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A FAUNAL SURVEY OF SABAH

Prepared by
World Wildlife Fund Malaysia
For
Game Branch, Forest Dept. Sabah

IUCN/WWF Project No. 1692

Although this plan was prepared with the assistance of IUCN/WWF, the views that are expressed in it do not necessarily reflect the policies of IUCN/WWF

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FAUNAL SURVEY OF SABAH

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PREFACE

The Faunal Survey of Sabah commenced in July 1979 and lasted for two-and-a-half-years. The Survey was co-ordinated as a World Wildlife Fund Project (No. 1692), carried out by the Wildlife Section of the Sabah Forest Department and the Sabah National Parks with technical assistance from the authors of this report. The project was made possible from the outset by a donation from Tractors Malaysia Berhad whose responsible, generous and exemplary action is gratefully acknowledged.

It is hoped that the information and suggestions presented in this report will serve both as a record of the status of some mammal and bird populations in Sabah at the time of writing and give an initial framework on which to base future research and conservation efforts. It is not a complete study of all aspects of wildlife conservation, but the first step towards the development of systematic and effective wildlife conservation policies. There is a need to collect many more details on different forms of wildlife, some of which have received scant attention in this Survey, before a comprehensive, long-term wildlife conservation policy can be drawn up.

Of crucial importance is the need to demonstrate to all levels of State government that the next decade is a critical period for wildlife conservation. If government policies combine wildlife and ecosystem conservation with land development, Sabah will enjoy socio-economic advancement without losing any components of its natural heritage, thereby achieving development of the highest quality often unattained in many so-called developed nations. If no new areas are set aside for conservation of nature, it will not be possible to ensure against the extinction of species. The Sumatran rhinoceros is already in a precarious position and other species could follow suit. Such

extinction can be avoided if the problems are appreciated at an early stage and simple measures taken to avoid irreplaceable losses.

The recommendations made represent the opinions of the authors and do not necessarily represent those of World Wildlife Fund. Although every effort has been made to ensure complete accuracy any errors are wholly the responsibility of the authors.

Glyn Davies
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The assistance and hospitality of many people throughout Sabah has not been forgotten, but not all can be listed here. Of those individuals who made our work more enjoyable and productive, we would like particularly to mention Austen Buggatt, Kenneth Chung, Moray Graham, the Jayasuriya family, Norman Jones, Tony Lamb, Jimmy and Joyce Leow, Lady Y.P. McNeice, the Phillipps family, Pirian Mat Saleh, Anwar and Farida Sullivan, Ronnie Young and the people of the Tongud district, Ulu Kinabatangan.

The project was supported by World Wildlife Fund Malaysia, largely through a donation from Tractors Malaysia Berhad. The Earl of Cranbrook made useful suggestions for initiating the Survey. The constant support of WWF Malaysia staff Mr Ken Scriven (Director, and Cindy Cheah (Executive Secretary) is greatly appreciated. The report was ably typed by Josephine Phang. The numbered maps were drawn by Hasnah bte. Megat Ahmad.

GLOSSARY

arboreal	living in the trees
a.s.l.	altitude above sea level
biomass	the total weight of living material in a particular area; a measure of the abundance of a particular type of animal or plant which takes account of both number of individuals and their weight
carnivorous	feeding entirely or to a large extent on animals
conservation	the management of the natural world so that it may yield the greatest sustainable benefit to the present generation, while maintaining its potential to meet the needs and aspirations of future generations
diurnal	active in the day-time
ecosystem	all the living and non-living natural resources within a defined area and the relationships between them
exploited habitat	habitat from which all or a substantial amount of the original plant material has been removed and in the case of plantations, continues to be removed
fauna	all the wild animals of a particular region

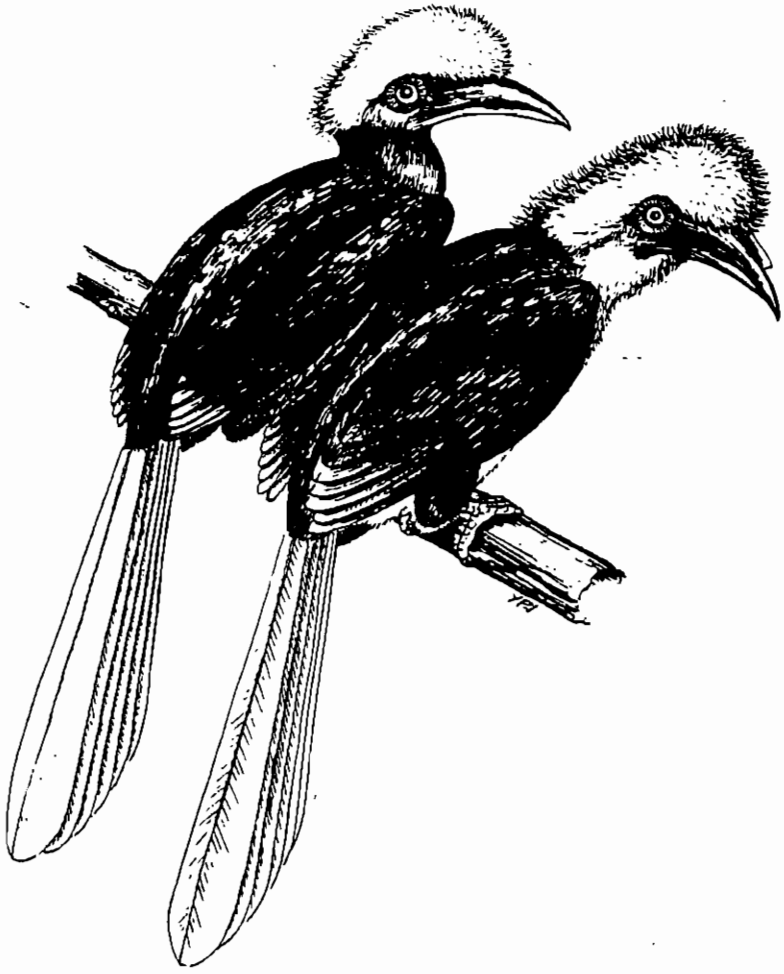
FD(WS)	the Wildlife Section (or Game Branch) of the Sabah Forest Department
feral	originally domesticated animals which have gone wild
flora	all the wild plants of a particular region
folivorous	feeding mainly on leaves
frugivorous	feeding mainly on fruits
habitat	the type of place in which animals live as defined by the types of plants present and their relative abundance
herbivore	animals which feed only or mainly on plant material
home range	the area occupied by an individual or group of animals
invertebrate	all animals other than mammals, birds, reptiles, amphibians or fish
liana	a woody climbing plant supported by trees
p.a.	per annum = in each year
population density	the number of individuals of a particular species per unit area
primary	habitat which has not been exploited by man

pristine	a term used in this report specifically to distinguish habitats which have not been logged or cultivated
SAFODA	Sabah Forest Development Authority
secondary	forest growing after it has been exploited
SNP	Sabah National Parks
syntopic	occurring in the same place
terrestrial	living on the ground
Ulu	the upper reaches of a river (for example, Ulu Segama)
wildlife	all kinds of living things, including fauna and flora
World Wildlife Fund (WWF)	an international fund-raising organisation concerned with wildlife conservation

MEASUREMENTS CONVERSIONS

1 hectare	= 1 ha. = 2.47 acres
10 millimetres	= 10 mm. = 0.39 inch
1 metre	= 1 m. = 1.094 yards
1 foot	= 0.305 metre
1 square kilometre	= 1 sq. km. = 100 ha. = 0.386 sq. mile

1. GENERAL BACKGROUND



White-crested Hornbill

1,1 INTRODUCTION

Sabah, occupying 76,115 square kilometres of the northern part of the island of Borneo, is the second largest of the thirteen States in the federation of Malaysia (Map 1). Geologically, most of Sabah consists of relatively young sedimentary formations. The terrain is hilly throughout the interior and western regions and Mt. Kinabalu (13,455 feet a.s.l.), which dominates the western region, is the highest peak in Southeast Asia. Extensive flat lowlands are found in the eastern part of the State, fringed by mangroves along the coast (Maps 2 and 3).

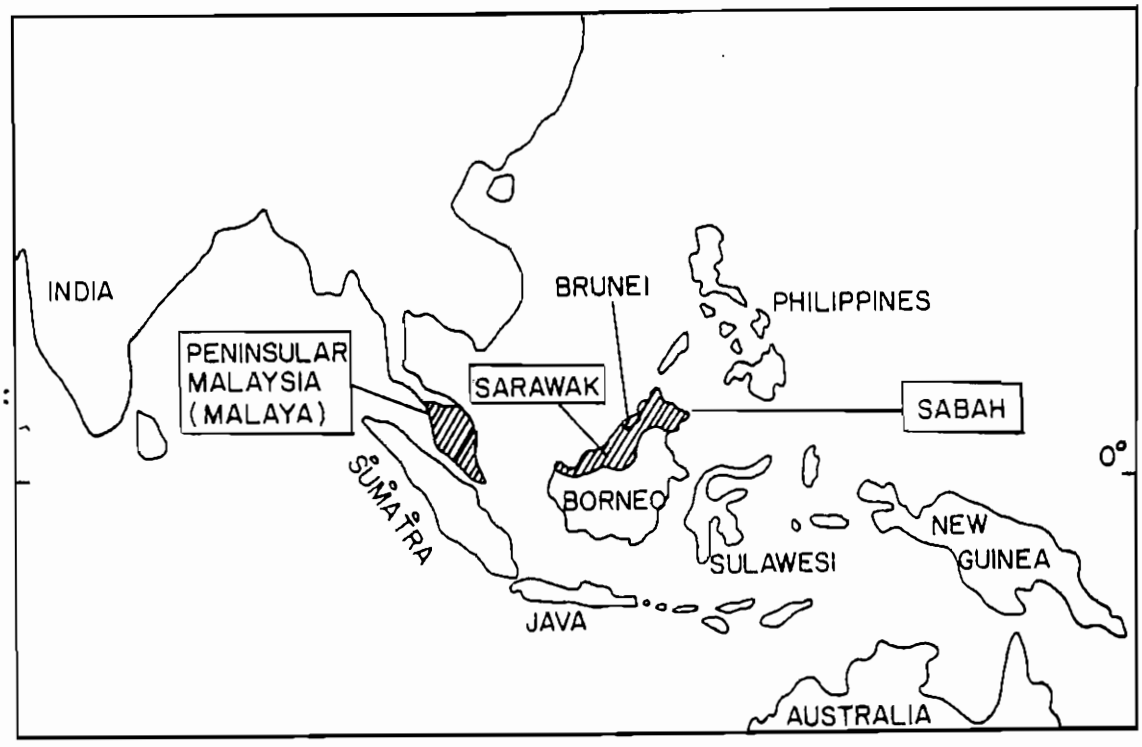
Sabah's climate is tropical. The atmosphere is always damp and relative humidity often exceeds 80%. The maximum daytime temperatures in the lowlands average 30°C (90°F), with little annual variation. The heavy rainfall (about 3,000 mm. p.a.) is distributed throughout the year, with heavier rains during the unpredictable monsoon seasons. This climate gives rise to a luxuriant vegetation comprising thousands of species of flowering plants, including trees, shrubs, lianas, orchids, herbs, etc. These in turn support a diverse fauna.

Sabah is dependent on timber for its major source of income. The sale of native hardwoods (valued at M$1.2 billion, 1979) has accounted for up to 80% of the State's revenue. Timber and wood products will continue to be a major source of the State's income although oil and copper are becoming increasingly important. Timber extraction is the cause of the most extensive change in habitat, with only 27% of Sabah remaining as primary, "high" forest in 1980, compared with 61% in 1971 (1).

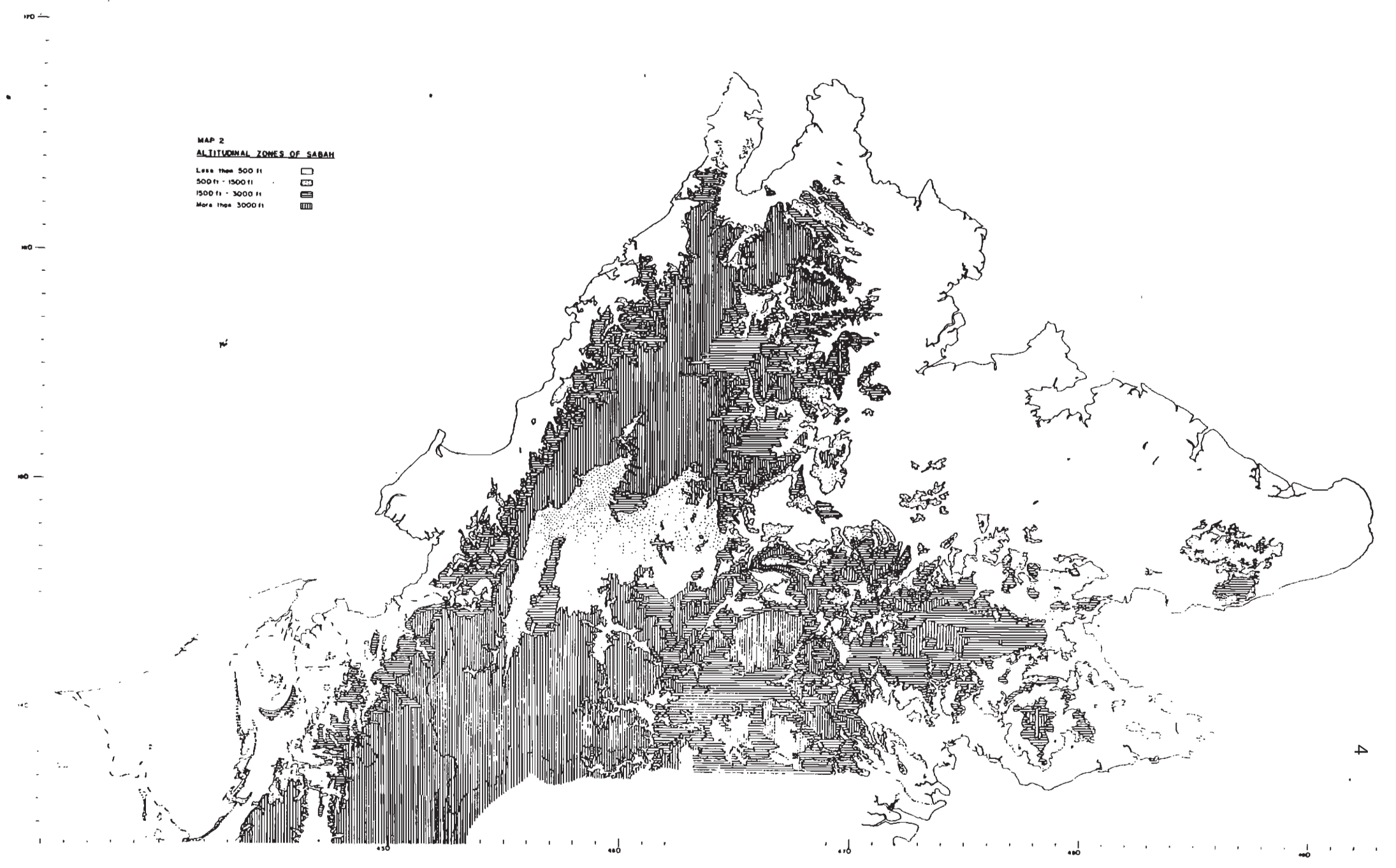
More drastic, although less extensive changes in habitat have been brought about by agricultural development, which is being encouraged on all lands with suitable soils (about 30% of the State). The first large-scale agriculture (pre-1940) consisted mainly of rubber and tobacco estates. This changed in 1960's, when oil palm was planted on a large scale and now cocoa is being planted on most large land development schemes. The speed

