Forestry involves a rather small segment of the population, but it is of considerable significance in terms of its influence on habitats. In reference to the economic systems, rural agricultural productivity is internalized; that is, what is grown is primarily

TABLE 7
DAFTAR 7

PEOPLE AND LAND USE NEAR THE MERU-BETIRI RESERVE
KEADAAN SOSIAL EKONOMI PENDUDUK DESA-DESA
SEKITAR SUAKA MARGASATWA MERU-BETIRI

No. Urut	Kecamatan Sub. District	Juml. Desa Village	Penduduk/Population			Rata2/KK No./Family	
			Laki2/ Male	Peremp/ Female	Jumlah/ Total	Kepala Keluarga/ Family Heads	
A	Tempurejo	1. Curah Nongko	7,604	8,551	16,155	3,335	4.84
		2. Sanenrejo	6,628	6,518	13,146	2,990	4.39
		3. Curah Takir	5,032	5,200	10,232	2,042	5.01
B	Ambulu	1. Sumberejo	9,592	9,531	19,183	4,105	4.67
		2. Sabrang	5,674	5,867	11,541	2,441	4.73
C	Posanggaran	Serongan	7,714	8,586	16,300	4,423	3.69
Jumlah			42,244	44,253	86,557	19,336	4.48

TABLE 7
DAFTAR 7 (Continued)

TANAH/LAND USE

Sawah/ Rice Fields	Regalan Other Fields	Pekarangan/ Yarda	Jumlah/ Total
Ha	Rate2/RK Ha/Family	Ha	Rate2/RK Ha/Family
61,885	0.019	158,230	0.047
71,969	0.024	444,944	0.149
190	0.093	192	0.094
935	0.228	76	0.019
674,230	0.276	34,365	0.014
190	0.043	200	0.045
		225	0.051
2,123,084		1,105,539	
		2,513,443	
			5,742,066

TABLE 7 (Continued).
DAFTAR 7

TERNAK/LIVESTOCK

Sapi/ Cattle		Kambing/ Goat		Kuda/ Horse		Kerbau/ Buffalo		Jumlah/ Total	
Ekor/ No.	Rata2/KK No./Family	Ekor/ No.	Rata2/KK No./Family	Ekor/ No.	Rata2/KK No./Family	Ekor/ No.	Rata2/KK No./Family	Ekor/ No.	Rata2/KK No./Family
1077	0.323	726	0.218	6	0.002	-	-	1809	0.543
1514	0.506	540	0.181	6	0.002	9	0.003	2069	0.692
1047	0.513	1010	0.495	1	-	2	0.001	2060	1.009
802	0.195	329	0.080	25	0.006	351	0.086	1507	0.367
678	0.278	417	0.171	4	0.002	24	0.010	1123	0.461
1297	0.293	410	0.093	36	0.008	38	0.009	1781	0.403
6415	3432	78	424	10349					

Information supplied by KD's
September 1, 1976
Compiled by Ir. Suwono

utilized by the people who produce it. In the second system, forestry and plantation agriculture, products are produced for export; production is externalized.

Based on our samples and estimates, the density of persons supported by plantation agriculture is about 350/km²; with traditional agriculture, there are 1500 persons/km².

Historically (c. 1000 A.D.) population density supported by wet rice agriculture was in the 250-300/km² range (47) and, historically, land use was closely related to site conditions. Population centers and farming activities were tied to the most productive areas. Nowadays agricultural activities are not at all related to the potentials and limitations of the sites. Increasing demands from expanding populations, together with rapid developments in modernized agriculture, have resulted in bringing marginal areas under cultivation. This has accelerated a destruction of wildlife habitat and decreased ecological diversity. The expansion of cultivation into sensitive areas threatens the entire basis of the agricultural system, as has been emphasized in so many government reports and studies. When cultivation is expanded on to the poorer upland soils and steeper slopes, erosion leads to the siltation of rivers; deforestation of catchment areas increases the run-off of water; the risk of damaging floods is increased (this was one of the causes of the disastrous Solo flood of 1966 (90)).

The recent land capability survey for Indonesia (91) points out that in the Meru-Betiri complex, which includes the area extending from Mcrawan to Pugar in the west and Kesilir in the east, there is less than 5% cultivatable area. This is primarily the consequence of poor soils and strongly incised slopes usually exceeding 30%. The majority of the Reserve, itself offers no potential for agricultural development and the topography makes logging unfeasible. It can be assured that if it were feasible to farm large areas of the Reserve or conduct forestry operations, it would have already been done. As it is, the percentage of the area in cultivation already greatly exceeds land capability, which means that the cultivated areas suffer from low productivity and are in continual danger from climatic perturbations. Clearly the greatest value of the Meru-Betiri Reserve to surrounding areas lies in its watershed protection function. Even seemingly minor violations of the ecological integrity of the forest reduce their protective capability. The welfare of all people living in the surrounding region is dependent upon the maintenance of the Reserve as a viable natural area.

The greatest threat by far to the ecological integrity of the Reserve lies in the 5000 or so people who live within the boundaries. This is an astounding number. The greatest number, approximately 4000, are associated with the two plantation enclaves, Bandalir and Sukamade Baru. An additional 316 people live in the desa of Rajegwesi in the Kali Karangtambak drainage. Another 237 live at Kebun Pantai between

the Sandialit Plantation and the beach. About 470 live at Wonowiri on the western edge of the Reserve and 142 live at Sumbersalak Dsrungan, which is an area skirting the upper edge of the Sandialit Plantation (Fig. 3; Table 8).

These settlements are an unavoidable problem inherited by P.P.A. when the Reserve was created. The boundaries of the Reserve are based on the boundaries of the old blocks of protection forest that date from the early 1900s. The settlements were established during the period of turmoil following the Second World War. With the exception of Pondok Macan, the remaining group of people listed in Table 8 do not presently live within the boundaries of the Reserve, but in the forests north of Gn. Setiri.

This is within protection forests and within the ranging area of the Javan tiger; thus, they constitute a serious threat. In surveying this rugged area, we located a number of settlements with a population total of 57. We estimate there are probably 100 people living in this area of about 7000 ha. These people are farming small ridge-top clearings usually about 0.5 ha in size; their only cash crop is the sugar they make from the ssp of the arun palm (Arenga pinnata).

People living in adjacent areas come into the Reserve in large numbers to collect products from the forest and the coastal zone. For example, in one day, travelling from Sandialit to Meru Bay, we interviewed 35 people in eight different groups. Three groups came from Sandialit; the other five came from outside the Reserve. They were here to fish and to collect bamboo, rattan, gadung (Dioscorea hirsuta) root, leminti (an algae) and shellfish. The most important product was gadung; all groups reported that western areas of the Reserve had been exhausted, forcing them to venture further into the Reserve in their search. A previous report by Lembaga Ekologi (18) Universitas Padjadjaran, Bandung, has suggested alternatives to these exploitation practices. The impact of these people on the ecological integrity of the Reserve goes far beyond the exhaustion of specific forest products. We discuss these impacts in detail in a later chapter.

The final group of people to consider in terms of their utilization of the Reserve are tourists and occasional visitors. In the past, tourism was practically non-existent in the Meru-Setiri area, but this condition is changing rapidly. The Meru-Setiri Reserve has been included in the new 'Java Tourism Master Plan' (92) and has also been singled out in the new 'Official Guide to Java' (93). The beauty and grandeur of the rugged coast, nesting sea turtles, and the chance, however remote, of seeing a Javan tiger are depicted in striking photographs and vivid prose. Most important is that the 'Guide' includes simple instructions for getting there. The quality of the series of which the 'Guide to Java' is a part, is probably unsurpassed. Although

TABLE B
DAFTAR B

PEOPLE IN THE MERU-BETIRI RESERVE AND THE PROPOSED NORTHERN EXTENSION
BANYAKNYA DESA MAGERARI DI SUKAMA MARGASATWA MERU-BETIRI

Blok Magerari Name	Desa	Kecamatan/ Sub. district	Luas/Size (ha)	Banyaknya Kepala Keluarga/ Family	Jumlah/ Total	Keterangan/ Date Established
Kebun Pantai Bandialite	Curah Nongko	Tepurajo	± 8.25	65	237	sejak Th. 1940
	Curah Nongko	Tapurajo	± 4.00	32	142	sejak Th. 1940
Sumberalak Darungan Bandialite	Curah Nongko	Tepurajo	± 13.50	109	469	sejak Th. 1956
Pondok macan	Sananrajo	Tepurajo	± 0.50	2	15	sejak Th. 1966
Curahwilis	Sananrajo	Tapurajo	± 1.25	3	13	sejak Th. 1973
Curah Buron	Sananrajo	Tapurajo	± 0.50	2	5	sejak Th. 1966
Pudaan	Sananrajo	Tepurajo	± 0.50	1	3	sejak Th. 1966
Curah Barkong	Sananrajo	Tepurajo	± 0.75	3	14	sejak Th. 1966
Curah Sangkorang	Sananrajo	Tapurajo	± 0.50	2	7	sejak Th. 1975
Rajegwest	Sarongan	Pesanggrahan	± 56.50	85	316	sejak Th. 1946
			B6.25	304	1220	
Sukamada Baru (Plantation)	-	-	± 1280	-	± 2000	
Bandialite (Plantation)	-	-	± 860	-	± 2000	

recently published, the book is widely distributed domestically and abroad; its effects are already being felt. Meru-Betiri is an easy day's travel from the tourist centres on Bali and its attractions are extremely enticing to the adventurous traveller.

The utilization of the Reserve by all the socio-economic groups can best be discussed in terms of impact on the ecological integrity of the Reserve and the danger they pose to the survival of the Javan tiger.

THE IMPACT OF THE HUMAN ELEMENT

Meru-Betiri and the National System of Natural Areas

Before discussing the impact of people on Meru-Betiri it is important to consider why the Reserve was set aside. Meru-Betiri was declared Suaka Margasatwa on June 6, 1972. By this decree, the Minister of Agriculture, acting on behalf of the Government and for the people of Indonesia, officially recognized Meru-Betiri as a unique and valuable area, the habitat of the last remaining Javan tigers that should be managed as a natural area. With this decree, the Reserve became part of the National System of Natural Areas and part of Indonesia's effort to preserve its rich natural heritage for the benefit of all citizens. P.P.A. is charged with the responsibility of preserving the Javan tiger and maintaining the ecological integrity of the Reserve. Meeting this responsibility requires compliance with standards in Indonesia's law for the Conservation of Nature and Natural Resources and international criteria for National Parks and Equivalent Reserves (B7, 94).

Effective protection and management can only be achieved through an ecosystem approach. This principle is so widely recognized that it hardly need be repeated. We do so to make it clear that in dividing the Reserve into eco-units, we do it not because these units are independent from each other, but only to facilitate a discussion of how impacts in one area can endanger the integrity of the entire Reserve.

The most important case in point concerns the plantation enclaves which the most productive valley floors. In the preceding two chapters we have outlined the ecological needs of the tiger and other endangered and extinction-prone species in the Reserve. We have emphasized how neither the rain forests nor the transitional forests and rain forests together constitute a habitat that is sufficient and suitable for the tiger. The tiger's chances for survival rest on the integration of valley bottoms, formerly the most suitable tiger habitat, with the adjacent forests. What is done with the river valleys affects the entire conservation effort of the Reserve.

When we speak of threats to the ecological integrity, we are speaking in terms of the entire ecosystem, including the plantation areas. By ecosystem, we mean not just the relationship between the living and non-living components of one area; we mean the inter-relationships of all the areas or units. By international definition and in terms of pragmatic management considerations, the area that constitutes the Reserve must be such that it is ecologically viable and able to provide for the biotic community that it is to protect (94).

Impacts

For the purpose of assessing the adverse impact of people, the Meru-Betiri Reserve can be divided into four units:

- Coastal areas
- River valleys
- Transitional forest
- Rain forest

A method for defining the kind and degree of human impact must be elaborated (95). We believe the four major human influences present in the Reserve are:

- Harvesting plants and animals or their parts from the forest, the coast and the sea;
- Disturbing the natural activities of wildlife;
- Polluting the area through the application and run-off of pesticides garbage and solid waste;
- Alteration of the habitat through vegetation-clearing for plantations, agriculture, erection of houses and other structures, and excavation and earth-moving for roads.

The degree of significance of each influence must be assessed. For this purpose, each can be considered to have both magnitude and importance; the two taken together constitute a measure of impact severity. Magnitude relates to the degree or extensiveness of the impact; importance to the consequences of the impact. For each we have employed a scale to show increasing severity:

- Low; little or no noticeable effect;
- Moderate; discernible or moderate effect;
- High; destructive effect.

The impacts affecting the Meru-Betiri ecosystem are summarized in the form of a matrix in Fig. 8e.

From Fig. 8a, it can be seen that the most disturbed areas of the ecosystem are the valleys and coastal zones; the rain forest is comparatively free of adverse impacts; the transitional forests are intermediate. Our judgement as to the magnitude of impact is based upon the results of observations made during our survey. The importance of each impact is judged in terms of the effect of impacts on the ecological integrity, the survival needs of the tiger, and aesthetic values.

A review of land-use activities and population centres revealed five major sources of human impacts:

- Tourists and casual visitors;
- People from desas (towns) located outside the Reserve boundaries;
- People from desas located inside the Reserve boundaries;
- People from the plantation desas;
- Plantation operations.

These can be related to kinds of impact and the severity of impact, again in the form of matrices (Fig. 8b and c).

The most serious threat to the ecological integrity of Meru-Betiri and the preservation of the tiger originates with the plantations, both from plantation operations and from the large number of people required to run them. They pollute, overharvest, disturb, and drastically alter the habitat of the Reserve ecosystem. They affect the river bottoms, the downstream coastal areas and the forests. The only eco-unit where they have little direct impact is the rain forest, yet because of the interdependence of all the eco-units, they pose a critical threat to this area as well.