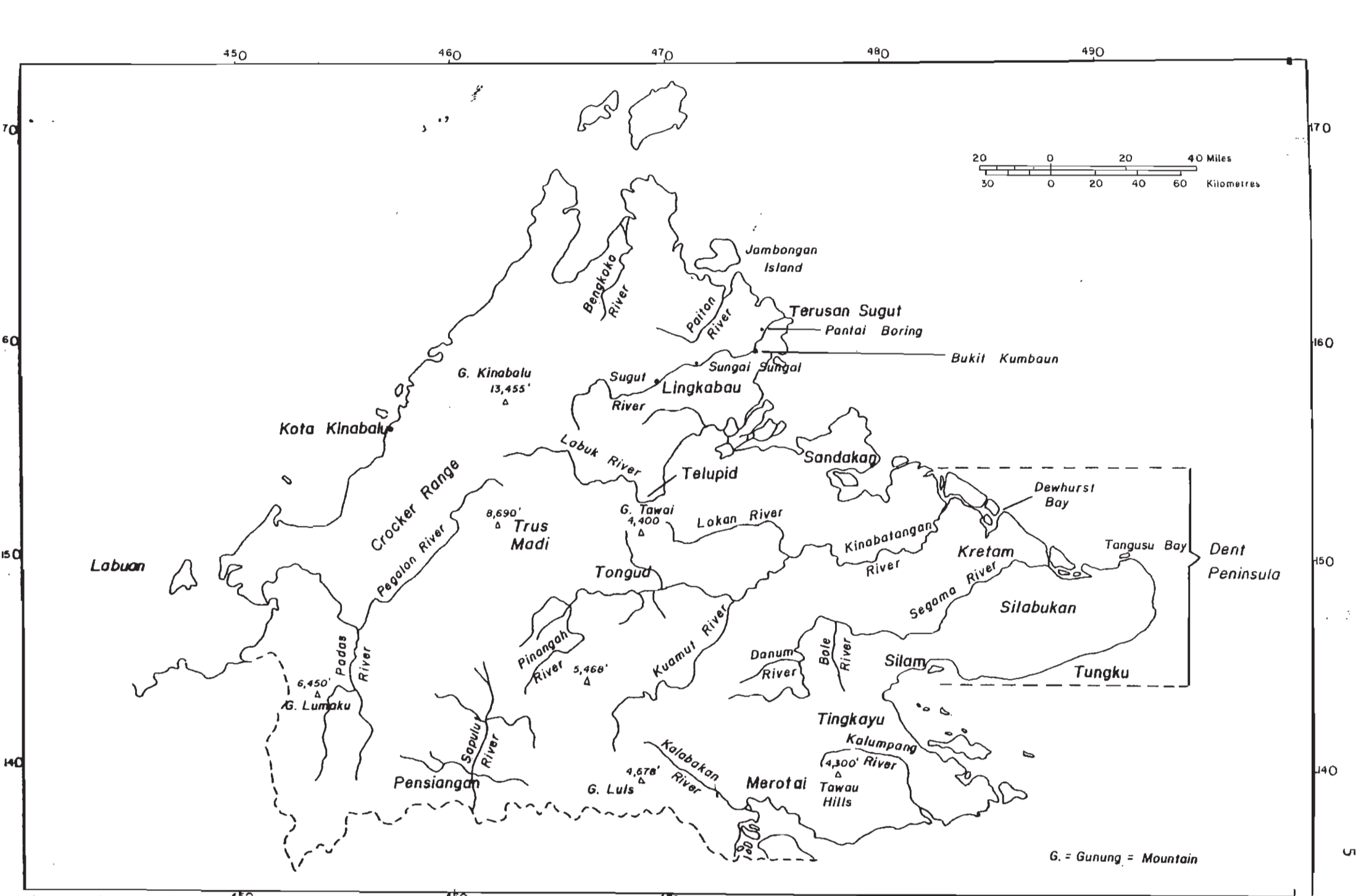
of agricultural development is extremely rapid, as exemplified by the Sandakan Division having a predicted 10.7% of its area cultivated by 1985, compared with 2.5% in 1976 (2,3). This agricultural development is concentrated in the eastern lowlands where wildlife is most abundant and diverse.

Indigenous rural communities still cultivate traditional crops, gather minor forest products and fish or hunt to obtain a substantial proportion of their requirements. In the northern, western and central parts of the State shifting agriculture has been practised over many generations, in some areas with little regard for soil suitability and topography. In the past, hunting activities have also been concentrated in these areas, but more recently the overall extent of hunting has increased throughout the State, especially in the eastern lowlands.



MAP I. MALAYSIA (shaded) IN RELATION TO ASIA AND AUSTRALIA.


MAP 2
ALTITUDINAL ZONES OF SABAH
Less than 500 ft
500 ft - 1500 ft
1500 ft - 3000 ft
More than 3000 ft



MAP 3. MOUNTAINS, RIVERS AND PLACE NAMES IN THE TEXT

1.2 FAUNAL BACKGROUND

Because Sabah is a land of dense tropical forests, it does not have the good conditions for viewing wildlife which prevail in other tropical countries which have drier, more seasonal climates. Most people, therefore, have not seen many tropical forest animals and do not realise that Sabah's forests have one of the greatest diversities of animal and plant species in the world.

There are at least 167 species of mammals in Sabah, excluding the marine mammals which were not surveyed during the Faunal Survey (Tables 1 and 2). Inconclusive evidence of two more species, previously known from Sarawak - a pigmy flying squirrel and a mongoose - was obtained during the Faunal Survey of Sabah. A total of 207 land mammal species have been recorded in Borneo (4). Of Sabah's mammals, 3 have been found only on Mt. Kinabalu and a further 30 are known only on the island of Borneo. There are a number of superlatives included within this impressive list. Sabah has Asia's largest ape, the orang-utan, and largest land mammal, the elephant, as well as one of the world's most endangered mammals, the Sumatran rhinoceros. Other exceptional species include the world's largest ground squirrel and smallest tree squirrel, the world's largest bat and the largest member of the order Insectivora.

The bird fauna is similarly diverse (Table 3), with 363 species being recorded as resident breeding birds in Sabah with a total of 388 species in Borneo (5). At least another 86 species migrate to Sabah from the northern hemisphere for the winter period and a further 68 species are recorded around Sabah's coasts, including seabirds, birds of the smaller islands and strays from other parts of the Asian mainland.

There are several factors which have contributed to this diversity. Firstly, Sabah is part of Borneo, which is one of the largest islands in the world and, as a general rule, the larger an area, the more species it contains. Secondly, changes in sea-level during the ice ages caused Borneo to be connected and disconnected several times from the Asian mainland which allowed new species to

TABLE 1

FAMILIES, GENERA AND SPECIES OF LAND MAMMALS IN SABAH

FAMILY	NO: OF GENERA	NO: OF SPECIES
Erinaceidae (Moonrats)	2	2
Soricidae (Shrews)	3	5
Tupaiidae (Treeshrews)	3	8
Cynocephalidae (Flying Lemur)	1	1
Pteropodidae (Fruit Bats)	9	12
Emballonuridae (Sheath-tailed Bats)	2	5
Megadermatidae (False Vampire)	1	1
Nycteridae (Hollow-faced Bat)	1	1
Rhinolophidae (Horseshoe Bats)	2	11
Vespertilionidae (Vespertilionid Bats)	10	22
Molossidae (Molossid Bats)	1	1
Lorisidae (Slow Loris)	1	1
Tarsiidae (Tarsier)	1	1
Cercopithecidae (Monkeys)	3	6
Pongidae (Apes)	2	2
Manidae (Pangolin)	1	1
Sciuridae (Squirrels)	15	27
Muridae (Rats and Mice)	5	24
Hystricidae (Porcupines)	3	3
Ursidae (Bear)	1	1
Mustelidae (Martens, Badgers, Otters etc.)	6	7
Viverridae (Civets and Mongooses)	9	12
Felidae (Cats)	2	5
Elephantidae (Elephant)	1	1
Rhinocerotidae (Rhinoceros)	1	1
Suidae (Bearded Pig)	1	1
Tragulidae (Mousedeer)	1	2
Cervidae (Deer)	2	2
Bovidae (Cattle)	1	1

TABLE 2

THE NUMBER OF MAMMAL SPECIES IN SABAH AND BORNEO

		NO: OF SPECIES	
MAMMALS IN SABAH	Species found mainly or only in the LOWLANDS AND HILLS (excluding bats)	89	167
	Species found mainly or only in the MOUNTAINS (excluding bats)	19	
	BATS	52	
	Species which live ASSOCIATED WITH MAN (including 5 rats)	7	
KALIMANTAN AND SARAWAK BUT NOT SABAH	Not bats	11	30
	Bats	19	

TABLE 3

THE FAMILIES OF BIRDS WITH SPECIES KNOWN TO OCCUR IN SABAH

(order follows Smythies, 1981 (5))

Podicipedidae	(Grebes)
Procellariidae	(Petrels)
Sulidae	(Boobies)
Fregatidae	(Frigate Birds)
Phalacrocoracidae	(Cormorants)
Anhingidae	(Darters)
Ardeidae	(Herons, Egrets, Bitterns)
Ciconiidae	(Storks)
Plataleidae	(Ibises, Spoonbills)
Anatidae	(Ducks)
Accipitridae	(Hawks, Eagles)
Pandionidae	(Osprey)
Falconidae	(Falcons)
Megapodiidae	(Megapodes)
Phasianidae	(Quail, Partridges, Pheasants)
Rallidae	(Crakes, Rails)
Rostratulidae	(Painted Snipes)
Charadriidae	(Plovers)
Scolopacidae	(Sandpipers, etc.)
Recurvirostridae	(Stilts)
Phalaropodidae	(Phalaropes)
Burhinidae	(Stone Plovers)
Glareolidae	(Pratincoles)
Stercorariidae	(Skuas)
Laridae	(Gulls, Terns)
Columbidae	(Pigeons, Doves)

Psittacidae	(Parakeets, Parrots)
Cuculidae	(Cuckoos, Malcohas, Coucals)
Tytonidae	(Bay Owls)
Strigidae	(Owls)
Podargidae	(Frogmouths)
Caprimulgidae	(nightjars)
Apodidae	(Swifts)
Trogonidae	(Trogons)
Alcedinidae	(Kingfishers)
Meropidae	(Bee-eaters)
Coraciidae	(Rollers)
Upupidae	(Hoopoe)
Bucerotidae	(Hornbills)
Indicatoridae	(Honeyguide)
Capitonidae	(Barbets)
Picidae	(Woodpeckers)
Eurylaimidae	(Broadbills)
Pittidae	(Pittas)
Alaudidae	(Larks)
Hirundinidae	(Martins, Swallows)
Motacillidae	(Wagtails, Pipits)
Campephagidae	(Greybirds, Trillers, Minivets)
Laniidae	(Shrikes)
Artamidae	(Swallow-shrikes)
Aegithinidae	(Ioras, Leafbirds)
Pycnonotidae	(Bulbuls)
Turdidae	(Shamas, Forktails, Thrushes etc.)
Timaliidae	(Babblers)
Sylviidae	(Warblers, Tailorbirds)
Muscicapidae	(Flycatchers)

Pachycephalidae	(Whistlers)
Paridae	(Tits)
Sittidae	(Nuthatch)
Dicaeidae	(Flowerpeckers)
Nectariniidae	(Sunbirds, Spiderhunters)
Zosteropidae	(White-eyes, Blackeye)
Sturnidae	(Starlings)
Prionopidae	(Wood-shrike or Bristlehead)
Passeridae	(Sparrows)
Estrildidae	(Munias)
Dicruridae	(Drongos)
Oriolidae	(Orioles)
Corvidae	(Jays, Magpies, Crows)

Plate 1. Moonrat (Echinosorex gymnurus), the largest member of the order Insectivora.

Plate 2. Primary upland dipterocarp forest in central Sabah.

colonise the island and mix with species which were already present. This periodic addition of species greatly increased the diversity in Borneo's forests.

Thirdly, the complexity of tropical forest, both in terms of plant species and structure, permits many animal species with different specialisations to co-exist in the same area. Forest resources available to animals are divided up in various ways. For example, the pangolin specialises on termites and ants as food; the pigmy squirrels specialise on feeding from trunks of trees and lianas, not in the tree crowns. Some species are active in the day, others at night, and some both day and night. Fourthly, there is a range of different types of forests in Sabah. Notably, vegetation changes with increasing altitude and there is a corresponding change in animal species composition.

1.3 WHY CONSERVATION

Development, through modification and utilisation of the natural environment, is undertaken to satisfy human needs and improve the quality of life. Conservation is the management of the human use of nature so as to yield the greatest sustained benefit to present generations while maintaining its potential to meet the needs of the future. Conservation, therefore, is not anti-development, nor anti-people.

Conservation is an old concept in Sabah and was recorded in local communities over 100 years ago. The Tambunan Kadazans established "Tegah", or reserves along stretches of river where there were good fish. No one was allowed to disturb these stretches of river for certain periods thereby allowing the fish to increase (6). In such ways, indigenous communities maintained a balance with their environment and ensured a sustained yield of food from the area. With technological development, the responsibility for management of natural resources passed from the local community to State government departments.

The rapid exploitation of natural resources permitted by the latest machinery has to be controlled through co-operative planning of different departments of government.

Malaysia has already demonstrated its intention to incorporate environmental conservation within its development policies. This is shown by the view expressed by the Assistant Secretary of the General Planning Unit of the Prime Minister's Department — "the objectives of economic development and environmental protection are the same - both bring about a better quality of life for all" — (7). Sabah's own government policies reflect a similar concern for conservation.

The Forest Department is responsible to ensure — "the sound climatic and physical conditions of the State, the safe-guarding of water supplies, soil fertility and environmental quality and the minimisation of damage by floods and erosion to rivers and agricultural land" — (8). Furthermore, the Forest Department is to ensure — "the conservation of adequate forest estate for recreation, education, research and the protection of the State's unique flora and fauna" —. The policy of the Sabah National Parks is to — "preserve for all time, areas which contain significant geographical, geological, biological or historical features as a natural heritage for the benefit, education and enjoyment of the people of Sabah" — (9).

These policies continue with the increased agricultural development of the State, as exemplified by the resolutions of the World Food Day Seminar in Kota Kinabalu — "agricultural development should be supported by soil conservation measures, protection of water resources and maintenance of a balanced ecological system so as to preserve our natural heritage" — (10). This resolution highlights another important concept; living systems can be renewed if conserved, but are lost forever if not.

Because living systems are made up of physical and biological components that are inextricably linked, conservation of living systems must be viewed as an overall strategy combining all facets of environmental management. For instance, plants depend on soil to anchor their roots

and on water for photosynthesis, yet plants contribute to soil production through the decomposition of their leaves and can affect rainfall. Soil, water and forest conservation cannot, therefore, be treated as separate issues. Similarly, animal and plant conservation are interdependent, because plants provide food and shelter for animals, while animals pollinate flowers and disperse seeds. It is appropriate, therefore, to consider the conservation of all natural resources in Sabah as a background to wildlife conservation (11).

1.3.1. Maintenance of Life Support Systems

The primary natural resources which must be conserved in Sabah are fresh water, soils, forests and coastal wetlands. Between them, these resources are the backbone of Sabah's wealth for the present and the future. Since timber is being extracted at a fast rate within the State, it is important to consider the deleterious effects of timber extraction on soil and water resources. This becomes especially important as the extent of logged forest increases and steeper land is worked.

Some of the important consequences are as follows:-

(1) Adverse changes in weather

High rainfall and high temperature are important attributes of Sabah's climate which give ideal conditions for the rapid growth of natural forests or agricultural crops. The deforestation of large areas of the State and subsequent agricultural development may lead to changes in this climate. The extraction of trees and exposure of bare soil during logging operations leads to an increase in the amount of heat reflected from an area, a reduction in the amount of warm air produced and a consequent decrease in convectional rain. Additionally, less moisture rises into the air so cloud formation is less frequent. If an area is subsequently planted with agricultural crops rainfall has been shown to decrease because the uniform nature of the crop does not give rise to air turbulence which is conducive to precipitation.

(2) Adverse changes in waterflow rates

The forest acts as a "sponge" which can absorb water during rainy times and store it so that it continues to supply water to rivers during periods of little rainfall. If an area is logged, however, raindrops fall directly on to the ground. Because of this direct impact, water tends to run along the surface and not to infiltrate into the soil. The run-off is further increased on steeper ground, especially if the soil is saturated with water from previous storms.

In Sabah, where rainfall tends to be concentrated within periods of several days or even weeks, massive surface run-off and consequent changes in river flow rates are very hazardous. During the rainy periods there have often been floods, but the magnitude and frequency of floods appears to have increased recently. The reverse problem of droughts during dry periods has already been experienced by Sandakan and Lahad Datu. The problem will increase as forested land is converted to agriculture. To minimise the costly annual loss of property and even life due to floods and to ensure water supply in dry periods, research is needed to assess how much of any catchment area can be logged. This information is urgently needed for the largest rivers of Sabah, such as the Padas, Segama and Kinabatangan, and for the steeper watersheds of the West Coast and Interior Districts.

(3) River sedimentation and soil loss

Soil erosion is a natural process, high during rainy periods, but on average occurring at the same rate as soil production in forested areas. Once forest cover is removed, soil particles are dislodged by raindrops and carried away in surface run-off. The streams of surface water further erode the soil by digging gullies, which may lead to land-slips where more massive erosion occurs.

Apart from the obvious difference in colour between rivers in logged and unlogged areas, there is ample quantitative data to show these effects. The deliterious effects of river sedimentation include reduction in qua-

lity of drinking water and loss of some fish species which many river people depend on. At places where flow rates are low and sediment settles, sand banks form, increasing the severity of floods during wet weather because the river cannot hold as much water. Sediment is also a major factor reducing the life of dams when the reservoirs silt up.

The loss of soil from future agricultural areas leads to major economic losses to the State. Through lack of soil conservation measures, Malaysia has lost "millions of dollars yearly" (12). An additional factor that impoverishes the soil is compaction by heavy machinery used during timber extraction, which stunts the growth of plants that subsequently grow in the area.

(4) Loss of coastal wetlands

The estuaries and coastal wetlands of Sabah, especially mangrove, are often considered inhospitable environments fit only to cut down for wood piling and wood chips. This, however, overlooks the fact that mangroves constitute a major resource by maintaining fish and prawn populations. The reason for this is that mangroves are fertile areas, rich in organic matter and they supply many nutrients for marine life. All young prawns live in the mangroves where they feed on decaying vegetation. Many fish, including mullet and snappers, depend on mangroves to support them during part of their life-cycles.

Studies in Indonesia have shown how prawn fishing industries have collapsed when local mangroves were destroyed. Yet prawns are the most valuable seafood in the world, with global export earnings exceeding US$1,000 million p.a. They contribute to Sabah's economy both through export earnings and by constituting a major source of protein for Sabah's people (13). Seafood resources must be conserved by regulating the extraction of mangrove wood and ensuring that areas are allowed to regenerate after cutting. This particularly applies in the mangroves of the Klias Peninsula, which are the only extensive mangroves in the west coast of Sabah and support important fishing industries in Brunei Bay.

1.3.2. Preservation of genetic diversity

Sabah has one of the highest diversities of animals, plants and micro-organisms in the world. Such a large number of different species constitutes a valuable gene-pool which may be defined as an array of species and individuals each of which has developed different characteristics for their survival. Some of these characteristics can be harnessed by man and managed for his own benefit. The biological components of Sabah's forests are an investment, therefore, for future breeding programmes and an insurance against the changing needs of the future. To ensure that these resources and their potential for the future are not lost, a representative sample of Sabah's different forest types needs to be set aside.

(1) Multiple use of biological resources

Because the rainforest is so diverse it houses a myriad of resources that can be exploited in different ways, but this has been overlooked in recent times because of the incentive to extract only timber, which is Sabah's main source of revenue. The importance of forests in maintaining essential life supports systems has already been discussed, but the biological resources should also be appreciated to ensure maximum benefits are derived.

The medicinal value of many rainforest plants has long been realised by Sabah's indigenous people, but only recently has western medicine begun to see the value of this resource; the National Cancer Institute (USA) spends US$1.5 million per annum on screening rainforest plants for chemicals that may be incorporated into new drugs. Although Sabah has yet to develop its pharmaceutical industry, it has the local peoples' knowledge of medicinal plants and need only keep some forested areas to be able to identify and isolate potential drugs from those plants in the future.

There are reports from local people of the medicinal properties of some animal species. These appear to be largely based on cures through faith healing, but

hirunidine, isolated from leeches, is important in open-heart surgery and there may be other medicinal compounds that can be isolated from forest animals. An attribute of rainforest animals which is more often directly beneficial to man at the present time is their ability to keep down populations of agricultural pests. Species of insectivorous birds are important in tree plantations where they feed on the insect larvae that do considerable damage through defoliation of Albizzia spp. trees. The effectiveness of this type of biological control depends on there being a number of forested areas near or inside plantations, from which the beneficial bird or predatory insect species can enter and control the past.

Another use of the forests is as a recreation resource. Inevitably, with such attractive local fauna and flora people enjoy taking their leisure time in the forests. Kinabalu National Park had 13,000 visitors in 1979 and Sepilok Orang-utan Centre had 15,000 visitors in the same year. A majority of these visitors are Sabahans, so an important social need is being fulfilled. The full economic potential of this resource, in encouraging international tourism, has yet to be realised.

(2) Domestication and Breeding of Indigenous Species

There are already plans to research into some plant and animal species in order to develop them as domesticated crops or livestock. To be able to domesticate a wild species it is necessary to select the desired characters from as many different individuals as possible, to ensure that a healthy and profitable breeding stock is established.

Over 40 species of forest trees in Sabah produce fruits which are edible to man. To develop a local fruit-growing industry the most palatable fruit from individuals of each tree species must be collected, grown and bred and the first steps in this process are being carried out by the Sabah Agriculture Department. Apart from the need for seeds of timber trees for replanting in logged areas, the Sabah Forest Department and SAFODA are both hoping to domesticate some indigenous trees as tree plantation spe-

cies and to cultivate rattan. These programmes are of great importance for Sabah's future economic development, but they rely on a supply of healthy and suitable plants from the wild, which can only be achieved if a diverse array of individuals is preserved. The proposals to develop an orchid industry depends to an even greater extent on the collection and propogation of plants from the wild, without which new marketable hybrids cannot be developed. There are two mammal species which are being considered for domestication in Sabah: the payau (Cervus unicolor) and the tembadau (Bos javanicus). Being adapted to local climatic conditions they should put on weight and breed readily; they are probably less susceptible to local diseases. (The Sabah Veterinary Department is currently involved in trapping payau to put into fenced areas where they may be domesticated, bred and cropped to supply local meat demands at reasonable prices. Bali cattle, a close relative of the tembadau, have long been a domestic animal and it is probable that tembadau will put on weight faster in poor pastures than domestic cattle if they are managed for meat production).

Once a species has been domesticated it is essential to maintain the vigour of the stock and improve yields, develop greater resistance to diseases etc. This can only be done by identifying individuals which have the desired characteristics and select them for breeding. It is possible, especially in the early stages of domestication, that the domestic stock lacks the required features and individuals from the wild, which possess the feature, must be introduced to the domestic stock.

It is important, therefore, to retain sufficient primary forest as the source of breeding individuals for the initial phases of crop and livestock domestication. It is also essential that these pristine areas are continually maintained to ensure that there is always wild stock of many different species and individuals which can be used to improve domestic stocks.

(3) Extinction of species

In addition to the apparent need for the protection of a representative sample of different areas to guard against the loss of future resources for breeding programmes and multiple use of biological resources, protected areas would serve to guard against species' extinctions. Although there has always been a loss of species from the world's ecosystems the origin of new species generally occurred at a similar rate. This steady turnover of species has been greatly influenced by human activities. It is clear that many species have become extinct as a result of human disturbances but few new species have evolved. This applies particularly to the mammals. It is no longer appropriate to consider these extinctions as part of a natural process, and necessary, therefore, to accept the responsibility for these extinctions and act to avoid them. This will ensure that future generations will have the opportunity to use these biological resources, since it is not possible to predict which species will be of value in the future and once a species is lost there is no way it can be recovered or replaced. Additionally, an increasingly urban and educated public will have the educational and recreational opportunity to see their natural heritage as it lives, rather than to have to read about it in books or see dilapidated specimens in museums.

1.3.3. The Sustained Use of Resources

Biological systems can maintain and renew themselves. The exploitation of natural resources must be managed, however, to ensure that there is always a breeding population left behind which is large enough to replace those which were taken.

The government policy to restrict the annual cut of timber trees shows that the principle is appreciated and part of the Forest Department's policies. In the case of wildlife the same principles apply. A considerable amount of hunting of deer and pigs occurs, which is

largely illegal but cannot be stopped because of a lack of law enforcement officers. Although the populations of game animals are currently high, they are being rapidly depleted and will soon be exterminated from some areas. To ensure that the meat supply and the sport are not lost it is appropriate to consider establishing hunting reserves which are stocked with game, and where hunting activities can be regulated to ensure a sustained yield of game animals.

1.4 ORGANISATIONS CONCERNED WITH WILDLIFE

The Wildlife Section of the Sabah Forest Department (hereafter called FD(WS)) and Sabah National Parks (hereafter called SNP) are the only two authorities in Sabah with power of law enforcement for wildlife conservation.

The responsibilities of these two authorities are distinct. The Wildlife Section's main policy aims are:-

(1) The enforcement of laws pertaining to the hunting and capture of wildlife.

(2) The control of large mammals raiding crops, notably elephants.

(3) The identification, gazettement and management of sanctuaries.

(4) Education of the public.

(5) The care and management of animals at Sepilok Orang-utan Centre and of swiftlets at Gomantong Caves.

The roles of Sabah National Parks are:-

(1) The establishment, protection and administration of National Parks.

(2) To preserve natural features such as geological formations, vegetation types and rare plants as well as wild animals.

(3) To provide recreation facilities for local visitors and tourists, including education centres and educational publications.

FD(WS) comprises 36 personnel occupying 9 posts of government. The Conservator of Forests is also the Chief Game Warden and FD(WS) is administered by an Assistant Chief Game Warden and junior staff members. As a section of the Forest Department, Wildlife Section comes under the Natural Resources Division of the Sabah Chief Minister's Department. The Sabah National Parks is a statutory body comprising 204 personnel occupying 35 posts. The SNP is administered by a Director and governed by a Board of Trustees consisting of a Chairman and seven other nominated members. SNP comes under the State Ministry of Resource Development. Both authorities are rather small. The Department of Wildlife and National Parks in Peninsular Malaysia has about 900 personnel compared with only 240 personnel in SNP and FD(WS) combined. As a statutory body, SNP is in a position to create new posts as required and fill them if State government finances are provided. FD(WS) suffers a chronic manpower shortage however, with about 20 rangers expected to uphold the law throughout the State, except in National Parks. To create new posts in FD(WS), several bureaucratic channels must be followed. The necessary clearance to create new posts depends on the attitudes of those civil servants who consider the applications and many of them do not consider wildlife conservation of any importance. Manpower shortage, coupled with lack of expertise in the technical aspects of wildlife management, has meant that FD(WS) is particularly dependent on assistance from international conservation bodies. If more personnel are sent overseas for training, and the Section slowly increases in size, this dependence will decrease.

The restriction on the number of posts that can be created by FD(WS) highlights a fundamental problem facing both SNP and FD(WS), that of policy decisions which prevent the two bodies from conducting effective conservation

work as development schemes progress. There is a great need for conservation education at all levels of government, and a platform from which conservation policies may be expressed. SNP is not represented at Land Utilisation Committee meetings despite decisions being made at these meetings about National Parks land on District and State levels. Forest Department representatives go to these meetings but do not necessarily advise on wildlife requirements due to a lack of information.

To strengthen their lobby, some administrators in both SNP and Forest Department would favour a merger of SNP and FD(WS). Such a merger would give the opportunity to review staff requirements and create more posts. There are several problems, however, which might arise in the course of such a merger. The status of the members of the two organisations would have to be agreed upon and their responsibilities in their new posts be identified. The issue of whether pension awards, accrued through service in either organisation could be directly transferred to the new organisation would have to be resolved. This latter problem would depend on whether the new organisation was a government department or a statutory body. Assuming that these details can be worked out a major problem remains in removing the responsibility of wildlife conservation from the Forest Department. Sympathetic forestry policies are essential for effective conservation since much wildlife depends on forest and there are few forested areas of importance for wildlife outside those administered by the Forest Department.

Conservation work would still require the sympathy of Forest Department and high-ranking government officials if the merger did occur. To ensure that this support is maintained, an advisory board should be formed to outline policies and actions required of the new National Parks and Wildlife body. This is known to work in Peninsular Malaysia for the Department of Wildlife and National Parks and it ensures that conservation interests are expressed at the highest levels of government. It is appropriate that a precursor of this advisory board meet on an

informal basis to outline the policies of the suggested National Parks and Wildlife body, and to assess which representatives from the SNP Board of Trustees, Forest Department and other government bodies should sit on the advisory board if a merger occurs.

There are four other organisations which are concerned with wildlife conservation but only indirectly because of their lack of legislative power. The Sabah Foundation is the largest organisation. It was granted a timber concession, recently enlarged to total more than 12,000 sq. km., and lasting for 100 years, to obtain revenue for financing projects to improve the educational opportunities of Sabah's people. As custodian of such a large tract of forested land, Sabah Foundation's policies are intended to show responsible management of resources, based on information as to which areas are important for conservation. Additionally the Sabah Foundation supplies funds for conservation education projects including contributions to the construction of an Education Centre at Sepilok and financing the printing of the latest edition of "Birds of Borneo" (5). A wildlife officer has been employed recently by the Sabah Foundation.

The Sabah Society was established to inquire into all aspects of culture and natural history within Sabah. It has made contributions to conservation awareness by publishing a monograph on Kinabalu and combining with the Malayan Nature Society to publish "Birds of Borneo". Finally two societies were formed in 1980, the Sabah Zoological Society and the Sandakan Zoo-Botanic Society. These two organisations will have their respective headquarters in Kota Kinabalu and Sandakan. Their recent establishment means that their contribution to wildlife conservation is yet to be made.

1.5 LEGISLATION

The laws concerning wildlife in Sabah are the Fauna Conservation Ordinance (1963) and amendments, the National

Parks Enactment (1977), the Birds' Nests Ordinance (1914) and amendments, and the Fauna Conservation (Turtle Farms) Regulations (1964). Of these, the first two are of great importance and the development of effective conservation policies must happen within the limits of these laws and, once effected, must be upheld by them.

The National Parks Enactment requires little change. Areas gazetted as National Parks may not be subjected to any form of degradation through removal of plants, animals and minerals. There is clearly a short-coming in this legislation in that parts or whole National Parks can be relatively easily degazetted. Currently it is necessary only for the Head of State to have — "consultation with the Board (of Trustees)" — before ordering the degazettement. The only change that might be made to the legislation is that a full scientific enquiry be required before an area may be degazetted. This enquiry must show that the reasons for making the area a National Park no longer apply and that there is no loss of important conservation areas arising from the degazetting.

The Fauna Conservation Ordinance is out-dated and, despite the urgent amendments of 1981, many aspects still need attention. In addition to the terminology being antiquated, the legislation referring to Bird and Game Sanctuaries is inadequate. It merely states that the Head of State may — "declare any area to be a Game Sanctuary or a Bird Sanctuary" — and may degazette a Sanctuary or alter its boundaries. No reference is made to what activities may occur in a Sanctuary. Several recommendations are outlined below:-

(1) Nomenclature

The term "Game" has a restricted meaning and should be replaced by term "wildlife". The official title "Game Branch" of the Forest Department should become the Wildlife Section, as it is already unofficially known. "Game Rangers" should become "Wildlife Rangers". The term "wild animal" should be amended to refer to amphibians, reptiles and bearded pigs.