The second critical threat comes from the people living in settlements that are within the Reserve boundaries and in the protection forests to the north. The most critical settlement is Kebun Pantai between the beach and the Sandialit plantation (Fig. 3). As long as this desa continues to exist, the Sandialit and Meru coastal system will be affected through exploitation of coastal and forest products, illegal cutting of trees, and the disturbance created. Because of the low density of people living in the north, their impact is less severe, but it is important in both the transitional and rain forest areas.

The people coming from outside the Reserve most severely affect the coastal zones through disturbance and harvesting of coastal and forest products.

Finally, the impact of tourists must be considered. As yet, they are coming in small numbers, but the activities of the few who are coming are having an adverse effect. Among other things, they disturb sea

turtles coming ashore to nest and they have marred the landscape with signs they paint on buildings, rocks and trees. This disturbance can easily be controlled.

SUMMARY

All of this does not paint a very bright picture for the future of the Maru-Betiri Reserve; but we do not believe the violations of the area are irremediable. The most essential point is that Maru-Betiri is a fine, but sensitive area, greatly deserving to be set aside as part of the National System of Natural Areas. However, to achieve its potential and to avoid irreversible damage through human impact, strong action will have to be taken immediately. If this is not done, the extinction of the island's largest predator, the Javan tiger, is assured.

MANAGEMENT OF MERU-BETIRI AS SUAKA MARGASATWA

LEGAL STATUS AND REGULATIONS

Meru-Betiri was declared Susks Margasatwa (Game Reserve) in resolution No. 276/Kpts/Um/6/1972, issued by the Minister of Agriculture on June 6, 1972. The supervision of the Reserve was delegated to P.P.A. By definition in the Nature Protection Ordinance of 1941, Suaka Margasatwa are areas where "the fauna, flora or the beautiful scenery are of such scientific and cultural or aesthetic value that the protection of it is desirable in the public interest" (96). The present rules and regulations that guide the management and administration of nature reserves in Indonesia all date from before independence and are being revised. The new law will be in effect during the period of the management plan. Accordingly, we will only deal with how former rules and regulations are being met in a general way under the discussion of specific management programmes. In reviewing the old laws, however, it is apparent that other than preventing hunting and the illegal cutting of trees (legally sanctioned logging is permitted), little in terms of protection could be accomplished in areas declared Suaka Margasatwa (35, 97).

BOUNDARIES AND POSSIBLE EXTENSIONS

Meru-Betiri lies within the Jember and the Banyuwangi subdistricts. Included in the Reserve are the forest protection areas of Sabrang Trate Ds, Karangtambak Atas, Sukmade Atas and Sukmade-Karangtambak. The total area is 50,000 ha, according to the formal decree, but more accurately measured by P.P.A. to be 49,464 ha. Not included in the Reserve are the small islets off the coast or a 500 m zone extending into the sea from the low tide mark, as is the case in the Ujung Kulon Reserve.

Only some of the western boundary from Nanggalan to Cursh Nongko has been marked. Some question was raised in reports about the exact location of the westernmost boundary point. The actual boundary marker is slightly to the west of the boundary shown on the official map. That boundary as marked is being recognized, but the forest has been cleared for teak plantations over this line just to the north. About 65 ha has been lost.

There are no possibilities to extend the Reserve boundaries further west than this is an area of teak and production forest, plantations of rubber or it is under cultivation. The boundary in the northeast, up to where it meets the Kali Snen, could be extended slightly to the edge of the cultivation to include the band of teak production forests. This would

provide an important buffer area to the forests of the Reserve. In the north, the boundary can and should be extended to include the forest area up to the Kali Sanen; this area is presently under the control of Perhutani. The eastern portion is classed as production forest, but it has never been logged, probably because the rugged topography makes it unfeasible. The remainder of this area lies in the Gn. Malangsari protection forest. The boundary of the Reserve could easily follow the Kali Sanen thence up the Kali Kejungmacan to the boundary of the Malangsari Plantation. The area between the present boundary on Karangtambak Atas and the Malangsari Plantation could be included. There is no possibility to extend the boundaries on the east in the Kali Karangtambak drainage because of plantation and agricultural development. There are banteng and rusa in the Sukamade-Karangtambak-Sel forest and some of this forest in the higher areas is still in good condition. Much of the lower area has been turned into teak production forest and inclusion in the Reserve does not seem advisable.

MANAGEMENT PROGRAMMES

Current management programmes for the Reserve fall into seven categories: staff recruitment and organization, construction of staff facilities, procurement of equipment, establishment of a protection system, the turtle conservation project, habitat management projects and future planning and feasibility studies.

Staff Recruitment and Organization

Overall management and planning for the Meru-Betiri Reserve has been the responsibility of the Chief of East Java II, Section of P.P.A. The area of Meru-Betiri in the Jember subdistrict is under a Kepala Rayon who also has responsibility for Nuaa Barung. Serving under him are the Kepala Resorts of Guci-Betiri and Sabrang Trate and their assistants. In the portion of the Reserve in the Banyuwangi subdistrict, the Kepala Resorts of Karangtambak, Sukamade and the turtle project are directly under the Section Chief. This is also true for all hunting guards.

The delegation of duties for the Kepala Rayon and Kepala Resorts is the responsibility of the Section Chief. The mandora or assistants serve at the direction of the field officers. There are no written job descriptions on file. In general, the duties of the hunting guards are to issue licences and control hunting in their districts. (Their duties are not directly related to the management of Meru-Betiri, but they are paid by W.W.F. funds, are considered part of the Reserve staff, and are issued motorcycles provided by W.W.F.) The field officers are responsible for the protection and management of the Reserve. Currently,

most of the time of the Kepala Resorts and Kepala Rayon is taken in the administration of the feeding ground projects. During the month of August 1976, the time of the Kepala Resort for Sukamade was totally involved in a dispute with the plantation regarding ownership of 10 ha of coffee for which he served time in jail.

Not including the Section Chief, the total staff of the Reserve numbers 23 (September 1, 1976). Included are the Kepala Rayon, five Kepala Resorts, nine hunting guards, six assistants and two office staff. The salaries of 11 staff are paid entirely by W.W.F. grant funds. These people do not have permanent government appointments; two staff members receive their salary from P.P.A., supplemented by W.W.F. funds; two are only paid by P.P.A. The salary of the Kepala Resort in charge of the turtle conservation project is paid with revenue from the sale of turtle eggs. The assistants listed as harian usually receive no salary. During the period of our survey (June-September 1976), no-one received any salary because of a delay in the budget, which usually starts each April. The only salary received was that provided through the W.W.F. grant.

No-one on the staff has attended University, but, in general, the level of formal education of the staff is relatively high. What is most noticeable is that few staff members have ever received special training from P.P.A. pertaining to the jobs they have been hired to perform.

Staff Accommodation

In the four years since Meru-Betiri was declared a Reserve, accommodation has been constructed at seven sites (Fig. 3 d, Table 9); six are for staff only and the seventh is a guest house for visitors.

The sites at Sumber Sari, Curah Nongko, Glenmore and Rajegwesi are suitable locations in terms of the management of the Reserve. The Rajegwesi guest house is located just behind the bay. Visitors can relax in the atmosphere of a small fishing village. In the protection cove, swimming is safe, the only safe beach on the coast of the Reserve. While the Glenmore site is located 40 km from the Reserve, it is near the main highway between Banyuwangi and Jember; in the future, it can serve as an information centre and check-point for people wishing to visit Meru-Betiri. The post at Curah Nongko is located very near the boundary on the western access road. Sumber Sari is situated above the plantation in the west of the Sukamade drainage; it serves to guard one of the most important tiger areas.

While Sanenrejo is a key point in establishing control over the northern region of the Reserve, the new post is located in the centre of the town, which greatly reduces its potential effectiveness as a check-point. The new post at Kali Saru serves no useful function in the management or protection of the Reserve, but we have included it in Table 9.

TABLE 9
DAFTAR 9

STAFF ACCOMMODATION FOR THE MERU-BETIRI RESERVE
GEDUNG-GEDUNG DI SUAKA WARGASATWA MERU-BETIRI

JENIS/ TYPE	LETAK/ LOCATION	TAHUN/ YEAR	LUAS/ SIZE	KETERANGAN/ STATUS
Pos Penjagaan	Sukamade (Sumber Sari)	1970/71	40 m ²	Permanen
Pos Penjagaan	Glamore	1974/75	40 m ²	Permanen
Pondok Penjagaan	Kalibaru	1975/76	30 m ²	Permanen
Pondok Penjagaan	Rajagwasi	1975/76	30 m ²	Permanen
Pondok Penjagaan	Samanrejo	1975/76	30 m ²	Permanen
Pondok Penjagaan	Curah Nongko	1974/75	30 m ²	Permanen
Pesanggerahan	Rajagwasi	1974/75		Permanen
Pos Penjagaan	= Guard Post			
Pondok Penjagaan	= Guard Post			
Pesanggerahan	= Guest House			

The Kepala Resorts of Sukamade, Karangtambak and the turtle conservation project live in private dwellings, although there are new facilities available at Rajegwesi and Sumber Sari. The Kepala Rayon for Meru-Betiri/Nusa Barung lives in a private dwelling in Ambuiu with other staff of East Java II Section of P.P.A.

Equipment

Major items of equipment for the Reserve management and protection programme include:

- Five motorcycles (100 cc): one is assigned to the Kepala Rayon, two to Kepala Resorts and two to hunting guards. All are from the W.W.P. grant; a sixth motorcycle from W.W.F. is unaccounted for.
- One Holden pick-up: from W.W.F., assigned to the Section Chief (never observed).
- Bicycles: nearly all staff have bicycles signed out to them, but very few are now in their hands, having been stolen or otherwise lost.
- Firearms: all senior staff have rifles (30.06) signed out to them, but with the exception of one rifle kept by the Kepala Rayon, all are reportedly kept in the office of the Section Chief. In our view this is a wise practice; firearms are not needed in the field.
- Post furnishings: most posts are only partially furnished; the staff must provide most of their own furniture.
- Field equipment: staff members have some of their own field equipment, but in general, field equipment is far from adequate.
- Uniforms: the older staff usually wear khaki shirts with the old P.P.A. emblem on the shoulder; younger staff usually dress in cycle boots and blue denim jackets with a W.W.F. emblem on the front. Head-wear is of the highly individualistic nature, which is so characteristic of East Java.

The Reserve staff have been handicapped in the performance of their duties by the lack of adequate equipment.

Protection

Under the laws and rules presently regulating the use of Suaka Margasatwa, it is nearly impossible to restrict the movements of people and the collection of minor forest products. Hunting and felling of trees is forbidden but logging is permitted under permit (97). Within the present Reserve boundaries we noted only two newly-cut trees and these were immediately recorded and investigated by the Kepala Rayon Sarkan. Our only evidence of hunting in the Reserve comes from the plantation workers at Sukamade who report they sometimes catch wild swine and sell them to the plantation manager; we found one box-trap

in the Sukamade plantation. While the Reserve staff do make trips into the Reserve at times, there is no regular patrol schedule.

Habitat Management Projects

The habitat management projects are the single most controversial issue in the current management programme for Meru-Betiri (18). A habitat management project relates to an area of forest cleared and planted with grass to create an area where ungulates can graze; thus, the local term "feeding ground". The forest is cleared using the Tumpang Sari system: people are engaged on a two-year contract to come in and clear 0.5 to 1 ha of forest each; they are allowed to live in the area. After the trees and/or bamboo are cut they are left for a time to dry before burning. After burning, vegetables, tobacco, cassava and other crops are planted. In the first year only harvestable crops are planted, but in the second year, they are requested to plant grass with the crop. After the second year, the people are expected to leave; if they do not, their houses are to be burned. There are four feeding ground projects within the Reserve boundaries totalling about 250 ha (Fig. 3b). Approximately 200 people are living and working there at the present time. (Note: by 1968 the areas cleared were doubled in size.)

The creation of feeding grounds as a wildlife management technique has a long history in Java. Hoogerwerf (1) gives a long discussion and justification in his monograph, 'Ujung Kulon'. Administratively, they are considered special projects for which special budget allocations are requested. Scientifically, they are conceived with the general idea of improving the habitat situation for individual grazing species, but this is not necessarily worked out in advance. For example, the grass species to be planted have yet to be selected. The area at Sajegwesi was first created as a feeding ground with banteng in mind; after it was cleared it was decided that would not work because of its proximity to human residence. Now there are discussions of planting fruit trees for birds. In the meantime, the hillsides are eroding away. It is recognized that there are no banteng or rusa in the Sukamade drainage and in discussions, various suggestions have been put forth, ranging from importing banteng calves from the Baluran Reserve to turning out horses there to graze as food for tigers.

A discussion of whether or not the feeding grounds are ill-conceived serves no useful function; the areas have already been cleared. The problem remaining is what to do about them, how best to salvage something from the situation, and especially how to assure that the approximately 200 people living there now move out when expected. We take up these matters in the management plan.

Turtle Conservation Project

We have discussed the consequences of the present conservation programme for turtles at Sukamade (Fig. 7). The project is a joint venture between the Regency and P.P.A. Aside from the P.P.A. staff, from the Regency there is one man under the direction of Mr. David Hadikesuma, former manager of Sukamade Baru. It is unfair to say that no progress has been made; controlling exploitation of the beach was a difficult job. The next step is to give the turtles total protection. Currently, all the eggs are being taken by the protection staff. This practice must be stopped immediately.