(2) Sanctuaries and Reserves

The "Game Sanctuaries" and "Bird Sanctuaries" should both be termed "Wildlife Sanctuaries". The main difference between a National Park and Wildlife Sanctuary is that the former should be developed with recreational, educational and/or tourist facilities while the latter is primarily to preserve wildlife, although not excluding tourism or research. Furthermore, it is suggested that a new category of "Wildlife Reserve" be created. Wildlife Reserves would also be primarily for wildlife conservation but could be in an area that has been logged or where timber extraction is going to occur, but where wildlife species require special protection.

i) Wildlife sanctuaries or wildlife reserves could be established on any class of land.

ii) Wildlife sanctuaries or wildlife reserves may be of any size.

iii) The legal status of wildlife sanctuaries or wildlife reserves can be changed only if a public enquiry shows that the reasons for originally gazetting the land no longer apply.

With reference to Wildlife Sanctuaries:-

i) Subsequent to gazettement the sanctuary cannot be grossly disturbed e.g. by timber extraction, quarrying, domestic grazing, agricultural practices, etc. This is irrespective of previous activities within the area.

ii) No one may enter the area without permission from the Game Warden.

iii) No one may hunt within a sanctuary, although an authorised officer may kill animals if this is deemed necessary.

iv) Management of the area will be kept to a minimum e.g. planting local animal food plants, setting up salt-licks etc. Small clearings may improve the habitat for some species, but these may only be made assuming no timber is extracted

and no more than 5% of any one sanctuary comprises clearings.

v) Wildlife may be introduced to, or removed from, sanctuaries in translocation efforts, if thorough research shows that this is beneficial to the species and is approved by the Game Warden. No exotic animal or plant species may be introduced into game sanctuaries.

With reference to Wildlife Reserves:-

i) The habitat may be logged.

ii) Licenced hunting may occur, although some species not already in schedule 1 of the Fauna Conservation Ordinance may receive special protection.

iii) Indigenous and exotic animals and plants may be introduced into Reserves if thorough research shows this is beneficial for wildlife conservation, and is approved by the Game Warden.

(3) Powers of investigation

Part IV of the Ordinance restricts the powers of game rangers and forest rangers to "search, seize and arrest" but does not authorise investigation. Since wildlife rangers must investigate the killing of animals, e.g. rhinoceros, it is important that their statements be acceptable as evidence in court. If not, as is the case now, then suspects can often get away because police officers are not available when the investigators receive admissions of guilt that are later denied. Some re-wording of the Ordinance is required.

(4) Trapping

The problem of preventing trapping of animals in Forest Reserves is difficult because trappers can disclaim knowledge of the traps. If the Game Warden has power at his discretion to prosecute the company operating in the concession areas where the traps are set, then there will be scope to dissuade trappers through warnings from timber camp managers.

The potential problem of village people setting traps, which rarely occurs now but may increase as new forest reserves are gazetted in inhabitated areas, can be overcome by using discretion when prosecuting or by issuing trapping licences at minimal or no charge.

1.6 SURVEY OBJECTIVES

Lacking a comprehensive wildlife conservation policy and with a very small manpower, it became apparent to FD(WS) in 1978 that, with the rapid exploitation of Sabah's forests, there was a need for conservation priorities to be identified quickly. Priorities could not be properly identified, however, until there was considerably more information available on wildlife populations throughout Sabah. The short zoological expeditions and two intensive field studies of orang-utans done before 1978 did not provide sufficient information. There was a particular need for information on the location of areas with abundant and diverse wildlife populations, suitable as long-term conservation areas. The urgency for the information is illustrated by the fact that Sabah had (and to date still has) only 1.4% of its land area gazetted as National Parks, no Game Sanctuaries and less than 30% of its land area under tall primary forest.

A suitable project was drawn up by FD(WS) and World Wildlife Fund Malaysia. The objectives of this project, the Faunal Survey of Sabah, were:-

(1) To collect data on the current distribution of wild mammal and bird populations in Sabah and, where possible, to assess their population densities. Special emphasis was placed on those species believed to be most threatened by human activities.

(2) To assess the effects of geographical location, altitude, habitat and human disturbance on the mammal and bird populations.

(3) To use the data to identify species and areas of

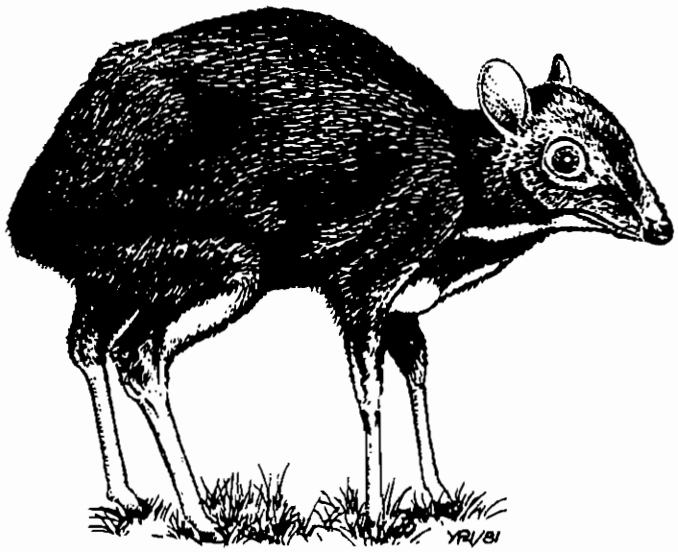
special conservation importance.

(4) To train Wildlife Rangers (from FD(WS)) in survey methods and field techniques. SNP Rangers received similar training when National Parks were surveyed.

The generalised nature of these objective allowed details of surveys to be planned in the light of up-to-date information and needs. The most important function of the Faunal Survey was to provide an objective basis for identifying conservation areas and priorities.

It is hoped that this report will be a source of data and recommendations to which Sabah government departments can refer, so that land use planning need no longer be done in ignorance of the needs of wildlife conservation. FD(WS) and SNP can draw on original data for future modification of policies or for incorporation into proposals for presentation to government.

2. THE SABAH ECOSYSTEM



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2.1 THE PHYSICAL GEOGRAPHY OF SABAH

Ninety-five percent of Sabah's land area consists of sedimentary and sedimentary-volcanic rock formations. There is some volcanic, intrusive igneous and crystalline basement rock.

Sabah may be divided into physiographic regions (Map 4) which, for convenience, are described here as seven groups with similar features.

(1) Coastal swamps

All the east-coast deltas and part of Klias Peninsula. Nipah and mangrove, with freshwater or peat swamp hinterlands.

(2) Extensive dry or seasonally swampy flatlands

The Kinabatangan and Labian Lowlands. 0-500 feet altitude. Alluvium, sandstone and mudstone.

(3) Alluvial plains

Flattish, usually fertile plains at various altitudes in the western part of Sabah.

(4) Lowlands with mixed relief

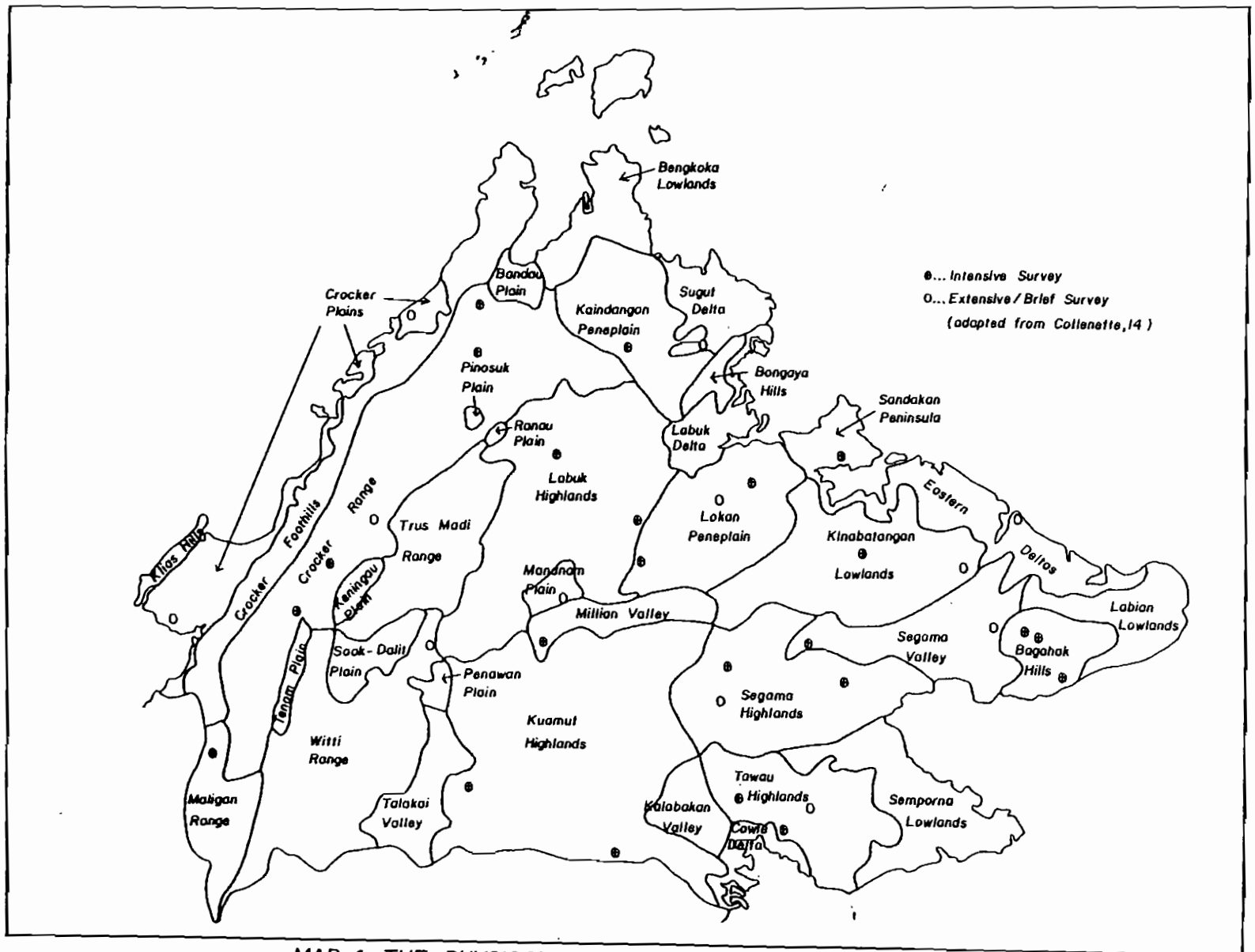
Land on sedimentary and volcanic rocks, containing fertile flat areas and hills up to 1,000 feet altitude, sometimes higher. Includes the Lokan Peneplain, Sandakan Peninsula, Mananam Plain/ Milian Valley, Segama Valley, Semporna Lowlands, Kalabakan Valley and Bengkoka Lowlands.

(5) Uplands

Mainly rather steep areas of 500-1,500 feet altitude on sandstone, with flatter areas along the larger rivers. Includes the Bongaya Hills, Kaindangan Peneplain, Dent Hills, Crocker Foothills and Talangkai Valley.

(6) Central Highlands

Mainly 1,500-3,000 feet altitude with some lower areas and peaks to 5,000 feet. Sedimentary, ultrabasic, igneous and basaltic rocks. Includes the Labuk, Kuamut, Segama and Tawau Highlands.



MAP 4. THE PHYSIOGRAPHIC REGIONS OF SABAH

(7) Western Hill Ranges

Mainly sedimentary formations at 1,000-5,000 feet altitude, with higher peaks (including Mount Kinabalu 13,455 feet). Inhabited in some places to 4,000 feet by shifting cultivators. Includes the Crocker, Witti, Maligan and Trus Madi Ranges.

2.2 SABAH'S FLORA

As indicated earlier (Section 1.2), Sabah is a land of floristically diverse and structurally complex forests The species of flowering plants are numbered in thousands and there are no extensive areas naturally devoid of tree cover.

Around much of the coast are brackish water swamps subjected to tidal influences, covered by expanses of broad-leaved mangrove trees or, where there is periodic fresh-water flow, nipah palms. The mangrove forests are floristically and structurally simple compared to the forest to be seen further inland, the trees present most commonly belonging to the genera Rhizophora, Sonneratia, Avicennia and Bruguiera. Up-river there is forest along the banks where there is no tidal influence but where it floods periodically. Here, there are grasses, herbs and a variety of small, bushy trees, but the taller trees are of only one or a very few species, often of the family Leguminosae (bean family) or benuang (Octomeles sumatrana).

Away from the river-bank and on all dry land up to 3,000 feet a.s.l. or more, the forest is characterised by bewildering diversity. One hectare may contain 180 species of tree (over 30 cm. girth), many species being represented by only one individual. This forest is known as dipterocarp forest, after the family of trees which dominate it. The name "dipterocarp" refers to the fruits, characteristic of many species in the family, which consist of a single seed surrounded by a pericarp

bearing two wings. In these forests, which originally covered most of Sabah, 20% of all trees present may belong to the family Dipterocarpaceae and of the biggest trees (40-80 m. tall) 80% are likely to be dipterocarps. Among the many other plant families usually represented by trees in the dipterocarp forests are the Leguminosae to which the spectacular menqaris (Koompassia excelsa) Sabah's largest tree belongs; Euphorbiaceae (typically small trees with three-seeded, splitting fruits); Annonaceae, Flacourtaceae and Rubiaceae (all diverse families, usually with dry or hard fruits). A variety of trees, all uncommon in the forest, bear fruits edible to man and many exist in cultivated form. There are several species of durian (family Bombacaceae) some with distinct local varieties and one species, as yet undescribed in Sabah, was found during the Faunal Survey. The large, spiky fruits are sought by many larger mammals, as well as by man, for their pulpy, nutritious flesh. Other trees whose fruits are eaten by man and wild animals alike include Diospyros spp. (Ebenaceae), Garcinia spp. (Guttiferae), Aglaia spp. (Meliaceae), Artocarpus spp. (Moraceae), Nephelium spp. (Sapindaceae), Dracontomelum and Mangifera spp. (Anacardiaceae).

Many trees are laden with climbing plants and epiphytes such as ferns and orchids, which add considerably to the volume of plant material and to the diversity of the forests. Spectacular strangling fig plants, which grow down and around tall trees from seeds deposited on their branches, are another feature of the dipterocarp forests. Sabah's lowland dipterocarp forest is the home of a tree with wood of extreme hardness and durability, the Borneo Ironwood or belian (Eusideroxylon zwageri). Here also is found Alocasia macrorrhiza, with leaves up to 3 m. long, the largest undivided leaves in the world.

Progressing up into the hills, there is a very gradual reduction in species diversity of the dipterocarp forest and a change in species composition. Orchids and tree palms tend to become more numerous, at least locally. Also is the hill dipterocarp forests occurs a parasitic plant, Rafflesia spp., whose flowers, measuring up to 90

cm. across, are the largest in the world.

At around 3,000 feet a.s.l. there is a relatively rapid change from dipterocarp to montane forest. The change may occur at somewhat less than 3,000 feet on isolated peaks and ridges, but may be at a considerably higher altitude on large massifs (notably Mount Kinabalu) and where the hills are not steep (such as parts of the Maligan Range). The most noticeable changes include a great reduction in the number of dipterocarp trees, in the number of climbing plants and in the stature of the forest. Trees of the families Fagaceae, Myrtaceae and Lauraceae become very common. On the very highest mountain peaks, the stature of the vegetation is much smaller still, and the top of Mount Kinabalu is bare of soil or vegetation.

In scattered areas of Sabah, there are freshwater and peat swamp forests, as well as a variety of forests on peculiar soils. These are described in the next section.

2.3 HABITATS AND DEVELOPMENT

The term 'habitat' means the place in which wild animals live. Habitats are classified primarily according to which species of plants are most abundant or conspicuous, which in turn depends on such factors as climate, soil and topography.