Future Planning

A feasibility study on the development of the Meru-Betiri Reserve for the second five-year development plan, prepared by the forestry faculty at the Institut Pertanian, Bogor (98) was issued in October 1976. It is our understanding that this study was prepared from existing reports; the actual site was never visited by the team. There are serious omissions in the report, but many of their findings should be noted. The authors identify qualifications of personnel, expenditures, attitudes of the people, and the ability to organize the development programme as the principal limiting factors in the future management of the Reserve. Institutional and socio-economic limiting factors are recognized, but biological constraints to management have been ignored. P.P.A. should be commended for commissioning these studies as a basis for directing future management of the Republic's Reserve system; but it is imperative that the planning process be rational, explicit, and repeatable, and based on an understanding of the natural features and processes, the structure and function of the eco-system, which the reserves are created to protect (99). If it is not, the values of these reserves will surely be eroded and finally lost.

BUDGET

In the years 1972-73, 1973-74 and 1974-75, approximately 9, 13 and 30 million Rupiahs respectively were appropriated for East Java Section II of P.P.A. The budget is allocated in a single sum for the entire Section; it is not possible from records in Bogor to determine how much money has actually been spent on the management of Meru-Betiri alone. Apparently the single biggest expenditure has been for the construction of staff facilities. Through WWF/IUCN Project No. 1015, funds have been provided for the purchase of motorcycles, uniforms, supplementary salaries for ten guards and the Section Chief, and other expenses. An examination of the staff pay-base, staff organization chart, and the section on equipment shows how these funds are disbursed in relation to the management of the Reserve.

SUMMARY

Meru-Betiri is beset by problems which will have to be solved if it is to remain a viable Reserve and fulfil its function as a home for the last remaining Javan tigers. Considering this is a newly-created Reserve and that the Reserve staff has to deal with many long-established patterns of land use, we feel that a notable effort has been made towards developing many of the necessary components that go into creating a viable reserve. Progress in some areas is more evident than in others; many of the major threats have not yet been addressed. Their identification and the strategy to deal with them will be the major focus of the first five-year management plan.

MERU-BETIRI AND THE FUTURE: SYNTHESIS AND NEEDS

In the preceding chapters, we have summarized pertinent information on the natural features and processes of the Meru-Betiri complex, the survival needs of the Javan tiger and other endangered flora and fauna, the impact of man, regional relationships and the present management programme. This background can be synthesized in seven propositions which will form the basis of the management plan:

THE PROPOSITIONS

- Meru-Betiri is beautiful and valuable.
- Meru-Betiri is vulnerable.
- Uncontrolled exploitation and disruption are inevitably destructive.
- Observation of conservation principles can avert destruction and ensure enhancement.
- Protection and management can only be achieved through an ecosystem approach.
- Survival of the Reserve is dependent on a clear formulation of policy and on the people employed.
- The power of public opinion can decide the fate of Meru-Betiri and the last Javan tiger.

SYNTHESIS AND NEEDS

Meru-Betiri is beautiful and valuable

Meru-Betiri is one of the finest natural areas in Java. Extending over 50,000 ha, from the sea to 1200 m, it contains five major vegetation types. It is the home of the last Javan tigers and a number of endangered and extinction-prone species.

Meru-Betiri has been singled out in the "Java Tourism Master Plan" and the "Guide to Java" as an outstanding area where a visitor can enjoy solitude and tranquillity among great trees and along its rugged coast.

Agriculture and forestry operations have already exceeded land capability and violated the limitation of many sensitive sites. The welfare of the people and the economy of the surrounding region are dependent upon the watershed protection provided by the Reserve.

Meru-Betiri is a valuable essential part of the system of natural areas that are being set aside in a National effort to preserve Indonesia's rich natural diversity for the benefit of all the citizens of the Republic.

Meru-Betiri is vulnerable

As an isolated region in the Southern Mountains, Meru-Betiri was insulated from man's influence in the past by its precipitous and dissected topography, conditions unsuitable for agriculture development. Land capabilities have not changed, but man's ability to violate the limitations of sensitive sites has.

Today the Reserve is essentially an island circumscribed and disrupted by cultivation and plantations. The physiographic position and topographic ruggedness that once served to inhibit development increases its vulnerability and decreases its resilience to man's disruptive influences. Steep slopes, poor soils, long recovery time for forests, and the island-like nature of the Reserve all add to the already recognized frailty of this tropical forest ecosystem.

Uncontrolled exploitation and disruption are inevitably destructive

If no power of authority is granted to curb exploitation and disturbance of the Meru-Betiri ecosystem, it can be expected that the ecological integrity of the Reserve will be destroyed, its unique character will be lost and the extinction-prone species will disappear. Seemingly minor and unimportant influences can lead to irreversible changes; the rate of change can be overwhelmingly rapid. The only chance in preserving the last Javan tigers depends on immediate action.

Observation of conservation principles can avert destruction and ensure enhancement

The acceptance of conservation principles is mandatory if the environmental integrity of the Meru-Betiri Reserve is to be maintained. The basic formula for ensuring that sound conservation principles are met has been worked out over many years and is reflected in the international definition for National Parks and Equivalent Reserves, approved unanimously at the Eleventh General Assembly of the International Union for Conservation of Nature and Natural Resources and the Second World Conference on National Parks.

Protection and Management can only be achieved through an ecosystem approach

The primary function of a reserve is to conserve the natural community; this is dependent on recognizing the extent and wholeness of the Reserve ecosystem. Boundaries must be set to include the seasonal and life-cycle needs of the flora and fauna. Careful guidance on the complex

natural processes which sustain endangered and extinction-prone species will be required. Threatening and disruptive influences to the integrity or completeness of the ecosystem must be eliminated.

Survival of the Reserve is dependent on a clear formulation of policy and on the people employed

A clear formulation of goals and guidelines is required and must be adhered to, if the expectations of the Reserve are to be fulfilled. Only with a clear formulation of policy, articulated in a comprehensive management plan, will Reserve employees know what to strive for and what management actions are required. The implementation of a successful management programme is a complicated task that requires the finesse and ingenuity that only a skilled and dedicated staff can provide.

THE MANAGEMENT PLAN

PUBLIC AWARENESS AND THE PRESERVATION OF THE JAVAN TIGER

It is absolutely necessary to prevent any further killing of Javan tigers if there is to be a chance of preserving the race in the wild. The new conservation law and other laws already enacted give protection to the tiger in Indonesia and these must be rigidly enforced. However, when a race has so few individuals, even the death of one tiger may make the difference between survival or extinction. The most rigidly enforced law cannot be expected to provide this level of protection. The desire to protect this big cat must come from the people, themselves, from a wide-spread public awareness of its value and plight. We suggest the following three measures as steps in developing this public awareness:

The first step would be to inform the President of Indonesia of the current status of the tiger, and ask him to declare the Javan tiger a National Treasure and request the support of the people of the Republic in the effort to save the remaining individuals of this race for future generations. The declaration should ask all people to cooperate fully with the nature conservation authorities (P.P.A.) in this task. It should be widely published by newspapers, radio and television. Posters could be prepared and distributed throughout southeastern Java. The poster could picture the President, the Javan tiger and the declaration in Javan, Bahasa Indonesia and Maduran.

Secondly, an intensive education effort may be aimed at the primary and secondary school levels. P.P.A. should prepare a conservation poster for wide-spread distribution, showing the value, the plight and the conservation needs of the Javan tiger. A lecture on the subject should also be prepared and distributed to schools. A slide-illustrated lecture should be prepared for use by conservation groups and P.P.A. staff in public education work.

Thirdly, P.P.A. can work to increase public awareness not only of the Javan tiger, but also of the value of conservation, by instigating interpretive programmes as part of the management of Meru-Betiri. The interpretive programme could begin with simple displays and gradually be increased to include a variety of other interpretive activities. Such interpretive programmes are an integral part of the management for many national parks throughout the world.

AIMS OF MANAGEMENT

A management plan is a device that directs the decision-making process in achieving articulated goals. Management is the process of converting information into action, and guidelines are the steps taken to achieve the goals.

STATEMENT OF PURPOSE

The goals of management for the Meru-Betiri Reserve are:

- To manage this natural area in a way that its essential character and value remain intact - that the natural fauna, flora and scenic features of the area are conserved for future generations.
- To promote and regulate appropriate use of the natural resources of the area for educational, aesthetic, recreational and scientific purposes in such a manner that the natural character of the area will be preserved.

STRATEGY FOR ATTAINMENT OF GOALS

The main requirements for realizing the first goal are: to upgrade the status of the Reserve; to extend boundaries to include all the ranging area of the Javan tiger; to eliminate, restrict and redirect extractive exploitation of the Reserve's natural resources; and to acquire control of all inholdings, legal and illegal, and reconvert these areas to a natural state.

Only a revision of the legal status of the Reserve from Suks Margasatwa to Cagar Alam will give P.P.A. the legal authority needed to protect the ecological integrity of the area and its natural resources. This and the extension of boundaries should be accomplished within the first year of the plan.

The elimination of extractive exploitation from the Reserve can be accomplished through a four-point plan:

1. Embark on an upgrading programme to systematically phase out exploitation from all areas of the Reserve within the period of the plan;
2. Control the movements of people in the Reserve through the use of check-points and an active patrol system;
3. Acquire control of the plantation enclaves and close down their operations;
4. Prevent any further expansion of cultivated areas, effect control of all inholdings and move the people living there from the Reserve.

A Settlements Officer will need to be employed to analyse the extent and land tenure of the people living within the Reserve and to determine to what compensation, if any, they are entitled. With the assistance of other concerned agencies, P.P.A. will have to move these people from the Reserve, making every effort to ensure that they are provided

with a new home and means of support. The two towns on the borders of the Reserve should be examined by the Settlements Officer to determine land tenure and to make a detailed plan for their control, management and disposition, in keeping with the purposes of the Reserve.

Unless these measures are undertaken, there will be no chance of preserving the Javan tiger or maintaining the ecological integrity of this area.

The second goal raises two principal problems: to ensure that no form of use should conflict with conservation aims and to avoid conflict between one form of use and another. This problem can be avoided by careful planning and control of visitor direction and by designating special areas to provide for different visitor needs. A recreation area will be designated to eliminate pressure from sensitive areas of the Reserve. Arrangements should be made to ensure that visitor use is always well-distributed. The provision of good education and interpretation facilities is vital if the Reserve is to be used properly and its aims are to be met. Although some development is clearly necessary, it must be restricted to essential services. All facilities that are created should provide solely for uses that are in strict accord with the Reserve's goals.

MANAGEMENT GUIDELINES

The main guidelines for directing the management of the Meru-Betiri Reserve are:

Conservation

- To preserve the rain forest, coastal and other ecosystems found in the Reserve in as natural a state as possible, subject only to such minimum interference as may be necessary for the perpetuation of endangered and extinction-prone species;
- To have as a management priority the survival of the Javan tiger;
- To undertake a programme to acquire control of all inholdings, legal and illegal, in order to preserve the ecological integrity of all the ecosystems in the Reserve;
- To undertake a programme to eliminate all extractive exploitation of the Reserve;
- To undertake special measures for the conservation of marine turtles and the endangered parasitic plants, Rafflesia and Balanophora, including the use of artificial means if necessary;

- To reintroduce species known to have, or likely to have, occurred in the past, subject to prior studies to investigate the feasibility of such reintroductions and to guard against possible harmful ecological consequences;
- To prevent the introduction of exotic species, either animal or plant.

Research

- To establish a monitoring service to keep continuous check on the changes taking place in the vegetation and animal numbers and distribution within the Reserve;
- To conduct ecological studies of individual species and communities in order to further an understanding of life processes and relationships;
- To supply accurate information to the interpretive division, so that the visiting public can learn about the interactions of plants and animals in natural areas.

Visitor Use

- To encourage limited visitor use for the primary purpose of enjoyment of nature, subject to the overriding goal of preserving the ecological integrity of the Reserve;
- To facilitate wildlife viewing and photography and other recreational activities, such as hiking and camping, subject to conservation goals and the safety of the visitors;
- To discourage recreational and other activities likely to cause environmental disturbance or which would otherwise not be in keeping with the functions and purpose of the Reserve.

Education and Interpretation

- To explain the history, purpose and value of the Reserve and the significance of its unique flora and fauna to visitors in the context of Indonesia's overall conservation programme;
- To help visitors to see the maximum possible diversity of flora and fauna and help them to understand what they are seeing in an ecological context;
- To provide special facilities for visits by students and other organized educational groups;
- To provide extension activities to encourage an understanding of the value and functions of the Reserve to people living nearby and to enlist their cooperation.

Public Relations

- To integrate the existence of a viable nature reserve into the lives of the local people most directly affected through education and demonstration of conservation principles that will enhance their lives, through employment when possible, by integrating the Reserve in the regional management plan, by establishing an advisory committee of local officials, and by cooperating with regional officials in planning rural development projects that protect the values of the Reserve and enhance the lives of people living in surrounding areas.

Estate Management

- To keep building construction and other developments within the Reserve boundaries to the minimum necessary for management purposes and as unobtrusive as possible;
- To limit the roads in the Reserve only to those needed for plantation access and to prevent construction of airstrips or commercial developments of any kind, except at the Rajegweal development site;
- To close all foot trails, except those needed for control purposes, and to prevent the construction of any new trails, except when it may be necessary to fulfil the functions of the Reserve.

INTERNATIONAL REQUIREMENTS

The Meru-Betiri Reserve has been included in the United Nations List of National Parks and Equivalent Reserves, but only on a tentative basis (94). Inclusion in the list is based on internationally accepted criteria; newly-created parks and reserves that fail to meet these standards, such as Meru-Betiri, may be tentatively included, provided a course of action to rectify deficiencies is being actively pursued and there are grounds for assuming that this will be achieved within a reasonable period of time. This management programme is based on these international standards. If all provisions are carried out, the Reserve will meet the requirements for inclusion in the United Nations List during the period of the plan.

PERIOD OF THE PLAN

This plan has been prepared for a period of five years with implementation set for 1977. To keep the implementation date flexible, the sequence of operations is listed by number of years and not actual dates.