It is necessary to classify the vegetation of Sabah into habitat types because habitat is the most important factor influencing the distribution and abundance of the animals with which this report is concerned. Sabah contains such a diverse flora that, to some extent, classification of habitats is arbitary. Foresters base their classification on which species of commercially valuable trees are present, but these trees may be of little importance in determining which mammals and birds are present. Our classification (Table 4) is

TABLE 4 HABITAT TYPES OF SABAH AND THEIR DIAGNOSTIC FEATURES

Pristine Habitats

HABITAT TYPE	ALTITUDE FT. ABOVE SEA LEVEL	TOPOGRAPHY	CONSPICUOUS TREES	OCCURRENCE IN SABAH	OTHER FEATURES
MANGROVE/NIPAH	0	Flat	Rhizophora, Sonneratia, Avicennia, Bruquiera Spp.; Nypa fruticans (nipah palm).	Most of the east coast of Sabah. Parts of west coast, especially Klias Plain.	Brackish water.
RIPARIAN (RIVERINE) FOREST	Below 100	Flat	Various - e.g. Dipterocarpus warburgii, Octomeles sumatrana.	Lower reaches of major east-coast rivers.	Fertile alluvium; seasonally flooded.
LOWLAND DIPTEROCARP FOREST	0 - 500	Flat or gently undulating	Shorea, Parashorea Spp., Koompassia excelsa, Eusideroxylon zwageri	Formerly throughout most of the Kinabatangan Lowlands, Labian Lowlands, Segama Valley, Sandakan Peninsula, Lokan Peneplain and Semporna Lowlands. Now, a few isolated patches.	Plant species composition variable but always diverse.
UPLAND DIPTEROCARP FOREST	500 - 1,500	Gently undulating to steep, but mainly intermediate between the two extremes.	Shorea, Dipterocarpus Parashorea Spp.	Most regions, except coastal and high hill ranges.	Recently and currently most commercial logging is in this habitat. Generally, the upper altitudinal limit of large legume trees (Koompassia, Intsia, Dialium, Sindora).
HIGHLAND DIPTEROCARP FOREST	1,500 - 3,000	Generally steep.	Shorea Spp.	Mostly the western hill ranges, and Labuk and Kuamut highlands.	As a result of the generally steep topography, there may be marked local variation in flora between ridge-tops, hill sides and valley bottoms.
LOWER MONTANE FOREST	3,000 - 4,500	Generally steep, with thin, poor topsoil.	Trees of the families Fagaceae, Myrtaceae, Lauraceae common. Dipterocarps scarce.	Mostly the western and interior hill ranges, with some isolated peaks in South-eastern Sabah.	Major contrasts with dipterocarp forests include a lower, more homogeneous tree canopy with few climbing plants; fewer insect and bird noises; often shrouded in mist or cloud.
UPPER MONTANE FOREST	4,500 - 11,000	Steep	Trees of the families Fagaceae, Magnoliaceae, Rosaceae, Myrsinaceae, Myrtaceae.	Kinabalu, Trus Madi and some isolated peaks in western and central Sabah.	Trees of small stature; shrubs and herbs abundant. Mosses and lichens conspicuous. Biomass and productivity low.

Pristine Habitats (cont'd)

FRESHWATER SWAMP FOREST	About 0 feet	Flat	Various - e.g.:- (a) Quassia indica (b) Terminalia Sp. (c) Others, botanically little-known (e.g. Myristicaceae, Nauclea Spp.)	Mostly behind mangrove/nipah in the Eastern Deltas. Kinabatangan Lowlands. Labuk Delta, Sugut Delta, Segama Valley, Sandakan Peninsula, Labian Lowlands.	On fertile, clayish soils. Usually or always waterlogged. Sometimes heavily flooded. Soil $p^H > 6$.
PEAT SWAMP FOREST	Below 100 - Over 3,000	Flat	Various - e.g.:- (a) Gonystylus bancanus, Dactylocladus stenostachys, Dryobalanops rappa (b) Lophopetalum multinervium (c) Others, botanically little-known.	Klias Plain. Sugut Delta. Some flat areas west of the Crocker Range; Maligan Range; Eastern Deltas; Kinabatangan Lowlands.	Infertile soils, high in organic matter. Soil $p^H < 6$, usually 4.
KERANGAS (HEATH) FOREST	Mostly below 2,000	Flat to undulating; or steep sandstone escarpments	Various - e.g.:- Myrtaceae, Podocarpaceae, certain dipterocarps.	Patchily scattered throughout Sabah, but notable extensive areas are in the Sugut Delta, western part of the Lokan Peneplain, Sook Plain and Klias area.	Soils are acid, siliceous and often coarse (podzols). Poor in plant nutrients. Big trees and climbers are rare. Leaves tend to be small and leathery. Plants associated with insects usually present (for example, pitcher plants).
FOREST ON SOILS DERIVED FROM ULTRA-BASIC ROCK	400 - 8,462	Mostly steep	Variable (according to region, slope and altitude) but always distinctive. e.g., certain dipterocarps, Tristania, Casuarina. Dipterocarps common below 3,000 feet. Shrubs dominate at highest elevations.	Tambuyukon, Kinabalu, Labuk and Segama highlands. Also some offshore islands and parts of the Kuamut and Tawau highlands.	Soil has elements toxic to plants. Plant parts protected chemically and/or physically from animals. Forest is usually structurally smaller and simpler than forest at similar altitude elsewhere. Diversity lower.
BEACH VEGETATION	0	Flat	Casuarina equisetifolia (sand being deposited) Barringtonia asiatica and other trees (stable).	All around the coast, interspersed with mangrove.	

Pristine Habitats (cont'd)

VEGETATION ON LIMESTONE	0 - 2,000	Isolated, steep outcrops	Various. Mainly shrubs and small trees.	Mainly in the eastern lowlands, (south of the Labuk River) and interior.	

Exploited Habitats

LOGGED MANGROVE	0	Flat	(As in pristine mangrove)	(a) Small scale, by local people: patchy along west coast and Eastern Deltas. (b) Commercially: Eastern Deltas.	Can regenerate to original condition if exploitation is managed.
LOGGED LOWLAND DIPTEROCARP FOREST (5-25 years after first logging)	0 - 500	Flat or gently undulating	Macaranga Spp., Anthocephalus chinensis, Trema Spp., Koompassia excelsa.	Most of the Kinabatangan Lowlands, Labian Lowlands, Segama Valley and Lokan Peneplain.	Low diversity of plant species compared to pristine forest. Grasses, herbs, shrubs and small trees abundant. Few emergent trees remaining after logging. Most of this habitat is forest logged over twice (the second logging 1-20 years after the first).
LOGGED UPLAND DIPTEROCARP FOREST (5-25 years after first logging)	500 - 1,500	Gently undulating to steep, but mainly intermediate between the two extremes.	Macaranga Spp., Anthocephalus chinensis	Most regions except coastal and high hill ranges.	Variable, regeneration depending on extraction intensity, topography, soil, type of logging equipment, and so forth.
LOGGED HIGHLAND DIPTEROCARP FOREST (<15 years old)	1,500 - 3,000	Generally steep	Macaranga Spp.	Small parts of all highland areas.	Commercial logging in highland dipterocarp forest has started only in recent years, except Gunung Bagahak (Dent Hills) mid 1960's. Prone to land-slips.
SHIFTING CULTIVATION	0 - 4,000 +	Flat to steep, mostly undulating.	(a) Under cultivation: rice, tapioca, maize, etc. (b) Regenerating: Macaranga Spp. (c) Degraded areas: Melastoma, Lantana, Imperata cylindrica (shrubs, herbs, grasses)	All regions of western and northern Sabah. Along the larger east-coast rivers.	The land area on which shifting cultivation is practised is decreasing. Formerly more widespread and important to grazing mammals.

Exploited Habitats (cont'd)

PERMANENT MIXED AGRICULTURE	0 - 4,000 +	Flat to undulating, occasionally steep.	Rice, vegetables, fruit trees, rubber, coconut etc.	In the regions around towns, old roads and settlements.	Very heterogeneous. Substantial patches of abandoned rubber are common. Rice only in western Sabah.
TREE PLANTATIONS	0 - 4,000	Flat to steep, mostly undulating.	Acacia mangium, Albizia falcataria, Gmelina arborea, Eucalyptus Spp. Pinus Spp.	Crocker foothills, Tawau Highlands, Sook Plain, Bengkoka Lowlands, Segama Highlands.	Mostly A. mangium except in Tawau and Segama Highlands.
COCOA	0 - 1,300	Flat or undulating	Gliricidia sepium (shade tree) Theobroma cacao	Tawau Highlands, Semporna Lowlands, Segama Valley, Kinabatangan Lowlands, Lokan Peneplain, Sandakan Peninsula, Tenom Plain.	Mostly large-scale monocultures.
OIL PALM	0 - 300	Flat or undulating	Elaeis guineensis	Sandakan Peninsula, Labuk Delta, Kinabatangan Lowlands, Segama Valley, Semporna Lowlands.	Large-scale monocultures.

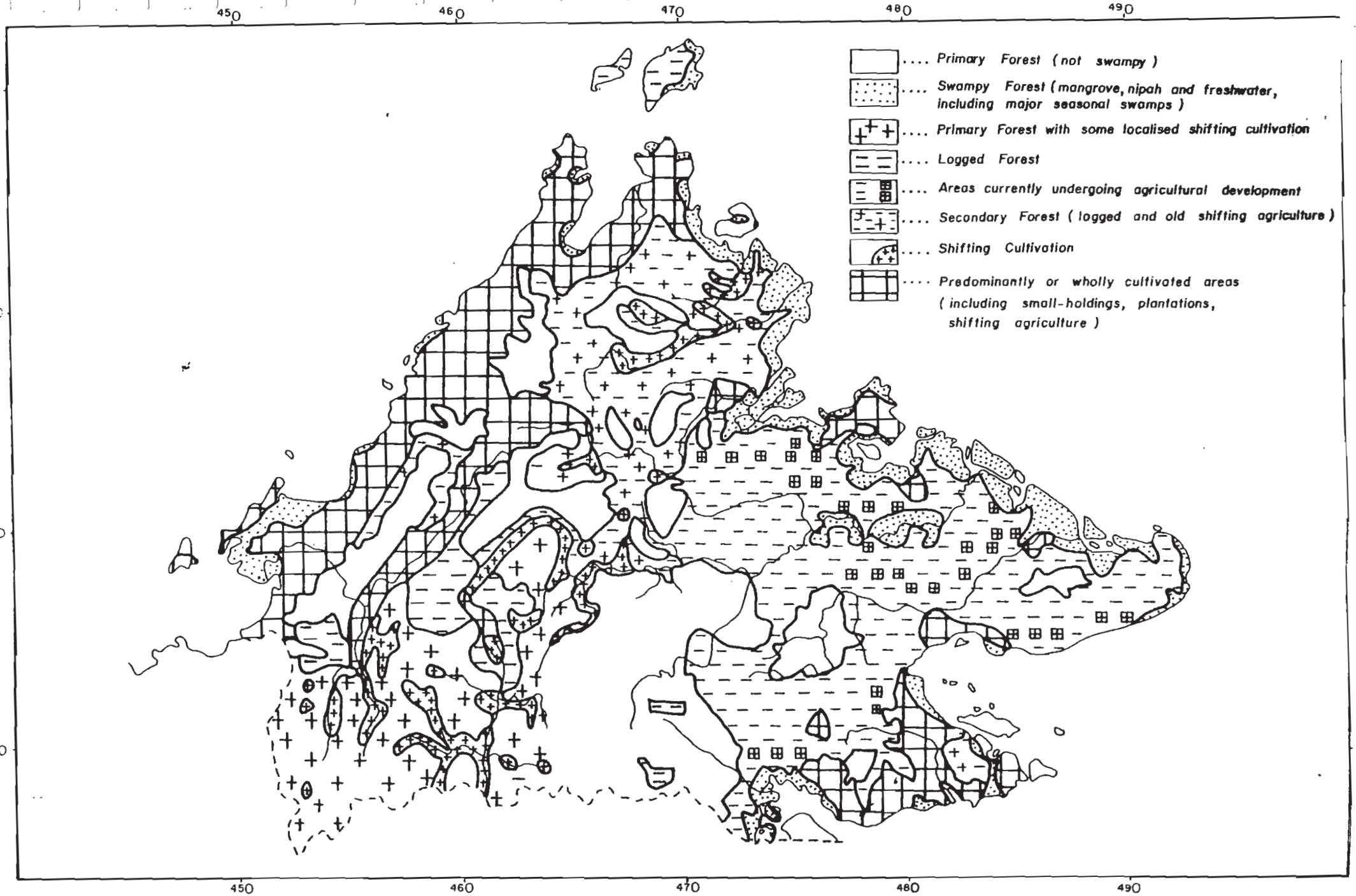
based on features believed to be more relevant to mammals and birds.

Our major division in classifying wildlife habitats in Sabah is whether the habitat is pristine (disturbed very little or not at all by man) or exploited (including logged forest and any kind of cultivation). Elsewhere in this report, two other terms are used with reference to forest habitats: primary (essentially undisturbed) and secondary (where many big trees have been removed either by logging or because the land has been subjected to cultivation). Another term, belukar, refers to relatively small patches of secondary forest remaining in areas largely under permanent cultivation.

2.3.1. Pristine Habitats

Thirteen pristine habitat types were recognised for the purpose of the Faunal Survey. The extent and distribution of pristine habitats in Sabah is roughly delineated in Map 5.

Mangrove and nipah were counted together as one although they are botanically different. Riverine, Swamp and Kerangas Forests, and forests on Ultrabasic-derived Soils all exhibit great regional and local variation in species composition and structure. Since they occupy a small fraction of Sabah's land area, however, and contain low wildlife densities, they were not sub-divided botanically. The dipterocarp forest habitats are easily the most important, both in terms of the large area that they cover and the future of wildlife conservation in Sabah. Early impressions, confirmed later by field-work, indicated that a division of the dipterocarp forests into three habitats was appropriate for the Faunal Survey, particularly when considering the larger mammals. For convenience, these habitats were divided according to altitude into Lowland (less than 500 feet), Upland (500-1,500 feet) and Highland (1,500-3,000 feet) Dipterocarp Forests. It is likely that the major altitude-related factors involved in determining wildlife diversity and abundance are soil



MAP 5. DISTRIBUTION OF FOREST AND AGRICULTURE IN SABAH, 1981-82

fertility, slope and climate.

Most of the various pristine habitats have features of importance to conservation - and therefore to development - associated with them. Mangrove/nipah is the nursery for the development of many prawn and some fish species. It is known to be the main habitat of the proboscis monkey, a species unique to Borneo, and together with the swampy hinterlands, important for estuarine crocodile populations. The most extensive undisturbed areas of mangrove/nipah are in the deltas between the Sugut and Labuk Rivers, and on the north side of the Dent Peninsula.

Riverine forests have an important function in absorbing the effects of flooding, and constitute a part of the habitat for various river-dwelling animals.

Lowland dipterocarp forests are characterised by high productivity of living material and high diversity of plant and animal species. Natural products beneficial to man, as yet undiscovered or unexploited, are most likely to occur in these forests. The only remaining substantial tracts are part of Sepilok Forest Reserve (less than 4,000 ha.) and within the Silabukan and Lumerau Forest Reserves (currently about 14,000 ha. and decreasing rapidly).

The quality of upland and highland dipterocarp forest is variable, with topography and associated features apparently exerting a major influence on floral and faunal composition. Retention of sufficient primary forest cover in the uplands and highlands is essential for water and soil conservation, and for forestry purposes. As will be seen later (Sections 4.1 and 4.2), the highlands generally contain a lower diversity and density of wildlife than the lowlands, but they will remain the least disturbed areas of dipterocarp forest.

Montane forests are represented in the Crocker Range Forest Reserve and Kinabalu National Park (Section 5.2). The unique flora that they contain is to some extent protected by the fact that terrain and soil are unsuitable for logging or cultivation. Even localised

clearance of the natural vegetation cover (e.g. for mining, experimental agriculture or recreational facilities) may inflict irreparable harm to the survival of rare or localised plant species.

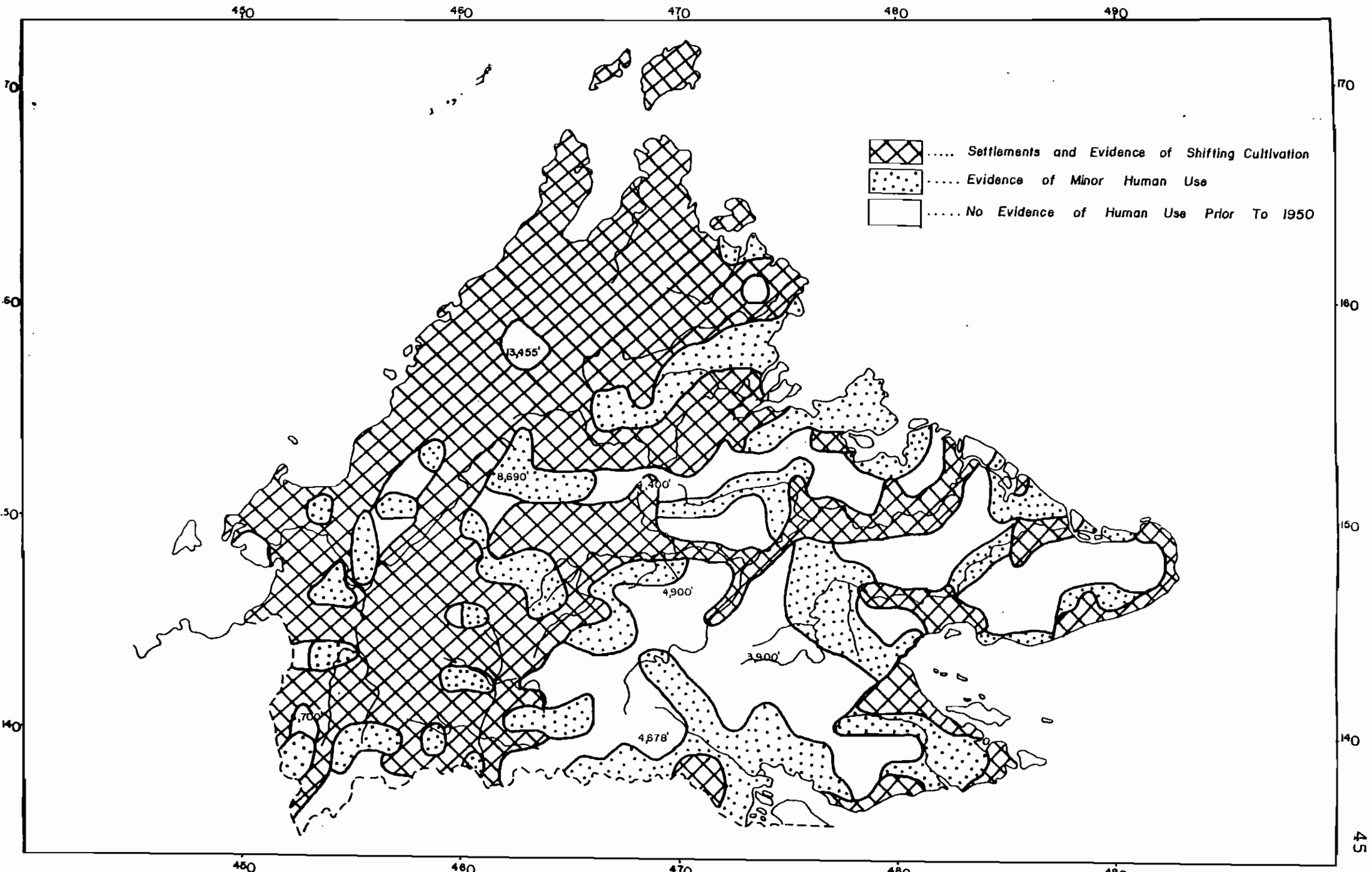
Freshwater and peat swamp forests are of interest for their specialised flora. With a few exceptions, they do not contain much timber of value currently, and the soils are unsuitable for most forms of agriculture. Ultimately, many of these habitats will be exploited for wood products, or planted with crops tolerant of their peculiar conditions. Efforts should be made, therefore, to identify and reserve pristine samples of each while there is little pressure to exploit them.

Beach vegetation is much the same throughout South-east Asia. The main coloniser tree, Casuarina equisetifolia, produces excellent firewood. The specialised flora of vegetation on limestone is of botanical interest. Most of Sabah's limestone outcrops contain caves of vital importance as nesting sites for cave swiftlets (Collocalia spp.). These caves have produced and are likely to continue to produce much of Sabah's archaeological material.

2.3.2. Shifting Cultivation

Human activities have had a considerable impact on Sabah's vegetation. The oldest form, dating back for thousands of years, is shifting cultivation. Indigenous communities have not been spread evenly through Sabah (Map 6). The greatest concentrations of people and the amount of shifting cultivation appear always to have been in the west and north (Map 5). Scattered communities did exist in the past in many other regions, predominantly along the rivers. But large parts of central Sabah and the middle of the Dent Peninsula appear to have remained completely unexploited until recent years.

Although little is known of prehistoric man's activities, it was estimated in 1951 (15) that the vegetation covering 33% of Sabah was secondary growth result-ing from shifting cultivation, that up to 10% was growth



MAP 6 DISTRIBUTION OF INDIGENOUS COMMUNITIES

less than ten years old and that 0.3% was actually under such cultivation. The estimate of 33% seems rather high, and may have been based on biased data, but these figures do serve to show that indigenous man has for long exerted a considerable influence on Sabah's forests. There has evidently been a decrease in the geographical extent and in the amount of shifting cultivation over the last century since there are indications that man once lived in some of the now-uninhabited parts of southern and central Sabah. Nevertheless, it is clear that in historical times indigenous man's activities have been mainly in western and northern Sabah, and along the larger east-coast rivers.

The general practice of shifting-cultivators is to cut down most of the trees in an area, burn the felled timber and plant rice for about 2-5 years until the soil looses its fertility. A new area of forest is then selected and the cycle repeated. The effect of this shifting cultivation is to produce a patchwork of vegetation in different stages of use and regrowth. There are areas under cultivation (rice and probably some fruit trees); areas of regenerating forest (initially Macaranga trees, which are gradually replaced by a more diverse flora); degraded areas which have suffered excessive use, covered with lalang grass (Imperata cylindrica) with few herbs and shrubs (e.g. east of Kota Belud).

2.3.3. Logged Forest

Timber has for long been regarded as Sabah's greatest natural resource and exports have provided more than half the State's revenue. The great majority of timber sold comes from large dipterocarp trees and most tree species are never used. Timber is extracted on a selective basis, a process widely known as logging. In Sabah, the minimum trunk girth limit below which trees may not be felled for sale varies with species, but is generally above four feet (120 cm. girth) and for many

tree species is above six feet (180 cm. girth). The current distribution of logged forest is shown in Map 5.

Before 1950's, logging was done largely without machinery on flat terrain. Trees were cut with axes and logs were hauled by manpower, usually to a narrow-gauge railway which transported them out of the forest. Relatively small tractors had virtually replaced manpower by 1960 in taking logs from the site of felling to the railway or to a point where they were stacked on to lorries. From that time, the trend has been towards logging on increasingly steeper terrain, using increasingly more powerful machinery. The great majority of logging in Sabah now involves heavy tractors which are used from the point at which the tree is felled to the logging roads built to be accessible to large lorries. Only two companies currently use the high-lead method on steep terrain, in which logs are hauled to a spar on the road-side by steel cables without the use of a tractor.

The number of trees felled for extraction as timber varies considerably according to the density per unit area of commercially valuable trees, to the steepness of the terrain and other factors. The amount of damage to the forest varies accordingly. There is much unavoidable damage to non-commercial trees and to the soil, in the form of compaction and erosion, but often some avoidable damage, too. In a detailed study of logging on flat terrain in 1965 in the Sandakan district, it was found that 62% of commercially valuable trees (over 30 cm. girth) were removed or destroyed during logging. A further 23% were damaged and some would subsequently have died (40).

Where soils are suitable, it is common policy in Sabah to re-log the forest to extract any saleable timber, clear-fell all remaining vegetation, and develop the land for permanent agriculture (Section 2.3.4, below). Otherwise, the logged forest is left to regenerate, usually without any subsequent silvicultural treatment.

Regeneration is a very slow process. To date, there have been no studies and it is impossible to predict what forest logged by modern methods will look like more than twenty-five years from now. The regeneration process varies according to many factors, such as (1) the original species composition of the forest, (2) the terrain and soil type, (3) the number of trees extracted per unit area and the rate of the extraction process, (4) weather conditions during and immediately after logging, (5) the size of tractors used in logging and the number of tractor paths per unit area, (6) efforts made to minimise damage during logging and to maintain pristine forest patches within logged areas, (7) the interval between initial and subsequent cutting. All these factors vary enormously. It must be appreciated that logged forest is a variable and continuously changing habitat.

While conducting mammal and bird surveys (described more fully in Section 3.1.2), three 0.6 ha. sample tree plots were enumerated. The results are summarised in Table 5. They indicate that 15-20 years after logging in upland dipterocarp forest, 42% of the trees present may belong to the coloniser genus Macaranga and an additional 36% may be of other species characteristic of secondary forests, such as laran (Anthocephalus chinensis), Trema spp. and benuang (Octomeles sumatrana). The proportion of trees bearing climbing plants is evidently variable. There are only a few very big trees in such forest, all left during logging, and consisting mainly of poorly-formed dipterocarps and non-commercial species such as mengaris (Koompassia excelsa). It is evident from these plots that where only 8-10 trees are taken from each hectare for timber, about 200 trees (over 30 cm. girth) may be destroyed. In terms of species composition of woody plants, dipterocarp forest twenty years after logging is much as it was one year after logging; the major difference is that the secondary trees are much bigger.

The loss of tree species due to logging is demon-

TABLE 5

COMPARISON OF PRIMARY AND LOGGED UPLAND DIPTEROCARP FOREST

Data from one 0.6 ha. plot at each site; all trees ⩾30 cm. girth.

	Primary dipterocarp forest, Ulu Tabin, Silabukan Forest Reserve. 400-500 ft a.s.l.	Forest logged in 1962, Bakapit, Silabukan F.R. 600-700 ft a.s.l. High lead and tractors. About 8 trees extracted /ha.	Forest logged in 1965, Malubuk, Kuamut F.R. 500-600 ft a.s.l. D7E Tractors. About 10 trees extracted/ha.
Number of tree species present	132	45	N.A.
Total number of trees	307	369	325
Number of dipterocarp trees	N.A.	19 (5%)	31 (10%)
Number of Macaranga trees	0	155 (42%)	137 (42%)
Number of trees of species characteristic of secondary forest	1	287 (78%)	N.A.
Number of trees bearing climbing plants	N.A.	146 (40%)	240 (74%)

(%) - expressed as a percentage of total trees.

N.A. - data not available.

Tree Species Diversity in Primary & Logged Forest in Silabukan Forest Reserve (forest logged in 1962)

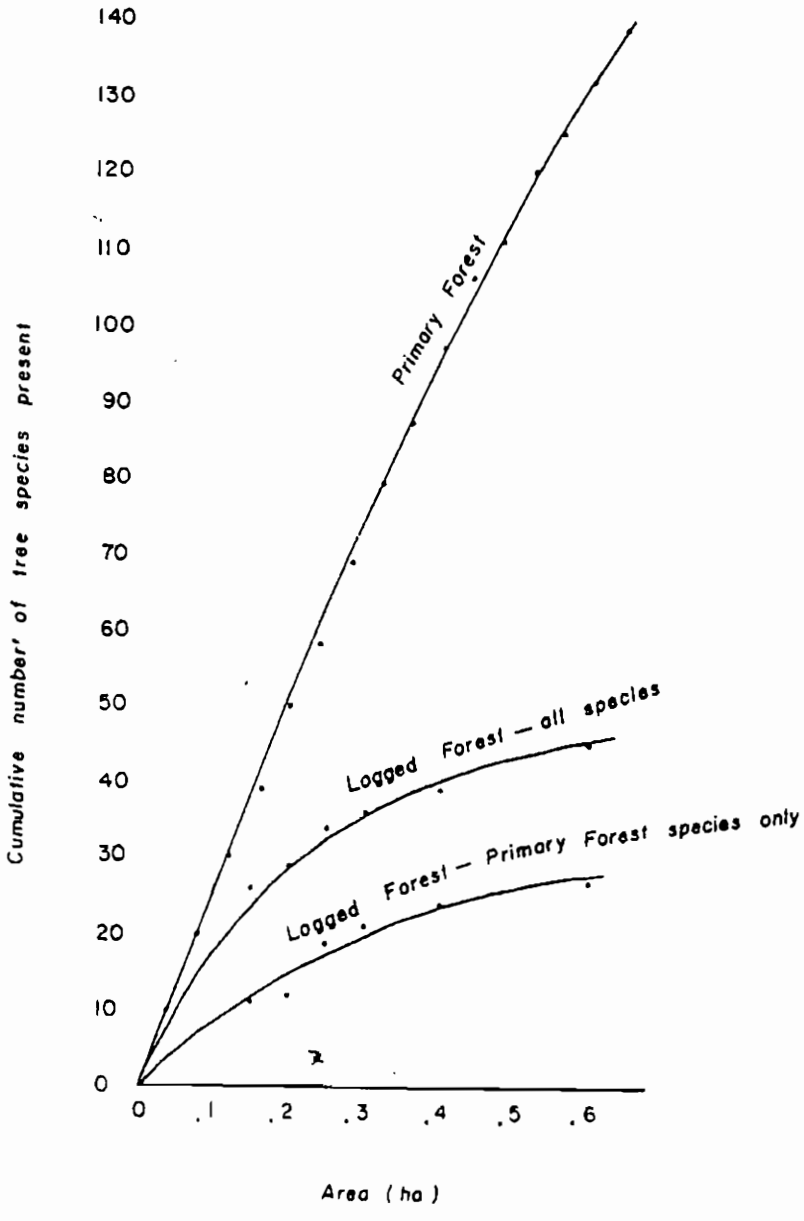


Figure 1

strated graphically by comparing data from primary forest and twenty-year-old logged forest in Silabukan Forest Reserve (Figure 1). It is clear that the lowest curve is unlikely ever to reach the uppermost curve (primary forest) even if extended greatly. This indicates that some tree species disappear completely over large areas after logging. If insufficient seedlings are left to grow into trees, then species will be lost permanently.

2.3.4. Permanent Cultivation

Neither shifting cultivation nor logging lead to a total loss of original vegetation. Permanent cultivation is preceded in most cases by total clearing and burning of the forest over large areas, with only a few patches of belukar remaining. For the Faunal Survey, two broad categories of permanent cultivation were distinguished: mixed agriculture and monoculture plantations. The former is a patchwork of human settlements with orchards, vegetable gardens, occasional small cash-crop plantations, belukar and - in western and northern Sabah - wet rice. This habitat occurs mainly on fertile plains and in the vicinity of all urban areas.

Large-scale plantations have been started mainly since the 1950's and there are now four major crops:-

(1) Rubber constitutes a homogeneous habitat, with mature rubber trees up to 30 m. high planted in lines. Most occurs in south-western Sabah. Currently, this is an unpopular crop in Sabah but is likely to become more important in the future.

(2) Cocoa is the present most popular crop, until the 1970's having been planted almost exclusively on the volcanic soils of the Tawau area, but now being planted throughout eastern Sabah. It requires shade for growth, which may be provided by leaving some forest trees or by clear-felling and planting fast-growing shade trees, usually Gliricidia sepium.

(3) Oil palm is usually a monoculture with a ground cover herb planted to suppress weeds.

Plate 3. Logged upland dipterocarp forest (aerial view). The pale stems of the trees remaining after logging are visible. Subsequent growth of new plants (most obvious along the roadside) indicates that this forest was logged several years ago.

Plate 4. Agricultural development. Foreground: Shade trees under which are young cocoa plants. Mid-distance: Land being prepared for planting. Tawau Hills National Park lies in the distant haze.

(4) Coconut is a relatively minor, localised crop, likely to gain in popularity with the introduction of dwarf forms.