The plan provides a realistic statement of conditions, needs, goals and prescriptions for the time when it was written (November 1976), but it will have to be reviewed and modified as more information

becomes available. No substantial revisions of the plan are likely to be required during the first five-year period, but more detailed proposals in certain areas will have to be formulated. The purpose of the record-keeping system and research and monitoring programmes for the Reserve is to provide the documented information base needed to review and modify the plan for subsequent five-year periods.

MANAGEMENT PRESCRIPTIONS

LEGAL STATUS AND BOUNDARIES

Meru-Betiri should immediately be declared Cagar Alam with an extension of boundaries to include:

1. The present Reserve area with the exception of the long-established settlement area known as Wonowiri;
2. All adjacent off-shore islets;
3. An area of the sea extending 500m beyond the low tide line of the mainland and off-shore islets;
4. The area of protection and production forests north of the present Reserve boundary and south of the Kali Saen and Kali Kalungusan to the boundary of the Malangsari estate.

The total area of the Reserve will be approximately 56,200 ha, not including the area of sea. The approximate boundaries of Cagar Alam Meru-Betiri are shown in Figure 9.

All boundaries not affected by the above extensions should be immediately surveyed and marked. Once established by decree, all the remaining boundaries must be marked, using permanent numbered posts interconnected by a cut line 2m wide. All access roads, foot trails and landing places along the coast should be clearly posted with durable signs noting that the area is Cagar Alam and prohibiting unauthorized landing or entry.

PROTECTION AND LAW ENFORCEMENT

The principal task of the protection staff during the period of this plan will be to effectuate a guard system that provides the Javan tiger with maximum security and to systematically eliminate disturbance and exploitation of forest products that threaten the ecological integrity of the Reserve. The protection programme is under the direct supervision of the Reserve Manager and should include establishing a no-hunting zone around the Reserve, control of access points to the Reserve, control of movements of people within the Reserve, and a programme to phase out all exploitation of forest products.

If the provisions of the plan are carried out, the area will have been upgraded within five years to fulfil the legal requirements of Cagar Alam and also meet the International requirements for inclusion in the United Nations List of National Parks and Equivalent Reserves.

No-Hunting Zone

By declaration of the President or Minister, no hunting of any kind should be allowed in any area up to a distance of 20 km from the boundaries of the Maru-Betiri Reserve. No hunting is to be allowed in any of the adjacent production or protection forest blocks, regardless of their extent. While the Reserve boundaries should be extended to include the present known range of the tiger, this measure is necessary to prevent the killing of any tiger that may occasionally range outside. The no-hunting zone should be well-posted with durable well-designed signs stating this regulation. The signs must be tended and maintained. This is an essential feature in the no-hunting zone, as the condition of the signs will, to a large extent, express the attitude of the P.P.A. staff on this matter.

As required by the new conservation law, the no-hunting areas should be indicated on all hunting permits issued in East Java. The no-hunting zones should also be indicated on signs posted in all P.P.A. guard posts in East Java. The zones should be patrolled regularly by the Reserve's protection staff in cooperation with the hunting guards of the staff of the East Java Section Chief. Of course, anyone in violation of the regulation must be prosecuted to the full extent of the law.

Access Points

Access to the Reserve must be allowed only at designated points and only with the permits stated in the regulations. The number of entry points to the Reserve must be kept to a minimum, in the interest of economy and effective control.

Two road barriers will have to be erected, one on the Bendialit access road at Curah Nongko and the other on the Sukmade road at the boundary near Rajcgwesi. There should also be control points on the foot trails at Nanggalan, Kali Saneh and Malanghari (Fig. 9). All other access trails should be closed and allowed to fall into disrepair.

Each barrier should be manned by two uniformed guards. Accommodation for the guards should be located in the immediate vicinity of the barrier to facilitate continued vigilance. The guards will need to issue entry permits and collect admission fees and distribute information brochures.

Check Points within the Reserve

Check-points, each manned by two uniformed barrier guards, should be established at Sumber Sari, Sukmade East, Sukmade Beach and the edge of the Bendialit plantation on the trail to Meru Bay (Fig. 9). This is to control the movements of persons within the Reserve, as outlined in the upgrading programme which follows.

Figure 9

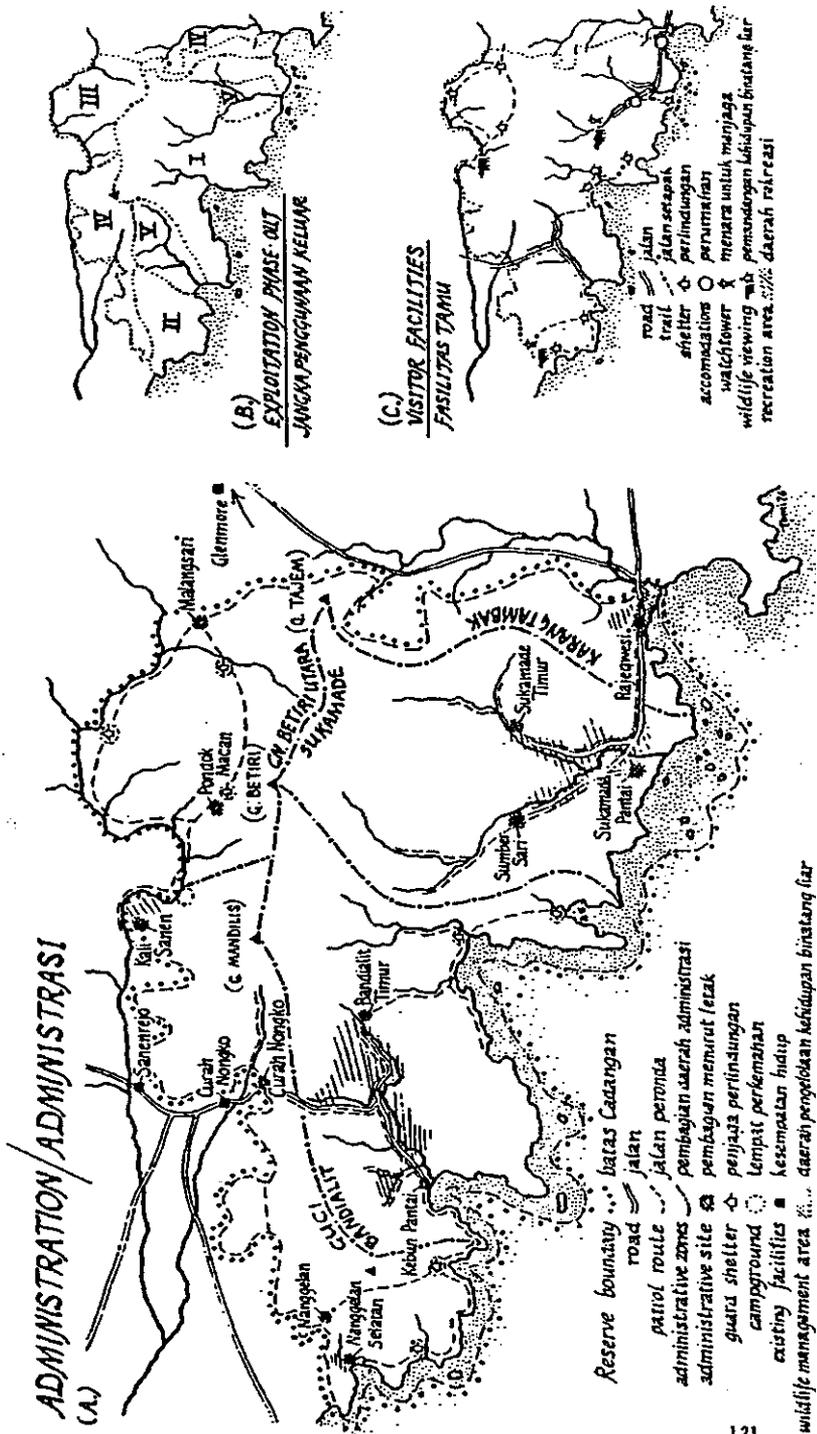
Management Prescriptions:

Through careful planning and management, it is possible to maintain the ecological integrity of the Meru-Betiri Reserve and provide for the ecological needs of the last remaining Javan tigers. The most urgent actions needed are:

- To extend the boundaries of the Reserve to include the northern area where tigers sometimes range, the off-shore islets, and a 500 m zone extending from the shore into the sea;
- To acquire control of the lower valley areas that were formerly the most important tiger habitats and manage these areas as feeding grounds for banteng and rusa;
- To expand the guard force and improve its efficacy;
- To upgrade the legal status of the Reserve from Suaka Margasatwa (game reserve) to Cagar Alam (nature reserve), making it possible to control the number and activity of people coming into the area;
- To instigate an education programme to develop public awareness and sympathy for the tiger's plight.

The recommendation for P.F.A. to acquire control of the plantation enclaves and turn them into wildlife habitat management areas is based on a careful analysis of the tiger's ecological needs and the danger plantation operations and the activities of the 4000 people who live there pose to the tiger's survival and the ecological integrity of this fine Reserve.

Figure 9



Patrol System

The Manager, in consultation with the Resort Chiefs, will develop a schedule for patrolling each administrative zone end along the coast. The requirements will depend upon the current level of utilization of the areas and the upgrading programme of phasing out exploitation and removing settlements.

In general, each patrol route should be covered at least once every five days; the coast should be patrolled at regular intervals. A suggested system of patrol routes is shown in Figure 9 - only one trail will need to be opened for this purpose from Meru Bay to Permisian Bay; the other trails and roads are already in existence. All other trails in the Reserve should be closed; no other trails should be opened.

It will be noted that no trails are recommended up the main forks of the Kali Sukamade. As the route follows the stream bed, it will not be possible to patrol this area during the wet season. It should, however, be patrolled regularly during the dry season.

Guarding the Sukamade and Damal beaches will be the responsibility of three guards. They will also guide visitors in this area and assist the Resident Ecologist in maintaining accurate records of the nesting and hatching success of sea turtles (see Research and Visitor Use sections).

Upgrading Programme

It may not be possible or even desirable, from a public relations point of view, to abruptly halt all the collection of minor forest and coastal products from the Reserve; but within the five-year period of this plan, all collection should come to an end so that the Reserve complies with the legal requirements of Cagar Alam. To accomplish this, a systematic phase-out programme will be initiated. The zones and their timed sequence of control are shown in Figure 9. Briefly, these are:

- Year 1 - Meru and Upper Sukamade, the critical tiger areas, the Sukamade and Damal beach areas
- Year 2 - Gunung Rika area, including all the western coast
- Year 3 - Gunung Retiri North
- Year 4 - All border areas
- Year 5 - All the plantation and settlement areas within the Reserve boundaries

As each area is closed, no entry will be allowed that is not permitted within the rules and regulations that govern the use of the Reserve. In areas not yet upgraded, the collection of minor forest products

will be permitted, but only within the months of July and August each year. No permit will be required, but access will be allowed only at recognized points of entry. During other months, movements in these areas will be subject to the normal rules and regulations governing entry into the Reserve.

This is a simple and logical system for phasing out exploitation and upgrading the status of the Reserve. Control in each area can be effected with check-points and an active patrol system. We can foresee two main problem areas. The first is the movement of people on the Kali Sanen trail in the north, and the second is the movement of people to and from plantations by the plantation access roads. In regard to the plantation people, this will be brought under control when P.P.A. acquires the plantations and terminates their operations. This is anticipated by the fourth year of the plan. The movements of people on the Kali Sanen trail need not be stopped, but the collection of forest products must be controlled. No permit for local people to use the trail should be required, but they should be allowed to camp only at designated sites in the Reserve. This will have to be enforced through an effective patrol system. The job of patrolling will be much simplified when all cultivation activities are terminated in Gunung Betiri North, scheduled for the third year of the plan (see below). It is recognized that patrol duty in this area will be the most difficult in the Reserve, but it must be effectively carried out.

The Resort Chief should be selected with care, keeping in mind that the job will require skill in public relations, field living and leadership. The Resort Chief who performs well in this job will be an excellent candidate as the Manager for another major Reserve in the future.

Removal of Settlements and Inholdings

There are three types of inholdings now in the Reserve: the scattered cultivated areas north of Gunung Setiri, the illegal settlements of Kebun Pantai and Summersalak Darungan in the Sandialit drainage, and the plantations of Sandialit and Sukamade Baru. The fishing village, Rajegwesi, is inside the Reserve, but within the administrative development site. Its position will be decided in future plans depending upon the development of visitor use in the area. It is recommended that the town of Wonowiri be excluded from the Reserve boundaries when the new boundaries are created under the Cagar Alam decree (see earlier

All scattered agriculture is programmed to be removed from the Reserve by the third year of the plan; the illegal settlements in the Sandialit drainage will be removed by the fifth year.

The removal of the people involved will be under a detailed plan prepared by a Settlements Officer. Initially, the principal need will be to determine the extent of illegal settlements. One of the Officer's principal duties will be to assure that every effort is made not to deprive these people of their means of livelihood, but to resettle them in other areas where their standard of living can be improved over their current situation. Very careful selection of the man to occupy the post of Settlements Officer is essential to ensure that the plan is successful and carried out with a minimum of disruption in the lives of the people involved.

The succession of control of plantations and the closing down of plantation operations should be placed in the hands of a special team from the office of the Director of P.P.A. It should consist of a lawyer and an engineer familiar with plantation operations. They will work in conjunction with the P.P.A. staff in Maru-Betiri, the Section Chief of East Java and the senior staff of P.P.A.'s central office. Again the principal task will be to carry out the goal with a minimum of disruption in the lives of the people involved. The P.P.A. team should make a concerted effort to find places for the affected people in transmigration programmes or on other plantations. This will be a demanding task. The responsible team must be of the highest competence and integrity. The plantations should be completely depopulated by the fifth year of the plan and all coffee trees should be cut down to assure they are taken out of production. All buildings, except the headquarter complexes, should be removed. All roads, except those needed as access to P.P.A. posts, should be closed.