Finally, in the category of permanent cultivation, we include tree plantations for wood products. To date, the most promising species appear to be Acacia mangium, Albizzia falcataria, Gmelina arborea and Eucalyptus species. These plantations are currently reckoned in tens of thousands of hectares, but their extent may increase greatly in the coming years. Trees can be cut within ten years of planting or less.

2.3.5. Development Trends

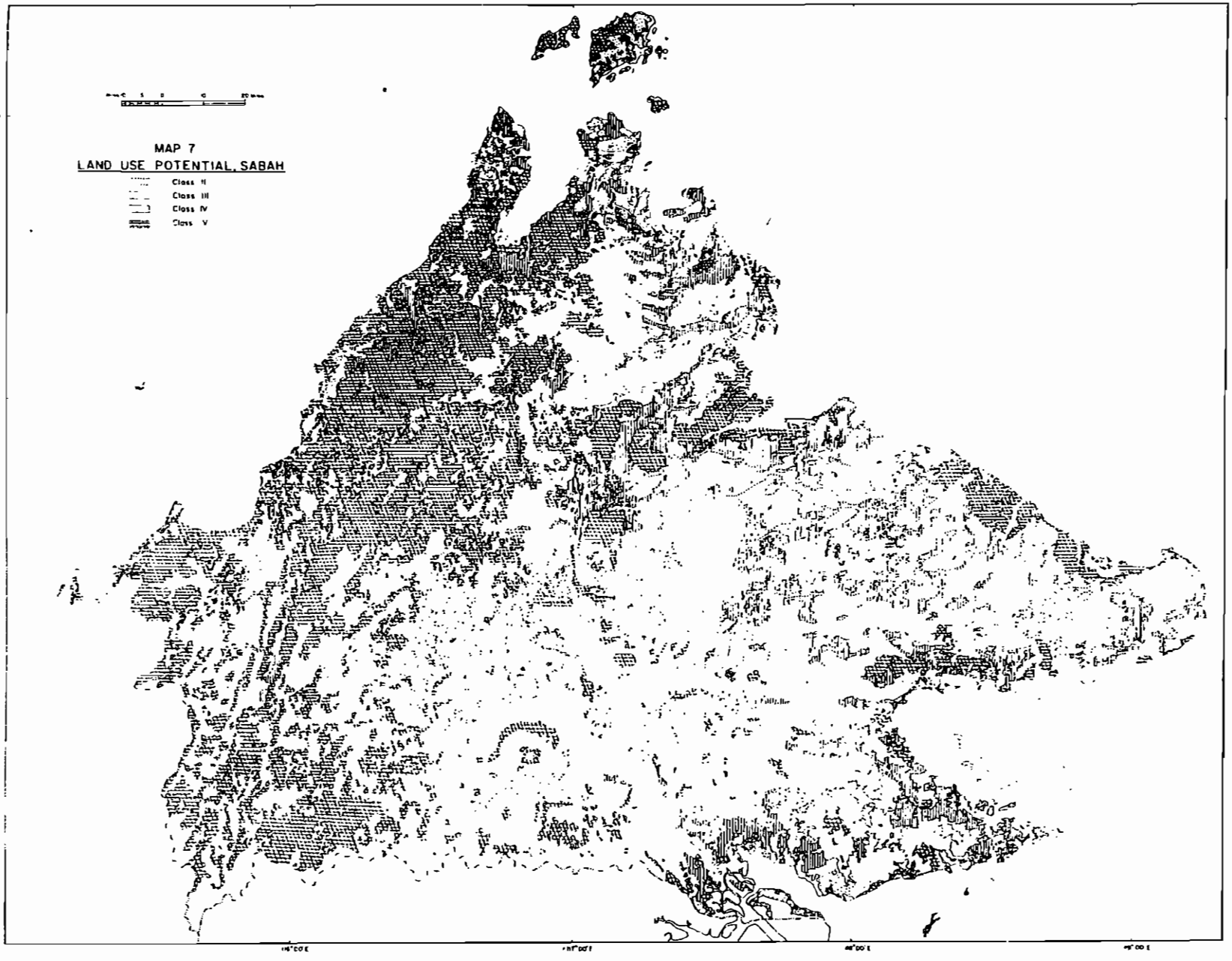
The majority of the dipterocarp forests in the eastern half of Sabah have now been logged. Wherever soil and terrain are suitable, land is likely to be developed with permanent agriculture, unless there are good reasons why forest cover should be retained. For the remainder of this century, most timber will come from central and South-western Sabah, where the remaining large tracts of dipterocarp forests presently occur (Map 5). Future land development will be based to a large extent on the guidelines set out in the Land Capability Classification of Sabah (3). This classification divides all of Sabah's land into five basic categories according to the potential usage which is expected to yield the greatest revenue (Map 7):-

Class I - mining land. A small fraction of Sabah, and mainly copper.

Class II - high quality agricultural land, suitable for a wide range of crops.

Class III - land suitable for agriculture, but with one or more limitations which restrict the number of suitable crop species.

Class IV - land unsuitable for most agriculture but suitable for forestry of some

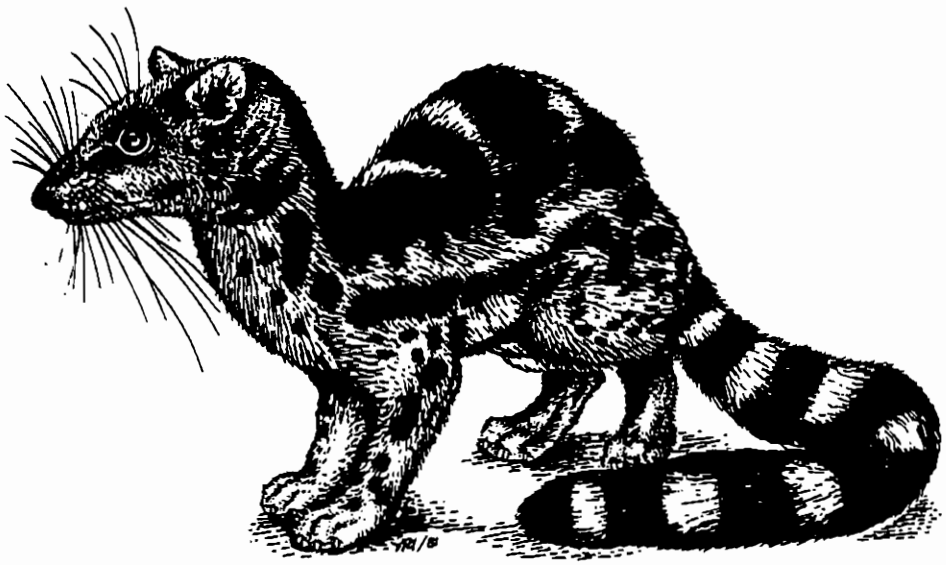

MAP 7
LAND USE POTENTIAL, SABAH
Class II
Class III
Class IV
Class V

sort (including logging, tree plantations, water catchment areas and tree species conservation).

Class V - land unsuitable for any of the above uses and designated as suitable for recreation or conservation.

It should be noted that the Land Capability Classification system classifies land independently of surrounding conditions. For example, small areas of good agricultural soil are marked although it may not be practical to develop plantation in the area for reasons of access. It is also not immediately concerned with the conservation of species or habitats and gives only brief guidelines for regional planning. The short-coming of regarding any land useless for exploitation as suitable for conservation is to some extent rectified by the inclusion of some suggestions for conservation areas on Class III and IV land.

3. THE SURVEYS



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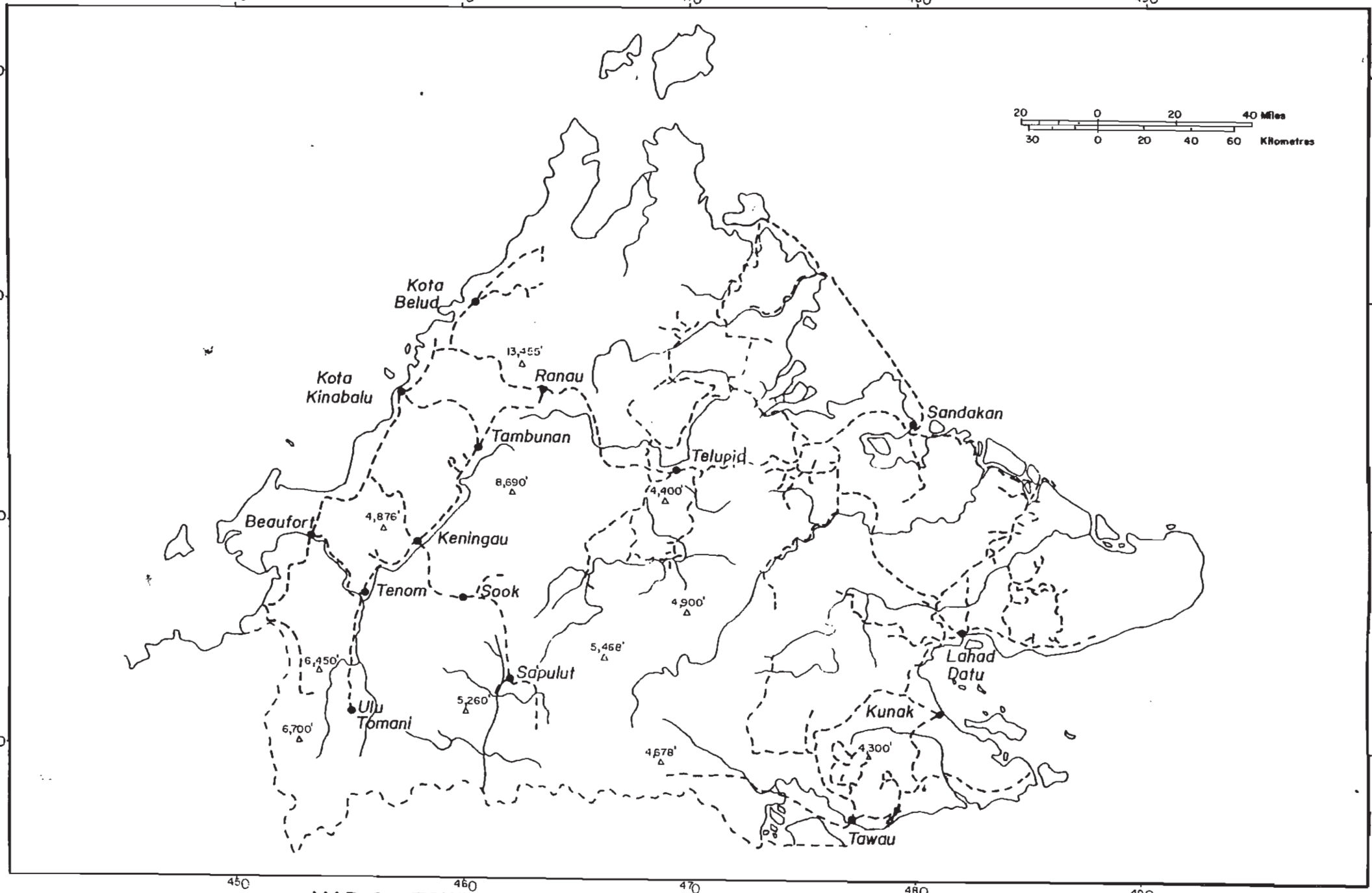
3.1 SURVEY SITES AND METHODS

The selection of survey sites (Maps 8,9) and methods was determined largely by the need to collect data on the distribution and population densities of large mammals (heavier than 2 kg.), since this group was known to be the most vulnerable to the changes in habitat and to hunting pressure occurring in Sabah. Methods were kept simple because survey teams were able to carry only basic equipment, and so that future surveys can be done unaided by Wildlife Rangers. The great majority of data from field work were obtained by direct observation of animals, with the aid of binoculars, or their signs. Very little trapping or netting was done for small mammals or birds. Supplementary information was obtained from local sources, especially on unmistakeable species. The accuracy of such information was sometimes uncertain and accepted only if from written reports by reliable field workers, verbal records from Wildlife or National Parks Rangers or information from local people whose reliability had been assessed over several days.

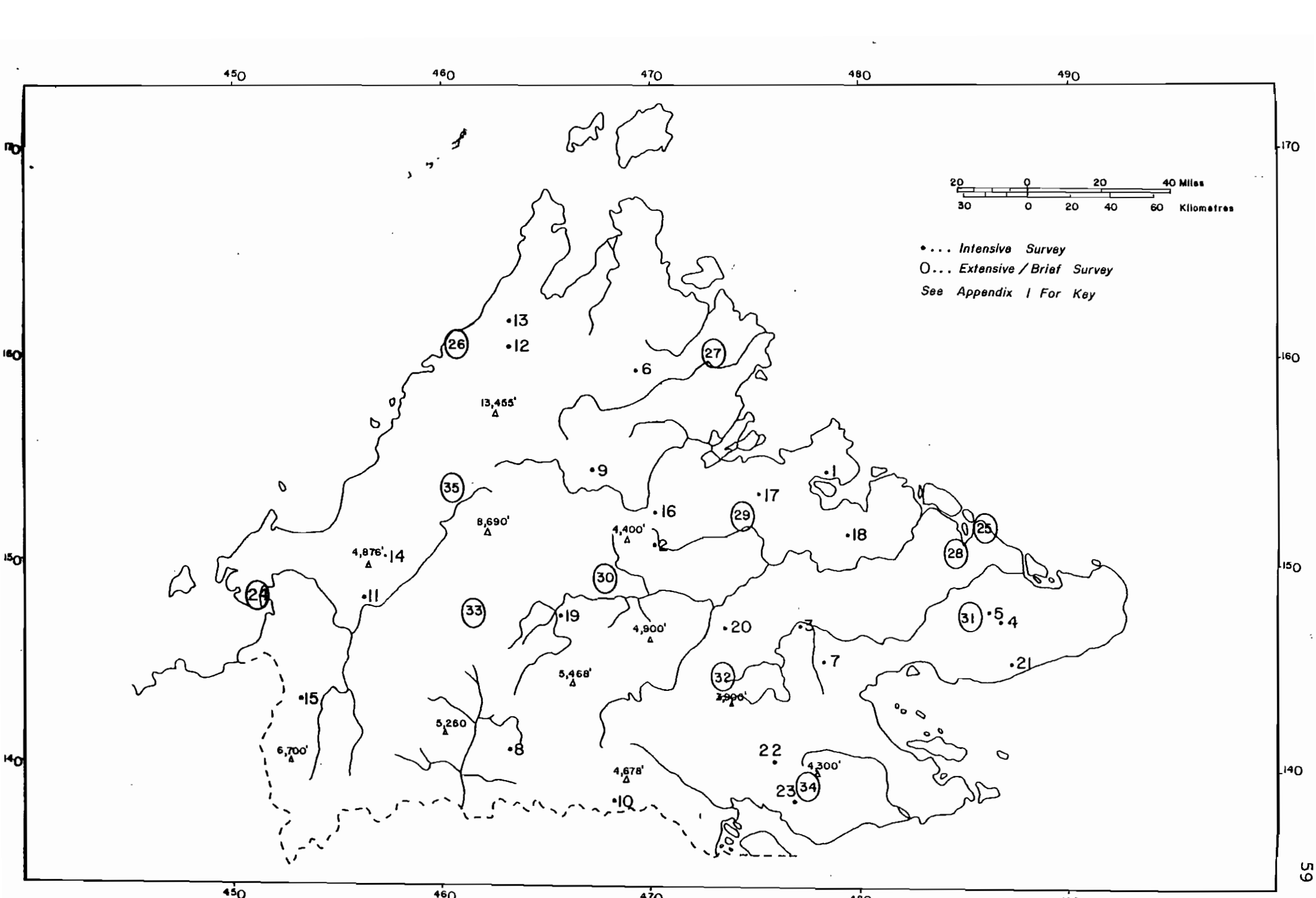
An integral part of each survey and the second main aim of the Faunal Survey project was to assist in the training of Rangers. At least one Wildlife or National Parks Ranger participated in each survey, together with one labourer and it was due largely to their hard work and amiable company that such a large amount of data were collected. Each Ranger was accompanied for at least two days during any survey and was shown the field procedure and note-taking methods. Rangers' performances were assessed according to four criteria: — general field ability; background knowledge of wildlife; interest in the work; and a written report after the survey.