It is envisaged that the plantation headquarter complexes will be converted into field stations jointly managed by L.I.P.I. and P.P.A. Provisions for their conversion and operation should be the subject of the second five-year plan. During the third year of the present plan, a committee appointed by L.I.P.I. and P.P.A. will prepare a plan for the future development and operation of the field station complex.

Fire Control

Fires, probably mostly man-caused, sometimes occur in the Reserve, especially in the west. We would expect that as the movement of people is restricted in these regions of the Reserve and all camp fires are restricted to designated camp sites, the danger of fire will be greatly reduced. Reserve visitors should be warned of the danger of fire from discarded cigarette ends and general carelessness. No camp fires should be permitted in the Reserve other than at authorized camping sites or with a special permit. The Reserve Manager must keep the problem of fire control under review throughout the period of the plan. If the Manager considers that a fire hazard has developed in some area of the Reserve, then he must prepare a local fire plan

to cover arrangements for staff and vehicles to be on duty during critical periods, for assistance in fire-fighting from local towns, and for the location of fire-fighting equipment at specific points. An overall strategy should be devised for fire-fighting in particular localities with regard to topography, position of roads and trails, and areas with high fire risk. It is unlikely that purchase of fire-fighting equipment will be required during the plan period, but emergency funding might be required if such a situation develops.

WILDLIFE MANAGEMENT

All animals in the Reserve are completely protected by Indonesian law and the rules and regulations of the Maru-Betiri Reserve. For the purpose of conserving the Javan tiger, a wildlife management programme consisting of two parts should be undertaken:

Habitat Management

During the period of this plan, no further clearing or manipulation of the vegetation for the purpose of habitat improvement should be undertaken, but the feeding grounds located at Nanggeian, Pringtali and Sukamade West should be maintained as feeding grounds for large ungulates. All people should be moved out of the areas planted with a mixture of grass seed of a type suitable as food for banteng and rusa. The species planted will depend upon availability, but the species selected should be perennial and in accordance with the food preferences of those ungulates listed in the monograph by Hoogerwerf (1).

The areas of teak forest lying within the Reserve boundaries should not be cut, thinned or otherwise manipulated. These provide an excellent buffer to the natural forests in the Reserve.

The area of the Reserve that has been cleared in the Ksli Karangtambak drainage outside the designated administrative area at Rajegwesi should be replanted with rapidly growing tree species. As inhabitants are moved from settlement areas, all houses should be destroyed and the cleared areas planted with the same mixture of grass seed used for the feeding grounds.

Immediately upon acquiring control of the plantation areas, all buildings, aside from the headquarters complexes, should be dismantled, burned or otherwise removed. All coffee trees should be cut down, but rubber and shade trees left standing. All roads, except those needed for direct access to administrative sites, should be closed.

Reintroductions

No control of any wildlife species should be required within the five-year plan; but to improve the food supply situation for the tiger, limited introductions of rusa and banteng should be made in the Sukamade drainage, and rusa in the Nanggelen and Kali Sanen areas of the Reserve.

The most suitable animals for reintroductions are wild stock from nearby areas, not stock from zoos or from vastly different habitats, such as Baluran or the Ijang highlands. For the purpose of reintroduction into the Meru-Betiri Reserve, it appears that all the necessary animals can be obtained in the Pulau Karah area to the west of Rajegresi. The area is readily accessible and the animals there are accustomed to coming into cultivation to feed. These animals should be live-trapped; no attempt should be made to capture them using immobilizing techniques. The methods for trapping these animals have been well worked out, and advice and assistance should be available from the staff at any number of zoos. We would suggest a goal of 20 banteng and 20 rusa, with a sex ratio for each species of about one male to four females, for the Sukamade area. About 20 rusa with the same sex ratio should be introduced in both Nanggelen and the Kali Sanen.

Salt-licks should be established at all feeding grounds. At Sukamade, the salt should be located at the far end, away from the plantation boundary.

Mitigation of Animal Damage

Animals sometimes cause certain damage to crops and livestock in the plantation enclaves and adjacent areas, and there has been some discussion about instigating a programme of mitigation of such damage by P.P.A. to relieve the hardship on people who have suffered losses. In our opinion, this is not advisable at this time. First, it should be recognized that the losses of large animals are relatively small as compared to those to insects and small mammals, although the former are frequently more conspicuous. Also there is the problem of determining what animal damage should be considered for compensation and who would assess the amount involved. Who would oversee the programme and ensure that proper control is exercised?

In such a programme for example, would P.P.A. pay for financial losses incurred when plantation operations are interrupted when a tiger is thought to be in an area and workers refuse to enter that area before daylight, as required when tapping rubber trees? Does P.P.A. pay for damage caused to gardens by pigs, muntjac and monkeys? Who determines whether or not these animals roamed out of the Reserve or just lived

in the immediate vicinity outside the Reserve? Certainly, such a consideration would need to be a part of any mitigation formula. If P.P.A. should decide to mitigate tiger depredation, who is to decide, for example, whether a goat was killed by a tiger or a leopard? A number of goats are killed each year in the plantation enclaves by large predators, but it is not possible, even for the most competent observer, to always tell which large cat is responsible.

Such decisions would have to be made when developing a mitigation programme, and we do not see how it would be possible to exercise the control needed to ensure it fulfilled its desired function.

It is also true that people who have lived for generations in the vicinity of wildlife have developed sophisticated techniques for minimizing animal damage. They know how to reduce damage in their fields and they know very well that if they exercise care in the husbandry of their livestock, losses will be reduced. If a goat is left tied out to feed in a plantation area at night, it is obviously inviting trouble from leopards. In a number of instances, we heard that a chicken was killed in the night by a tiger; upon careful investigation, we found that a chicken left to roost out at the forest edge was taken by a civet. These kinds of losses can easily be avoided. If need be, the protection and management staff and the Interpretation Officer can point out how this can be done. The knowledge is already available; most of such losses are a matter of carelessness.

There is a more important matter that must be given consideration, particularly as it affects the tiger. In the late 1950s, a tiger was killed at Sandialit Plantation for no more reason than damaging some rubber collection cups. In another instance, a tiger was shot there for killing a number of goats. As late as 1971, a tiger was killed at Sukamade Plantation for reportedly killing some goats and injuring one man. The tiger was shot because it was feared it would become a man-eater. When a large carnivore injures or kills someone, such an incident is clearly on a different order of magnitude in the minds of local citizens than when it damages a few rubber collection cups. In the past, however, the supposed offending animal in both cases was killed.

If that precedent is followed today, it will with certainty mean the end of the Javan tiger. The whole thrust of this management programme is to alleviate potential conflicts of this sort and restore the ecological integrity of the Reserve with all possible speed; but if, for whatever reason, a tiger gets itself into trouble amidst the 5000 or so people who presently come into the area by injuring or killing someone, action on the part of P.P.A. will have to be taken. In such an instance, we suggest that an area extending 2 km on all sides of the provocation be closed immediately. Any people living

within this area should be immediately moved out; all livestock should be moved out. If any compensation is required, the Settlements Officer should see that the proper claims are filed. If plantation operations need to be closed down, so be it. P.P.A. will have to determine what, if any, compensation is possible in such a case, but this loss will certainly have to be based on net, not gross, income from any production lost; and, at least in the case of the Sukamade Plantation, expenditure has exceeded income for the past few years.

The duration of the closure will depend on the circumstances and the relation of the area to the upgrading programme. If such a closure is necessary, it would only seem logical that it be permanent, in keeping with the management goals of the Reserve.

There is really no alternative to this guideline. If P.P.A. kills a tiger or allows one to be killed, it will mean the end of the Javan tiger. If the P.P.A. staff does not take immediate precautions by moving the people out of the area and closing it, they will not have acted in a responsible manner. This guideline will be difficult to carry out, but it is absolutely essential. A special contingency fund for such an emergency should be created and controlled by the Directorate, Central Office.

RESEARCH

Scientific research in the Maru-Betiri area has been confined to short-term surveys and collecting of botanical specimens. In the future, two types of research programmes will need to be undertaken. The first consists of management-oriented research and inventories, and monitoring studies to be undertaken by the Reserve staff. The second will comprise more detailed studies to be undertaken on selected subjects by universities, visiting scientists and government officials. Many studies will involve cooperation of the Reserve staff and outside personnel. In order to ensure continuity in the collection of data and coordination between studies, a field station should be established for library and other necessary facilities with a Resident Ecologist Director. This field station should be closely associated with the concerned agencies of L.I.P.I. and interested universities. As the management programme for the Reserve proceeds, it will become clear where more detailed studies are required to provide data needed for planning and management, but at present, the following investigations are needed and should commence soon.

Detailed Studies

- Vegetation Ecology

A research programme on the vegetation ecology of Maru-Betiri is of the utmost importance in planning for the future management of the Reserve.

This investigation should be under the active field direction of a Ph.D.-level vegetation ecologist. For the purpose of training, his research team should be biology graduates, who will use portions of the research as part of the requirements for their advanced degrees. All Reserve staff should be closely involved and assist in the programme to familiarize them with the identification of the flora of the area. The research objectives will be formulated by the Principal Investigator in consultation with and approved by P.P.A. In general, the research goals are:

1. To provide a basic inventory of vegetation types occurring within the Reserve, their extent and location (this will require aerial photographs of the region);
 2. To develop a predictive understanding of successional patterns and the impact of the main disturbance factors;
 3. To provide an inventory of the flora of the Reserve, to assess the potential of various vegetation types as habitat for endangered and extinction-prone species.
- Project design should be at the discretion of the Principal Investigator; the text, "Vegetation Ecology" (33), should serve as the guiding reference.

This is, obviously, a long-term investigation, but preliminary results on all the points listed should be compiled and summarized by the third year of this plan for the purpose of preparing the second five-year plan. Details of the budget must await the preparation of the study plan but it is envisaged that the research programme will be a cost-sharing programme with other institutions. P.P.A.'s contribution should not exceed half the total or one million Rp/year. The first six months of work for the preparation of the study plan should be funded by P.P.A.

- The Ecology and Behaviour of the Large Carnivores and their Prey

The primary function of the Reserve is to provide suitable habitat and protection for the Javan tiger, and it is clear from our discussion above that the basic information needed to ensure its survival is not yet available. However, no studies that threaten or in any way disturb the tiger population should be permitted. This precludes the use of modern field techniques, such as capture/markings/recapture and the use of radio telemetry. Research on the tiger must be confined to study by indirect means with the principal objective of monitoring distribution in the Reserve and assessing if reproduction is occurring. Careful records of tracks, sign and/or sightings must be maintained. Each year a survey should be carried out, duplicating as closely as possible the 1976 survey, so some indication of population trends can be obtained.

Both wild dog and leopard are species listed in the IUCN Red Data Book and are in need of detailed investigation. To provide the data needed to ensure their conservation, a research project utilizing

modern field techniques will be required. Experience has shown this to be the only means by which requisite data can be collected. A one- to two-year project should be undertaken by a Ph.D.-level ecologist with field experience in the study of large mammals in Asian habitats. The study must include a consideration of their prey. Again one of the primary purposes of the programme will be to provide training for two Indonesian students who will later be able to carry out similar studies in other areas. Preparing the research plan is the responsibility of the Principal Investigator in consultation with IUCN's Survival Service Commission, the staff of the Reserve and P.P.A., Central Office. All costs for Indonesian counterparts will be borne by P.P.A.; all other funds should be from outside sources.

- Other Detailed Research

No other detailed research with direct financial support from P.P.A. is envisaged in the five-year plan, but research in the Reserve should be encouraged. Proposals for studies must be submitted to P.P.A. to coordinate all ongoing research with the Reserve management programme. The Reserve staff should be prepared to provide all reasonable assistance and facilities in the execution of these investigations.

Basic Study Programme

- Climatological Studies

Under the supervision of the Resident Ecologist, climate data, including precipitation, relative humidity and maximum-minimum temperatures will be collected in the standard manner at Pondok Macan, Sandialit, Nanggelan, Malangseri, Sukamade and Sajegweel.

- Inventory and Management of Rafflesia

A careful search for and mapping of the locations of Rafflesia and Balanophora should be undertaken by the Reserve staff under the direction of the Resident Ecologist. Scientists at Laiden should be asked to prepare a detailed plan to ensure survival of these species and recommend methods of proper display to visitors.

- Inventory and Monitoring

Lists of all vertebrate animals, with locality and habitat where they occur, should be completed. Although local advice may be sought, no species should be entered into the record unless it has been seen by a competent observer. Collection of some species will be required, but only as part of a carefully worked out proposal, not on a haphazard basis. Any collection can only be done by permit and should be done

in cooperation with the concerned agencies of L.I.P.I.

Inventories should be made of features of the Reserve which may be of special management, scientific or recreational interest. This would include the mapping of caves, locating of areas of geological or scenic importance and the mapping of the nesting area of colonial nesting species.

The monitoring studies done under this programme will involve estimation of the abundance and distribution of large mammals and extinction-prone species. Regular counts of banteng should begin immediately; estimation of primate abundance should follow the procedures outlined by Wilson and Wilson (1960), procedures for other species are outlined in the publications of Eisenberg and Thorington (1964) and the Wildlife Society (1961).

Of special importance in the Reserve is the influence of droughts on the distribution of animals. A detailed study plan for investigating this should be prepared and implemented by the Resident Ecologist.

The general inventory and monitoring programmes are part of the regular duties of the Management and Protection staff, coordinated through the Resident Ecologist.

- Sea Turtles

One of the principal tasks of the Resident Ecologist will be to monitor the turtle nesting beaches in the Reserve. Three full-time assistants are required for this effort; they will also act as Protection Guards and assist visitors in viewing the turtles in ways that will minimize disturbance. Accurate records must be maintained on the number and species coming to the beach, the number nesting, and nesting success. After control of exploitation of all the beaches in the Reserve is secured, a programme for reestablishing nesting populations should be instigated with the advice and assistance of an outside expert. This should be started in the third year of the plan. All costs for the expert will have to be from outside sources, but the project costs, themselves, should be borne by P.P.A.

- Reintroduction Programme

This has been discussed in detail under Wildlife Management. The preparation of the plan and all preliminary arrangements will be the responsibility of the Management and Protection staff. Of course, with an operation such as this, all personnel will be involved at one point or another.

The possibility of reintroducing crocodiles into the Sukamade drainage should be investigated and a detailed plan prepared. This would be carried out in the second five-year plan for the Saserve (see 102).

Coordination of Research

All research and related programmes will be coordinated through the Sub-Directorate of Planning, P.P.A., and be directed in the field by the Resident Ecologist. The Resident Ecologist is responsible for collecting and summarizing all scientific data gathered by the staff and for preparing the reports for the purposes of planning and interpretation. He is responsible for publishing results for use by the scientific community at large. It is of the utmost importance that the research programme and the scientific and management reports prepared by the Resident Ecologist meet the standards of L.I.P.I. and the international scientific community.

EDUCATION AND INTERPRETATION

Just as "management" means more than just hiring staff and building accommodation, "interpretation" means more than just building visitor centres. It should be defined, not by its techniques, but by its goals. Defined, interpretation is the art of explaining the place of man in this environment, to increase public awareness of the importance of this relationship, and to awaken a desire to contribute to environmental conservation. The role of the Interpretive Officer is to make face-to-face contacts with Reserve visitors and to develop and execute a programme to explain the Saserve's values (103). In doing this, he will have to select the best media for presentation. A visitor centre is not anticipated as a necessary development within the period of this plan. Presentations will necessarily employ signs, wayside exhibits, graphics and photography, audio-visual programmes for local schools and meeting places, guided tours, brochures and other publications and newspaper articles. Themes would include the survival needs of the Javan tiger, the life cycles of sea turtles and of Rafflesia, the character of Meru-Betiri as revealed through the relationship between rocks, soils, plants, animals and men, the relationship of man and his environment, the value of Meru-Betiri as a Nature Reserve, and how it is a part of Indonesia's efforts to preserve its natural diversity.

The development of an interpretive programme is the responsibility of the Interpretive Officer, and in the beginning the programme should include:

Visual displays, using photographs and drawings of, for example, the survival needs of the Javan tiger or the life history of the sea turtles and the Rafflesia, to be erected in the guest house, headquarters, and as signs placed at appropriate places in the Reserve.

Public extension programmes given at regular intervals in local schools and meeting places, employing slides and films on conservation subjects. For this, projectors and a generator will be required.

Guided tour programme for visitors wishing to see any of the feeding ground areas and the turtle beach. Two English-speaking guides should be provided. These guides must be familiar with the area and its wildlife. Consideration should be given to employing on a temporary basis university students with backgrounds in biology. They will be under the supervision of the Interpretive Officer.

Large attractively designed notices providing the name of the Reserve, listing the regulations governing its use and a large-scale map of the area, showing the principal points and areas of interest. These should be erected at the entrance of the two motor roads into the Reserve, at the headquarters complex and at the Glenmore post. The Officer should also see that the route from the Glenmore post to the Reserve is well marked.

An information brochure in the form of a fold-out leaflet with a map of the Reserve on one side, showing boundaries, main topographical features, feeding grounds, guard posts, trails and roads, and other points of interest. On the other side should be a printed text giving a brief description of the park, a note on some of the more conspicuous forms of wildlife, a summary of the Reserve regulations, and other information of importance and interest. These leaflets should be printed separately in Indonesian and English and distributed free with the entrance permit.

Simple inexpensive leaflets, one for each nature trail and wilderness trail, giving essential information on routes, with maps and features of special interest, should be prepared. This should also include the rules of trail use, such as do not discard litter, do not leave the trail, etc.

In the beginning, the primary responsibility of the Interpretation Officer will be to design and execute the programme for increasing public awareness of the plight and value of the Javan tiger, outlined in the first chapter of this plan. He must also prepare a detailed plan for the overall interpretive and education programme. The 'FAO Manual for Planning Interpretive Programmes in National Parks' will be most useful (104).

VISITOR USE

The principal function of the Meru-Betiri Reserve is to protect the natural ecosystems and their floral and faunal elements, principally the endangered and extinction-prone species. It is possible to allow certain non-extractive uses of the area in keeping with sound conservation principles. A look at certain beach developments in Bali will vividly demonstrate what can happen without careful planning for tourism from the beginning, and if provisions are not made to control numbers, movements and activities of visitors in a manner that is compatible with the functions of the Reserve.

In the "Javan Tourism Master Plan," the Meru-Betiri Reserve is a recognized element in the development of the tourism potential in East Java (92). It is also included in the new "Official Guide to Java". With its close proximity to the tourism centres of Bali, it can be anticipated that tourism demands on the Reserve will increase. If the trends we noted during our survey continue, this increase will be rapid.

Type of Use and Accommodation

The Official Guide to Java (93) pictures the coast of Meru-Betiri as an outstanding example of an area of solitude, peace and tranquillity, and that is the only type of visitor use which should be encouraged or permitted. Care should be taken to provide the visitor with a quality experience and introduction to the wildlife and forests of Java. Recreation, such as motorcycling and surfing, should be best left to the resorts on Bali. Swimming at the beach in Rajegwesi is practical; the remainder of the coast is too rough and dangerous.

There already is a P.P.A. guest house at Rajegwesi with four beds in two rooms. Tenders should be invited for a concession to develop simple lodger-type accommodation (food and lodging) for no more than 20 visitors in the Rajegwesi development and administrative site. The construction of the lodger should be in keeping with the atmosphere of a quiet fishing village. P.P.A. must make stringent requirements concerning building design and materials, methods of operation and maximum numbers of both visitors and staff.

There should be a close liaison with tour operators in Bali, Yogyakarta and Jakarta to inform them about the Reserve, particularly on what visitors can do, how long it takes, what it costs, Reserve regulations, etc. Reputable tour operators should be encouraged to visit the Reserve themselves, so that they are better able to brief their customers.

Visitor Direction and Activities

Visitors should be encouraged to use only established trails in the Reserve. That preclude use of the upper Sukamade drainage, which is to be managed as a strictly protected area. Visitor direction can be achieved through regulations and placement of facilities:

- Nature Trails

Nature trails are a technique used in visitor direction. They are essentially self-guided walks through scenic areas to sites of unusual interest. They must be clearly marked so that the visitor can find his own way without danger of getting lost. In the beginning, three such trails are recommended:

1. Rajagwesi to Dsmai beach to view the rugged coast and Rafflesia.
2. Sukamade Beach - the road past the field station should be closed and allowed to fall into disrepair; only a foot trail should be maintained.
3. When banteng and rusa have been successfully reintroduced to the feeding ground in Sukamade West, a tower for viewing can be constructed. The trail should be located in such a way that the tower can be entered and left without disturbance to the animals in the cleared area.

At Sukamada beach, care must be taken to ensure visitors do not disturb any of the turtle nests or research work in progress. Visiting the beach at night to view nesting sea turtles can only be permitted when accompanied by a guard/guide to ensure that turtles are not disturbed while nesting.

- Wilderness Trails

The majority of visitors will be content to visit the turtle nesting beach, the feeding grounds and the Rafflesia at Dsmai Bay. However, a few will be interested in viewing other areas of the Reserve. Visitors should only be allowed to travel on established trails accompanied by Reserve Guards. Suggested routes would be from Sandiait to Neru Bay, from Nanggeln to Sekar Pisang, and along the patrol path in Gn. Betiri North. There should be a charge for use of patrol shelters. Camping should be permitted only at designated sites.

- Coastal Tours

Depending on the demand, the concessionaire may wish to establish tours of the coast by boat. This is a non-disruptive means of visiting the Reserve and it should be encouraged. The boat should stay well back

from the shore; landing along the coast should be only in unusual circumstances with the permission of the Reserve Manager, in line with normal regulations.

Future Trends and Problem Areas

The Interpretation Officer is responsible for keeping records of visitor use and in making predictions of future use trends. Each visitor should be required to supply relevant information in making application for his permit. Records will have to be compiled as to intensity of use of different areas and the number of guard days involved in assisting Reserve visitors. The Officer will have to analyse special problems resulting from visitor use. It is from these records that special management action can be taken to alleviate problems, and ensure that visitor use complies with the management policy of the Reserve.

PUBLIC RELATIONS

The establishment and upgrading of Meru-Beriri follows sound principles of conservation. Application of these conservation principles can lead to an enhancement of the lives of all citizens of the Republic, both directly and indirectly. It should be recognized, however, that in the process of upgrading the Reserve and taking the precaution needed to protect the last Javan tigers, there will be an inevitable conflict of interest with some people who are currently using the area. Every effort should be made by P.P.A. to maintain good relations with these people and assist in finding alternatives to present uses. Effort must be made to ensure that the lives of the people moved from the Reserve are actually improved. In addition, the following four steps should be undertaken as part of a comprehensive public relations programme:

1. Conduct extension activities to explain the purposes of the Reserve and the survival needs of the Javan tiger, and to introduce general conservation thinking into the local communities, especially through the use of films and slide talks (see earlier).
2. Involve local people in the management of the Reserve whenever suitably qualified individuals are available.
3. Establish a liaison committee, including the Manager of the Reserve, all local Kepala Desa, senior police officers and local managers of Perhutani, to deal with matters of law enforcement or conflict of interest between local people and the Reserve.

4. Integrate the Meru-Betiri plan into the regional development programme. This includes cooperating with regional officials in planning rural development projects that protect values of the Reserve and enhance the lives of people living in surrounding areas.

The P.P.A. staff must remember at all times that they have fixed responsibilities under law and that their management goals and time schedules are set through the work/operations plan, but it is also their responsibility to help to integrate the existence of a viable nature reserve into the lives of the local people. It is recommended that P.P.A. cooperate with Lembaga Ekologi Universitas Padjadjaran, Bandung in developing its extension programme.

ADMINISTRATION

Implementing the management plan for Meru-Betiri is a complicated task. The programme cannot succeed, nor the Reserve or the Javan tiger survive, if extreme care is not given to the selection, development, and training of the staff. The administrative prescriptions adapted here follow the recommendations of Dr. Kenton Miller (105), which are based on long experience and have been successful in national parks and equivalent reserves in many parts of the world.

Authority

Overall responsibility for the Reserve should remain within the Directorate of Nature Conservation. The P.P.A. Section Chief should remain responsible for overall supervision and planning, but subject to closer monitoring by the Directorate than has been the case in the past. The Manager in charge of the Reserve should enjoy a higher status than that of Kepala Rayon. He is the leader of the team that protects the Reserve and introduces it to the public. He is responsible for integrating, coordinating and stimulating his staff to implement the work/operations plan.

Staff Organization and Duties

Before outlining the staff organization and duties, it is important to consider the functions that must be performed to implement the management plan. Summarized, these are:

Decision-making: Direct and guide the necessary steps to achieve the objectives of the Reserve.

Protection: Protect the Reserve resources and Reserve visitors.

Management: Implement the necessary management prescriptions, particularly those related to the survival of endangered and extinction-prone species.

Developing facilities: Design and construct Reserve facilities.

Interpretation and public relations: Interpret Reserve resources to visitors and project the image of the programme to people outside the Reserve.

Maintenance: Maintain installations within the Reserve.

Administration: Administer the Reserve programmes.

Research: Seek to understand the natural features and processes of the Reserve and to understand the people who visit the Reserve.

Settlements: Analyze land tenure and guide the acquisition of land.

Planning: Plan the management, development operations, organization, and control aspects of the Reserve programmes, including the integration of all the above.

The organization of the staff will be centred around the functions performed. In certain instances, the functions will be shared by more than one person, but this should be avoided as much as possible so that there are clear divisions of duties and responsibilities.

The Manager:

He is ultimately in charge of the Reserve and directly responsible for protection and management, administration and future planning, although the planning function is shared with the Section Chief. He is responsible for planning and developing facilities, in this task assisted by an Architect and Civil Engineer from the Directorate, Central Office. He will also be assisted in the plantation acquisition programme by a special team from the Directorate; but his principal responsibility is to direct and guide the necessary steps to achieve the goals and objectives of the Reserve. Decisions must be made concerning the activities to be carried out, the individuals to whom they must be assigned, the budget to be allowed, and control of the various activities in terms of overall policy standards.

His staff will be organized in five Divisions:

1. Management and Protection
2. Interpretation and Public Relations
3. Settlements
4. Research
5. Administration

All staff are to be given permanent government appointments. The specific programmes for each Division have been outlined above.

1. Management and Protection Division:

The Management and Protection staff are responsible for the protection of the Reserve resources and Reserve visitors. They are responsible for the implementation of the special management programmes and for the proper function and upkeep of buildings, grounds, roads, trails and other installations and facilities. This Division assists the Research Division in monitoring programmes and also in meeting visitors, introducing them to the Reserve, and guiding them to enjoy their activities in ways compatible with Reserve policy. They all spend a great deal of their time in the interior of the Reserve where they are the law enforcement officers.

This Division will be divided into five administrative areas, each headed by a Kepala Resort: Guci, Sandialit, Sukamsde, Gn. Setiri Utara and Karangtambak (Fig. 9). Under the Kepala Resorts, Protection Officers will be assigned where it is anticipated that control will be most difficult. Depending on location, the Barrier Guards will be directly under the Kepala Resort or the Protection Officer. Depending again on the requirements of specific areas, Guards will be assigned to oversee specific projects and control activities, such as the feeding ground or areas, such as Pondok Macan in Gn. Setiri Utara. The Protection staff are also responsible for patrolling the no-hunting zone around the Reserve.

The Management and Protection Division will be organized as follows (see Table 10):

Guci:

Kepala Resort will be housed at Curah Nongko. A Protection Officer will be assigned to and housed at Nanggalan, and under him will be the four Barrier Guards at Nanggalan. The Protection Officer is responsible for the feeding ground at Nanggalan. A Protection Officer will be housed at Snenrejo and under him will be the Barrier Guards at Kali Snen.

TABLE 10
DAFTAR 10

PROTECTION AND MANAGEMENT STAFF - MERU-BETIRI
ORGANISASI PERLINDUNGAN DAN PENGELOLAAN MERU-BETIRI

<u>Jabatan/Position</u>	<u>Pos</u>	<u>Orang/No. of Staff</u>
<u>Manager</u>	Rajegwesi	1
<u>Kepala Resort/Area Chief</u>		5
Guci	Curah Nongko	
Bandialit	Kebun Pantai	
Sukamade	Sumber Sari	
Gn. Betiri Utara	Malangsari	
Kali Karangtambak	Rajegwesi	
<u>Pegawai Perlindungan/Protection Officer</u>		7
Guci	Nanggalan	
	Sananrejo	
Bandialit	Bandialit Timur	
Sukamade	Sukamade Timur	
Gn. Betiri Utara	Malangsari	
Kali Karang Tambak	Sarongan	
	Glenmore	
<u>Penjaga Batas/Barrier Guards</u>		18
Guci	Curah Nongko	
	Nanggalan 1	
	Nanggalan 2	
	Kali Sanen	
Bandialit	Bandialit Timur	
Gn Betiri	Malangsari	
Sukamade	Sumber Sari	
	Sukamade Timur	
Karangtambak	Rajegwesi	
<u>Penjaga/Guards</u>		4
Bandialit	Kebun Pantai	
	Bandialit Timur	
Sukamade	Sumber Sari	
Gn. Betiri, Utara	Pondok Macan	
<u>Penjaga Pantai/Beach Guards</u>		3
Sukamade	Pantai Sukawade	

English Notes

East = Timur
North = Utara
Beach = Pantai

Sandalit:

Kepala Resort will be housed at Kebun Pantai. Under him will be one Guard who is responsible for the feeding ground. He will be assisted by one Protection Officer to be housed at Sandialit East. They will have the Gate Guards and one Guard to assist in patrolling the Meru-Permisian route.

Sukamade:

Kepala Resort will live at Sumber Sari. He will be assisted by one Guard for control of the feeding ground. Directly under him will be the Barrier Guards at Sumber Sari. One Protection Officer will be housed at Sukmade East and under him will be the Barrier Guards for this check-point.

Protection of the Sukmade Beach will be effected by three guards, who will eventually be under the direction of the Resident Ecologist. Before the Ecologist is employed, these Guards will come directly under the Kepala Resort, Sukmade.

Gn. Getiri Utara:

Kepala Resort will live in new facilities near Malang Sari. He will be assisted by one Protection Officer for patrolling and one Guard who will be stationed at Pondok Macan. Directly under the Kepala Resort will be the two Barrier Guards on the Malang Sari-Kali Sanen Trail.

Karangtambak:

Kepala Resort will be housed in the headquarters complex at Rajegwesi. He will be directly responsible for the Barrier Guards at the Rajegwesi-Sukmade check-point. He will be assisted by one Protection Officer to be housed at Srengan and another housed at Glenmora. The Protection Officer at Glenmora is responsible for providing information to visitors and for patrolling the no-hunting zone around the northeast boundary of the Reserve.

Patrol of the shore will be conducted by boat. Assignment will be on a rotating basis among all the Protection staff and scheduled by the Manager.

2. Interpretation and Public Relations Division:

The Interpretive Officer and his staff are responsible for the educational aspects of the Reserve programme. They interpret the values and the features of the Reserve and present them to visitors in a language and manner which can be understood

end appreciated at all levels. This Division is also responsible for drafting and issuing information to the general public, primarily outside the Reserve, on the overall Reserve programme. It prepares material for publication, and aids in the design of speeches and materials which project the Reserve programme to the media and public. The Interpretive Officer will be assisted from time to time by a specialist from the Directorate. The Officer will be housed at Rajegwesi.

3. Settlements Division:

The Settlements Officer and his assistant are responsible for the study and analysis of land use within and around the Reserve boundaries. Initially, the principal needs will be to determine the land tenure and extent and number of people living in the Reserve, and to develop a plan for moving them to other areas. It is not envisaged that this Division will be necessary after the period of this plan. The Settlements Officer will be housed at Sanenrejo.

4. Research Division:

The Resident Ecologist is responsible for the investigations related to management problems and the Reserve interpretation programme. He studies the natural resources found in the Reserve and advises on management in relation to the adequate treatment of the Reserve's natural values. He spends a great deal of time in the field, analysing resource problems, consulting other members of the staff and advising the Manager on aspects related to overall resource management. He is responsible for coordinating all research activities in the Reserve. He will be housed in the field station to be constructed near Sukamada Beach.

5. Administration and Service Division:

This Division will be under the direct supervision of the Manager. Its function is to provide basic services in the operations of the Reserve. The staff required includes an accountant, boat crew (two), driver/mechanic, clerk/typist, guest house manager, and maintenance crew for the headquarters area (two). Accommodation for this staff should be provided in the headquarters complex at Rajegwesi.

Training

The biggest limiting factor in the implementation of this plan will be the shortage of trained staff. In terms of formal education, the present staff ranks quite high and this is certainly of benefit to

the future of the Reserve; but the implementation of the plan over the next five years will require a training programme to develop the special skills that are required. The training programme must be instituted through the Central Office of the Directorate. As noted previously, the Reserve staff has been divided into categories based on the level of training required to perform each job. The advanced level requires advanced formal education or equivalent wealth of experience; medium level requires some formal education and technical preparation; and the basic level requires little or no previous training. The skills required to successfully perform each function can be divided into general skills required by all personnel and specific skills required to perform specific functions (105). The training of all staff from the medium level upward will have to be provided through special courses given by the Central Office. Planning for this is in progress. Training basic level personnel will be the responsibility of the senior staff of the Reserve.

An important training method for advanced and middle level personnel will be for them to visit other working reserves and parks. An exchange of ideas with peers can help create a real P.P.A. cadre. Such exchanges will be important in evaluating performance and stimulating suggestions for improvements.

Budgeting for training will have to be provided through the Central Office of the Directorate as part of its overall training programme. Funds in the Reserve budget will provide for the training of basic level personnel.

Reports and Records

Regular monthly and annual reports should be submitted by the Manager to the Section Chief and the Director of P.P.A. These reports should include a general account of management activities and problems in the Reserve with special reference to matters of law enforcement, and relations with visitors and local people. Reports should also include observations on flora and fauna, notes on any unusual occurrences, monthly records of visitor numbers and meteorological data. It should also include a summary of revenue and expenditures. It is important for the Manager to accurately assess how his programme relates to the work/operation plan. If he is having difficulty following guidelines or implementing specific programmes, he should identify the reason so that steps can be taken by the Central Office to assist him. The Manager can only expect assistance if he can correctly analyse the situation in terms of problem areas and needs.

The Resort Chiefs and the Heads of Divisions must assist the Manager in his reporting duties. They must also strive to accurately assess problems and needs in complying with the work/operations plan. In addition to the documentation already discussed under individual programmes, each Division Head and Kepsia Resort should submit brief written monthly reports on their particular field to the Manager. Written patrol reports should be prepared by any field staff returning from patrol, including the itinerary of the route followed, and all observations of special interest.

ESTATE MANAGEMENT

Construction of New Facilities

Buildings and Other Structures:

The existing staff facilities which can be used in future management of the Reserve are:

- Curah Hongko, 30 m²
- Sanenrejo, 30 m²
- Glenmore, 40 m²
- Sambar Sari, 40 m²
- Rajegwesi, 30 m²
- Rajegwesi Guest House (4 beds, 3 rooms)
- Sukamada Beach (shelter)

The administrative facilities and staff accommodation which will need to be constructed during the period of this plan include:

Location and Facility	Construction Schedule (Year of Plan)
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Rajegwesi

Manager's quarters: 1	1-2
Headquarters office: 1	1-2
Staff quarters, A.L.: 2	1-2
Staff quarters, M.L.: 2	1-2
Staff quarters, S.L.: 7	1-2
Boat jetty: 1	1-2
Check post: 1	1-2
Garage/mechanic quarters: 1	3-4

Sukamada East

Staff quarters, M.L.: 1 1-2
Staff quarters, B.L.: 2 1-2
Check post: 1 1-2

Sukamade Beach

Field station: 1 1-2
Staff quarters, A.L.: 1 1-2
Staff quarters, B.L.: 3 1-2
Check post: 1 1-2

Sukamade, Sumber Sari

Staff quarters, B.L.: 3 3-4
Check post: 1 1-2

Nanggalan

Staff quarters, M.L.: 1 1-2
Staff quarters, B.L.: 4 1-2
Check post: 2 1-2
Watch-tower 3-4
Boat jatty 3-4

Curah Nongko

Staff quarters, B.L.: 2 3-4
Check post: 1 1-2

Kali Sanen

Staff quarters, B.L.: 2 3-4
Check post: 1 1-2

Bondialit, Pantai Kabun

Staff quarters, A.L. 1-2
Staff quarters, B.L.: 1 3-4

Bondialit East

Staff quarters, M.L.: 1 1-2
Staff quarters, B.L.: 3 1-2
Check post 1-2

Sarongan

Staff quarters, M.L.: 1 3-4

Malangsari

Staff quarters, A.L.: 1	3-4
Staff quarters, M.L.: 1	3-4
Staff quarters, B.L.: 2	3-4
Check post	3-4

Shelters

Sekar Pisang: 1	3-4
Sumber Cendab: 1	1-2
T. Meru: 1	1-2
T. Permisian: 1	1-2
Upper Kali Sanan: 1	3-4
Pondok Macan: 1	3-4

Administrative Sites:

For the purpose of administration, areas within the Reserva boundaries will be designated as administrative sites and will be posted as such. Construction and development will take place only within these areas. Size will depend upon the development needs, but should not exceed the following:

Cureh Nongko, $\frac{1}{2}$ ha
Nanggalan, 1 ha
Nanggelen, Barrier, (2), $\frac{1}{8}$ ha
Bandialit, Kebun Pantai, 1 ha
Bandialit East, $\frac{1}{2}$ ha
Kali Sanan, $\frac{1}{2}$ ha
Sukamade, Sumbar Sari, 1 ha
Sukamade East, 1 ha
Sukamade Beach, 1 ha
Malangsari, 1 ha
Pondok Macan, $\frac{1}{2}$ ha

The general location of these sites is shown in Fig. 9. Administrative sites should be located so as to fulfil their main administrative function, but should never be placed so as to disrupt the natural integrity of the area. For example, barriers and guard accommodation should be placed at the Reserva boundary or where the natural topography dictates; the field station at Sukamade should be located near the edge of the plantation, not on the beach itself. Cultivation of vegetables for food at administrative sites should only be allowed where a source is not readily available nearby, such as Pondok Macan.

The Rajegwesi area is to be designated as a recreation/administration site, which will include the entire area behind the beach up to about 50 m in elevation. In this area, as in all the Reserva, vehicle travel will only be allowed on designated roads. The beach at Rajegwesi will be closed to all motor vehicles and bicycles.

The design and selection of locations of facilities should be done by an Architect and Civil Engineer from the central office, working with the Manager and his staff. Supervision of construction can be carried out by the Reserve staff.

Trails and Roads:

Upkeep of trails and construction of the additional trails needed for patrol purposes and visitor use will be the responsibility of the Protection and Management staff. Two new trails will need to be constructed in the first years of the plan. Rajegwesi-Damai Bay (approx. 4 km) and Meru-Permisan Bay (approx. 5 km). The trail should be carefully constructed so that middle-aged and older tourists can make the trip. The trail that presently exists along part of this route is not adequate. The Rafflesia site at Damai Bay should be protected so that visitors cannot climb over the rock face where the lianas are growing. The other natura trails to be constructed include one from the post at Sumber Sari to the watch-tower overlooking the feeding ground, and one from the Nanggalan post to the Nanggalan watch-tower. These will be constructed in the second year of the plan; each will be about 2 km long.

Access roads into the Reserve are presently maintained by the plantations and will continue to be until production there ceases. In the fifth year of the plan, when control of these enclaves is ceded to P.P.A., provisions will have to be made for their upkeep; this will have to be included in a special supplementary budget.

Support for the upkeep of the headquarters complex at Rajegwesi will have to be provided on an annual basis.

Communications:

Telephone communication between all major posts is necessary for the efficient operation of the management plan and will require the installation of some new lines. This will be more practical than radio communication because of repair problems with radios and the steep topography, which will interfere with direct radio contact between the western and eastern edges of the Reserve.

Camp Grounds and Shelter Sites:

The new shelters to be constructed have been listed above and their general location is shown in Figure 9. Camp grounds are located near each shelter and also at Kali Gardung where it joins Kali Sanen. These sites should be no larger than $\frac{1}{2}$ ha and should be posted. No further development of these sites is envisaged during the period

of this plan. No other construction of any kind should be allowed. The shelters are primarily for patrol purposes, but they can be utilized by visitors with a permit on payment of the prescribed fee. Visitor use, however, should never take precedence over their primary patrol function.

Temporary Housing

Where facilities have not yet been provided, a current practice among the staff of Meru-Betiri is to take accommodation with other staff members, even if this means living many kilometers from their area of responsibility. This practice has been necessitated by lack of funds, but it clearly has detracted from the present management programme.

It is important that staff members live in, or very near, the areas where they must work. In the next few years, until all accommodation has been constructed, this will create some inconvenience. Where staff facilities have not yet been completed, an allowance for housing should be provided. A staff member should be required to live as close to his work area as possible.

Transport and Equipment

- Vehicles and Boats:

Five motorcycles, purchased by W.W.F., are currently assigned to personnel directly or indirectly involved with the management of the Reserve. A pick-up truck purchased for the Reserve by W.W.F., is reported to be in the hands of the Section Chief.

The Manager should have a four-wheel drive vehicle. All advanced level personnel will need good transport, and each should be provided with a motorcycle and safety helmet. Among the Protection Officers, those posted at Nanggelan, Sanenrejo and Glenmore should have motorcycles. All other Protection Officers, guards and other staff should be issued bicycles.

A 10 m boat, constructed of wood and equipped with an adequate inboard engine, will be required to patrol the coast.

- Firearms:

We do not believe that it is necessary to arm the Management and Protection staff, but all these men should have training in the use of firearms, and arms should be maintained at the Section Chief's Office, as is now reportedly being done. His inventory shows 32 rifles; no further purchases of firearms will be required.

- Supplies and Uniforms:

The Manager should be provided with an imprest account for the purchase of supplies, such as petrol, etc. and minor items of equipment. Major equipment should be identified by the Manager in consultation with the Section Chief. Emphasis will be placed on providing equipment to enable patrol activity under difficult field conditions. It is the responsibility of the Manager to see that his staff are adequately equipped for this task.

Provision of quality well-fitted uniforms of a standard design is important. All staff should be provided initially with two sets and, thereafter, be given a clothing allowance for maintenance.

Each post will have to be provided with beds, tables, chairs and other furnishings. The allowance for these will be in accordance with standard P.P.A. policy.

On Design

Roads, trails, signs, buildings - the facilities needed in the management programme - are not features unrelated to the natural setting of the Reserve. They can mar and detract if their design and location are too contrasting and visually unrelated to the characteristics of the landscape. Rather, such developments should borrow naturally established form, line, colour and texture so that their visual characteristics are compatible with the natural surroundings. With proper planning, facilities can subtly integrate into the landscape and attract little attention to themselves (Fig. 10; 106, 107).

Design considerations are important in other aspects of Reserve management. The staff should have distinctive uniforms, but ones that are compatible with the job and setting. We suggest a distinctive emblem for the Reserve, for vehicles, uniforms and signs. It should depict the character of the Reserve and the mission of the management programme. Uniforms and emblems help bind the staff together as a team and facilitate easy recognition.

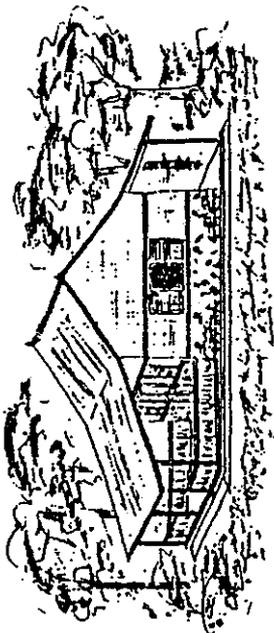
Signs should clearly impart necessary information, but do so in a way that is in keeping with good public relation principles and with the natural surroundings. The understanding, feeling, intent and determination of the staff are expressed by the design, wording, placement and upkeep of signs.

To date, not enough care has been exercised in the design and placement of facilities; many that have been built unfortunately mar and disrupt the natural setting. The notable exception is the shelter built of bamboo at Sukmade Beach. This is a critical stage in planning.

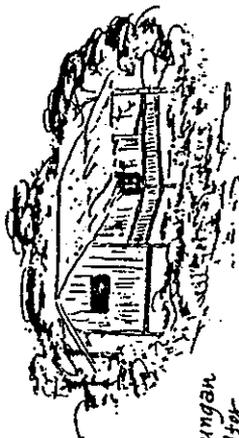
Figure 10 On Design:

The design, location and upkeep of buildings, roads, trails and signs present an image of the staff, their understanding and determination in their mission of preserving the natural integrity of the Reserve. If facilities disrupt the natural harmony of the area and are unrelated to the natural setting, that image will be projected to visitors and local residents. However, if accommodation subtly integrates with the surroundings and if structures and signs are carefully designed and maintained, an image of care, intent and determination by the staff will be projected for all to see.

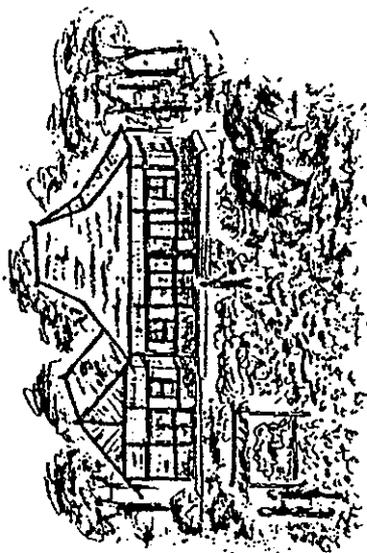
Javan architecture is rich in harmonious form and its traditionally used materials, such as stone, wood and bamboo, blend with the natural surroundings.



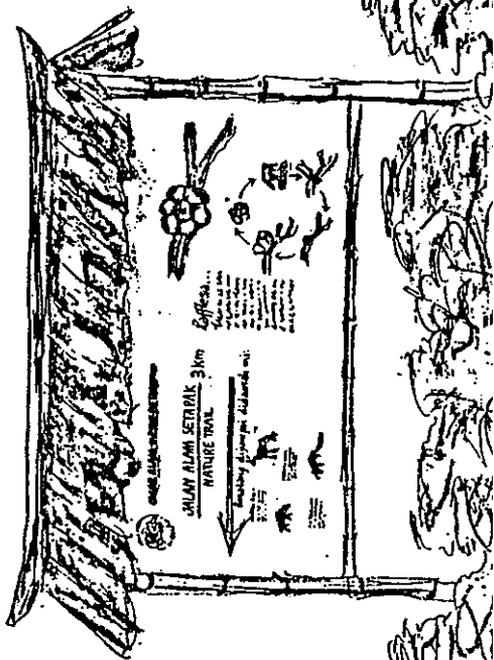
*Penjaga pos
A guard post*



*Perhutungan
A shelter*



*Bangunan hampir jadi
Headquarters*



Efficiency
The signpost is made of bamboo and wood. It is easy to carry and can be used in many ways. It is a good example of a simple and effective signpost.

SALAM ALAM SETRAN 3km

NATURE TRAIL

Headquarters

DILARANG

In the period of this plan, most of the facilities needed for years to come will be constructed. At this stage, it is relatively easy to prevent a detracton and deterioration of the vidual qualities of the landscape. Design is a job for specialists and a competent team should be employed by P.P.A. to ssaist in planning for buildings constructed in all reserves and parks, and to develop specifications for any constructions by concessionaires to be allowed.

REGULATIONS FOR NERU-BETIRI RESERVE

1. Authority and Short Title

These Regulations are issued under the Authority of the Article of the Protection and Conservation of Natural Resources Act, 197_, and may be cited as the Neru-Betiri Reserve Regulations, 197_.

2. Definitions

- a. Act means the Protection and Conservation of Natural Resources Act, 197_.
- b. Director means the Director of Nature Conservation.
- c. Reserve means the Neru-Betiri Reserve, as defined in Ministerial Decree No. __ of 197_.
- d. Manager means the senior officer of the Directorate of Nature Conservation in charge of the Reserve.

All other definitions shall be as defined in the preamble to the Act.

3. Designation of Special Sites

In accordance with the work/operations plan, the Director, in writing, will declare certain areas in the Reserve to be administrative sites, administrative/recreation sites (Rajegwesi area only) and wildlife habitat management sites (plantation enclaves and existing feeding grounds at Nanggalan, Pringtali and the West Fork of the Kali Sukamade only).

The remainder of the Reserve will be managed as a strict Nature Reserve and will be referred to as the Sanctuary Area.

The Director, in writing and in accordance with the work/operations plan, will declare certain roads as access roads and certain trails as nature trails and patrol trails. All other roads and trails in the Reserve will be closed.

4. Entry into Reserve

- a. No person shall enter the Reserve unless in possession of a valid entry permit authorizing him to do so.

- b. Entry permits may be issued either at the P.P.A. office, Banyuwangi or at the Reserve headquarters or designated check-points on payment of the fees prescribed in Schedule I and subject to the conditions specified in these Regulations.
- c. This shall not apply to any employees of the Reserve, to any government official on duty, to any person or group of persons granted free entry to the Reserve by the Director in writing, nor to any persons travelling the access road to the plantation enclosures.
- d. The Director or Manager may make exception to the entry permit requirement for specific designated areas during July and August of each year in accordance with the work/operations plan.
- e. The Director or Manager may grant free use of the Kali Sanen trail to local people who must use this route for travelling between markets and their homes.

5. Entry at Own Risk

Persons enter the Reserve at their own risk and the government shall bear no liability to pay compensation for injury, loss of life, damage or loss of property suffered within the Reserve.

6. Actions Prohibited within the Reserve

No person shall perform any of the following actions within the Reserve, except with the written permission of the Director, and when such action is considered necessary in the interest of management:

- a. Construct any building or other structure of any kind;
- h. Clear, occupy or cultivate any land;
- c. Introduce or allow any domestic animal to enter the Reserve, except in the case of an animal travelling along a recognized right-of-way through the Reserve;
- d. Land any aircraft, including a helicopter, in the Reserve or fly any aircraft over it at an altitude lower than 1000 m;
- e. Bring any vessel of more than 20 m in length within the seaward boundaries of the Reserve (i.e. within 500 m of low water mark).

- f. Construct any road or trail;
 - g. Cut, burn or otherwise damage or remove any tree, plant or other vegetation, whether dead or alive;
 - h. Remove any rock, sand, soil or other mineral substance or damage or remove any coral shell or other marine growth;
 - i. Engage in any scientific research work or mineral exploration.
7. No person shall perform any of the following actions within the Reserve boundaries without the permission of the Manager or the Director.
- a. Bring any boat within the seaward boundaries of the Reserve;
 - b. Enter the Sanctuary Area of the Reserve unless accompanied by a Guard/Guide;
 - c. Camp at any place other than an authorized camping ground;
 - d. Make a fire at any place other than an authorized camping ground;
 - e. Introduce or use any radio, tape-recorder, musical instrument, or voice amplifier;
 - f. Introduce or use scuba-diving equipment;
 - g. Enter or move within the Reserve between the hours of 6.00 p.m. and 6.00 a.m., except for movement on authorized camping grounds or within developed areas.

8. Prohibited Articles

No person other than an employee of the Reserve acting in the course of his duty shall possess or carry any of the following articles within the Reserve without the written permission of the Director: -

- a. Weapons or ammunition, including spear-guns;
- b. Explosives or explosive devices;
- c. Traps, nets or poison;
- d. Trophy or dry or fresh meat of any animal.

9. Hunting and Disturbance Prohibited

No person shall hunt, kill, capture or disturb any animal or disturb the nest or disrupt the nesting activity of any bird or reptile, except under the provisions of a scientific collecting permit issued by the Director for the purpose of genuine scientific research.

10. Fishing Prohibited

Fishing or setting of nets or fish traps within the Reserve is prohibited.

11. Commercial Photography

No person may make any film for commercial purposes or take any photographs intended for commercial use unless in possession of a photographic permit issued by the Director.

12. Advertisements Prohibited

No person shall display any posters, placards or advertising material of any kind.

13. Rubbish Disposal

No person shall dispose of any litter or rubbish other than in a receptacle provided for the purpose or by burying it.

14. Defacing of Buildings and Other Surfaces

No person shall damage or deface either with paint, carving or by other means any building, historical monument, boundary marker, tree, rock or other surface whatsoever.

15. Closure of Reserve

The Director may authorize the closure of the Reserve or of any part thereof where he considers it necessary in the interest of Management.

16. Refusal of Admission and Eviction

- a. The Manager may refuse permission for any person or persons to enter the Reserve where he considers that their entry may result in a disturbance or infringement of these Regulations;

- b. Where any person or persons are causing a disturbance or otherwise misbehaving, he may require them to leave the Reserve or, should they refuse to do so, have them forcibly evicted.

17. Powers or Arrest and Seizure

- a. An authorized Officer may arrest any person whom he suspects of having committed an offence against the Protection and Conservation of Natural Resources Act of these Regulations, and where he has reason to believe that if he is not arrested, he will abscond.

Any person so arrested shall be handed over to the Police without delay and charged with the offence or cautioned and released;

- b. An authorized Officer may seize any domestic animal found in the Reserve or any article or substance, the possession or use of which is prohibited under these Regulations; it shall be handed over to the Police without delay and a charge brought against the person or persons concerned.

18. Penalties

Any person convicted of an offence under these Regulations shall be liable to a fine of up to Rp. _____ or three years imprisonment, or both, in accordance with the provisions of the Act.

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23. Some geological terms:

Andesite is originally molten material which pours out through fissures and volcanoes. It contains little or no quartz and has a great proportion of ferro-magnesium minerals that give the rock a dark colour. It is an extrusive igneous rock.

Batholiths occur where a molten mass of igneous rock has solidified in spaces made by pushing the surrounding rocks apart or by melting or dissolving them. This is intrusive igneous rock.

Conglomerates are sedimentary rocks composed of rounded pebbles cemented in a matrix of fine material. Conglomerates in which the fragments are sharp and angular are called breccias.

Dikes are sheet-like intrusions rising from a batholith.

Hornblende is dark green to black and glassy, found in basic igneous rocks. It contains aluminum.

Granite is an igneous rock; it is usually light-colored and formed mainly of potash, feldspar and quartz, usually with mica or hornblende.

Igneous rocks solidify from a molten state. The highly-heated fluid rock or magma originates at considerable depth beneath the earth's surface.

Limestones consist mainly of the mineral calcite. Most are of marine origin; both plant and animal life contribute the minerals that form them, but some are chemical precipitates and others are cemented fragments of lime.

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