3.1.1. Intensive Survey Method

A major function of the Faunal Survey was to identify habitats and areas with high population densities of wildlife. It was necessary, wherever possible, to use the same survey method in order to collect quantitative



MAP 8. TOWNS AND ROUTES TAKEN DURING THE SURVEY



MAP 9. SURVEY SITES

KEY TO SURVEY SITES (Map 9, preceding page)

1. Sepilok Virgin Jungle Reserve
2. Kunkun
3. Bole Kecil
4. Ulu Tabin
5. Tabin Salt Spring
6. Ulu Telidusan
7. Kawag
8. Ulu Sapulut
9. Ulu Kiberibi
10. Samantulong
11. Ulu Losan
12. Langui Langui
13. Gunung Madalon
14. Ulu Kimanis
15. Bukit Ibul
16. Ulu Rukuruku
17. Lungmanis
18. Gomantong
19. Sungai Langut
20. Malubuk
21. Bakapit
22. Sabah Softwoods
23. Bal Estates
24. Klias Peninsula
25. Tanjung Linsang
26. Tempasuk Plain
27. Sugut/Paitan (Lower Sugut)
28. Kretam
29. Segaliud-Lokan
30. Mananam Plain
31. Silabukan
32. Danum Valley
33. Ulu Tiulon
34. Tawau Hills National Park
35. Tambunan (Crocker Range)

Plate 5. Preparing for an intensive survey. Food and equipment is packed at the side of a logging road prior to entering the forest on foot.

Plate 6. Survey camp in the Crocker Range.

data for comparison between different sites. This was achieved by Intensive Surveys, whereby a small area of forest representative of the surrounding region was investigated thoroughly. A systematic field procedure was developed for use at each intensive survey site, yet flexible enough to allow for variation in ease of access, terrain, weather, etc.

The survey team travelled as far as possible to the selected site by Landcruiser or boat, and thereafter they walked, usually less than 4 km., until a convenient camp site was located. After the camp had been built a trail was cut to form a loop beginning and ending at the camp site. The trail was a minimum of 1,500 m. long, marked at approximately 50 m. intervals; a map of the trail was drawn for inclusion in the report made on every field survey. The trail was followed for at least five hours (beginning between 06.00 and 07.30 hours, depending on weather) on each of a minimum of five days. The vicinity of the survey site was explored during the afternoons and on some mornings. An additional minimum of three hours was spent searching with the aid of a head-lamp for nocturnal animals at night-time.

Even though care was taken to conduct intensive surveys in a similar fashion always, there were uncontrolable factors which could influence the number of animals seen, such that only broad comparisons of population densities are valid. Weather is a major factor affecting mammal and bird activity; rainy weather generally depresses the number of sightings of animals. A daily weather record was kept during surveys and this was taken into consideration when interpreting results. The abundance of fruit in the habitat at the time of the survey may also affect animal dispersion and activity. An index of fruit abundance in the survey area was calculated by recording the number of trees with fallen fruits on the intensive survey trail.

3.1.2. Intensive Survey Sites

(1) Pristine Habitats

At least one survey was done in pristine habitat in

all the major physiographic regions (Section 2.1; Appendix 1). The Sook-Dalit Plain and Bengkoka Peninsula were not surveyed, because these regions have been degraded extensively by centuries of shifting agriculture and are not important to wildlife conservation. Five surveys were done within extensive areas of primary lowland dipterocarp forest (0-500 feet) on flat or gently sloping terrain. Six surveys were done in primary upland dipterocarp forest (500-about 1,500 feet), topography varying from shallow ridges to steep hills. Three surveys were done in primary highland dipterocarp forest on steep terrain (about 1,500-3,000 feet) and two in lower montane forests above 3,000 feet. No surveys were done at altitudes greater than 4,000 feet, firstly because wildlife species of interest to the Faunal Survey were known to be scarce above this altitude, and secondly because there is adequate information from studies on Mount Kinabalu. Other considerations for selecting survey sites included investigating the value of current conservation areas and assessing the effects of hunting. Areas likely to be logged in the near future were chosen preferentially over those probably safe for several years. Many more surveys need to be done in those areas omitted during the Faunal Survey, particularly in the Kuamut Highlands.

Sepilok Virgin Jungle Reserve (150 feet) is an area mainly of primary dipterocarp forest, over 4,000 ha. in extent, in the Sandakan Peninsula. A survey was done in this important conservation area, a site of botanical and forestry research for over forty years. There was also a study of red leaf monkeys being done here during the Faunal Survey, which was useful in checking the reliability of population density estimates for other survey sites. The Kunkun survey site (250 feet) was in an area of flat terrain on the western edge of the eastern lowlands, at the base of the upland region of central Sabah. This area was being opened up for logging and still has substantial stands of primary forest. About 10 km. to the north of Kunkun, another area, Ulu Rukuruku (250 feet) was surveyed. This area had a complex array of unusual soils, including podsol and ultrabasic-derived alluvium, which has given rise

to different forest types. The survey site covered four habitats: Kerangas forest on podsol; forest dominated by tall kapur trees (Dryobalanops beccarii; Dipterocarpaceae); forest dominated by Dipterocarpus lowii and climbing bamboo, Dinochloa sp., on ultrabasic-derived alluvium; and a more floristically diverse forest on seasonally swampy alluvium.

Two pairs of surveys, each with a survey done in lowland and in nearby upland dipterocarp forest, gave some indication of the effect of altitude-related factors on wildlife below 1,500 feet. In the Ulu Segama area, in which the proposed Danum Valley conservation area lies, surveys were done at Bole Kecil (400 feet) and at Kawaq (1,200 feet). It was in the Bole Kecil area that orang-utans were studied intensively in 1969 (16). Since that time, logging activity has approached on a broad front from the east, and so it was of interest to compare the 1969 primate population density figures with our estimates. Extensive surveys in the Silabukan area of the Dent Peninsula showed that the area is important for Rhinoceros conservation. Another pair of intensive surveys was done here: Ulu Tabin (450 feet) and at "Tabin Salt Spring", a site also in the Tabin River system, but at a somewhat higher altitude (600 feet) and adjacent to a large natural salt source in the form of an old mud volcano.

Ulu Telidusan (700 feet) and Ulu Kiberibi (1,500 feet) were two upland sites in the Sugut and Tungud watersheds respectively of north-eastern Sabah. The former was within a series of steep, parallel ridges rarely rising to more than 2,000 feet, while the latter was on a steep hillside rising to over 3,000 feet. In the south of the state, surveys were done at Samantulong (1,600 feet) and Ulu Sapulut (1,400 feet), on the eastern and western flanks respectively of the Kuamut Highlands. The former site, with small streams, deep gullies and upland-type forest-cover was counted as an upland site although altitude was rather high. The latter site was an area of shallow hills, large meandering rivers and an abundance of trees (dipterocarps, mengaris, belian) normally associated with lowland forests.

Plate 7. Primary lowland dipterocarp forest. Trees which have fallen naturally are broken down by micro-organisms, thereby releasing nutrients back into the soil.

Plate 8. [illegible] of the Jabal Akhdar Department takes a compass bearing to locate the position of a distant [illegible] during [illegible].

The three highland dipterocarp sites were in the Crocker Range. Two surveys were done in the northern extension of Kinabalu National Park, at Langui Langui (2,500 feet) and Gunung Madalon (2,600 feet), and one in the Crocker Range Forest Reserve at Ulu Losan (2,200 feet). In addition to indicating the effects of altitude on wildlife, these areas were subjected to hunting pressure and their value as conservation areas for mammals and birds needed verification. Another survey was done in the Crocker Range at Ulu Kimanis (3,500 feet), in lower montane forest on steep terrain. The area surveyed intensively at Bukit Ibul (3,700 feet) in the Maligan Range differed from the Ulu Kimanis site in having gentle slopes, forest intermediate in character between highland dipterocarp and lower montane, and a high density of large strangling figs.

(2) Exploited Habitats

Given the extensive and major changes in habitat that have occurred and continue to occur in Sabah (outlined in previous sections), it is insufficient to investigate only pristine habitats. The effects of the various forms of human disturbance to habitat on wildlife must be known before long-term wildlife conservation policies can be drawn up. Seven intensive surveys were done in areas that had experienced various kinds of habitat alteration.

Two surveys were done in Virgin Jungle Reserves of primary lowland dipterocarp forest, each less than 500 ha. in extent, and both within extensive areas of logged forest in the process of being converted to permanent monoculture. These two surveys were intended to assess the conservation importance of primary forest "pockets", into which mammals and birds might migrate from surrounding disturbance. Lungmanis (200 feet) is in the Lokan Peneplain region, while Gomantong (300 feet), in the Kinabatangan lowlands, contains caves in which breed the "edible bird's nest" cave swiftlets.

In order to assess the effects of logging on mammal and bird populations in dipterocarp forests, two surveys

were done in logged upland dipterocarp forest near to sites where surveys had also been done in primary dipterocarp forest. The two survey sites were selected because they are within the only two areas in Sabah where logging was done in the uplands more than fifteen years ago, using modern methods with heavy machinery. Since our aim was to assess the long-term effects of logging, and the regeneration process which follows logging is very slow, more recently logged sites would not have yielded appropriate data. The Malubuk site (600 feet) in central Sabah was logged in 1965 (using D7-E tractors; tree extraction intensity said to have averaged about 10 trees per ha.) and the Bakapit site (650 feet), on the south side of the Dent Hills, in 1962 (using high lead yarding and tractors; tree extraction intensity said to have averaged about 8 trees per ha.). No intensive surveys were done in logged forest in the flatter lowlands for two reasons. Firstly, almost all such sites have been re-logged more recently and suffered extremely heavy disturbance, and secondly, all such lowland areas are designated for agricultural development and have little potential as long-term conservation areas. There is still a need, however, for a thorough investigation of the effects of logging on wildlife in Sabah (Section 4.3.1.).

A site containing the patchwork of primary forest and regenerating forest associated with shifting cultivation was surveyed at Sungai Langut (300 feet), near Pinangah in the upper Kinabatangan River system. The site was dominated by Macaranga trees where tapioca and other crops had been planted up to about five years previously, with primary dipterocarp forest, slightly disturbed by occasional removal of tall trees for building perahu (dugout boats), on surrounding slopes. Another survey was done in Sabah's oldest extensive cocoa plantation (planted between 10-25 years ago) at Bal Estates, near Tawau, now part of a large area of monoculture plantations and small-holdings.

It seems likely that plantations of fast-growing, exotic trees will be a major source of wood products from Sabah in the future. A survey was done at Sabah Softwoods Plantation in the Brumas area, south-eastern

Sabah, to find out which animals are adapting to stands of Albizzia falcataria, Eucalyptus deglupta and Gmelina arborea. The survey was done in stands 5-7 years old, soon to be cut.

3.1.3. Extensive Surveys

Although intensive surveys provided the bulk of the field data, and were the basis for identifying differences between habitats of relevance to wildlife conservation, they could not provide information on the distribution or population densities of rare, large mammals which range over much larger areas than those investigated during intensive surveys. Extensive surveys were done primarily to identify the presence of such species and to collect more detailed information opportunistically wherever possible. Extensive surveys were done for data on elephants, rhinos, tembadau, proboscis monkeys, silvered leaf monkeys and also the estuarine crocodile.

The field procedure for extensive surveys varied considerably according to which species was of most interest and to the type of transport available, if any. In general, short periods were spent in each of several places where the species of interest had been reported or were expected to occur. Extensive areas were traversed, either on foot, or by Landcruiser, timber company transport or boats. People living or working locally were interviewed, and signs of the animals sought.

Surveys were done in mangrove/nipah in search of proboscis monkeys, silvered leaf monkeys and crocodiles. Areas investigated were the Klias Peninsula (the only extensive area of mangrove on Sabah's west coast), the Kinabatangan Delta area particularly around Dewhurst Bay, and the Sugut Estuary. The Kretam area, known from old reports to have been exceptionally rich in wildlife, was investigated by driving and walking extensively on old logging roads, now being used as access routes for agricultural development. Elephants were sought specifically in the Segaliud-Lokan area to the west of the Sandakan

Peninsula, in an attempt to assess numbers and ranging, and in the Suqut-Paitan area to confirm whether or not the species occurs to the north of the Labuk River. Extensive surveys were done in the Silabukan area (primarily for rhinos) and at Tanjung Linsang (primarily for tembadau).

Three parts of Tawau Hills National Park were surveyed: — a logged area on both the east and west sides, and a transect through primary forest from the southern edge to the centre. Another extensive survey was done in the Tambunan area of the Crocker Range, a hilly area with long-standing hunting and shifting cultivation. A brief survey was done in the upper (western) part of Danum Valley.

Finally, two surveys were done at the request of other parties. The Mananam Plain was surveyed during a period when consultants were drawing up a regional development plan for this area. Ulu Tiulon was investigated to give data on mammals and birds to the Forest Department's Ecologist as part of a pre-logging inventory for an area in the Witti Range where the effects of logging are being studied.

3.2. DATA COLLECTION

Data from direct observations were obtained by surveyors walking quietly and slowly, alert for visual, auditory and olfactory cues which would reveal the presence of an animal. Birds and smaller mammals were usually identified with the aid of binoculars. Sketches were made of unfamiliar species for later identification. Binoculars were useful for more detailed information even on large mammals. All observations were written directly into a field note-book. The following data were recorded:-

(1) Date

(2) Time of day

(3) Species identified

(4) Evidence or sign:
- direct sighting of the animal
- sighting after seeing movements or hearing call
- species-specific calls or noises
- tracks of ungulates and other large mammals
- claw marks (honey bear)
- nests (orang-utan)
- hair, quills or feathers
- odour (moonrat and teledu)
- corpses or skins
- animals trapped or netted

Where possible, the age of tracks and other such signs was estimated.

(5) Number of individuals. Usually, only a minimum could be estimated from sighting the animals or their movements, or from tracks.

(6) Age and sex. Such information was noted if possible, and was useful for identifying groups which might be encountered more than once.

(7) Map reference. Locations were recorded as grid co-ordinates based on the Dutch East Indies metric (10 km. sq.) grid. This grid was marked on all 1:50,000 topographical maps used during surveys.

(8) Ecological data. Heights above the ground were recorded for arboreal species. Use of salt sources and wallows was noted. The identity of any foods seen eaten was recorded, if possible to species level.

These data were transcribed from field note-books to primary data sheets, devised especially for the Faunal Survey and copies of which are stored in the Forest Department Headquarters, Sandakan and in the Sabah State Archives, Kota Kinabalu. Species distributions, according to the data collected during the Faunal Survey, were plotted on to maps of Sabah with a 10 km. square super-imposed grid.

3.3. ESTIMATION OF ABUNDANCE

In addition to the information stored on primary data sheets, other measures were taken to allow estimation of the number of individuals of a species either in Sabah or per unit area of habitat. Visibility is so poor in Sabah's forest habitats that it is not possible, at least in a period of less than two weeks, to count the actual number of individuals in a defined area. Estimation of abundance is based inevitably on incomplete counts and on assumptions. All absolute estimates presented in this report are approximate, being based on best available data, and all comparisons should be regarded as showing trends rather than precise estimates.

3.3.1. Large Mammals

The distribution through Sabah of elephants, rhinos and tembadau is highly uneven, as is the dispersion of individuals and herds, even in relatively homogeneous habitats. Without adequate time to conduct long-term, single-species studies, information was gathered on a somewhat opportunistic basis. Usually, the approximate location of these species was deduced from talking to local people. Searches were then made for the animals or their signs in whatever way was most suitable for the situation.

Rhinos were never seen, and attempts to identify individuals were made by measuring a sample of between-toe distances of hindfoot tracks. This method was adequate, when the results of Faunal Survey team work and other subsequent surveys were combined, to give an estimate of the minimum number of rhinos in the Silabukan area. Elsewhere, all but two records of rhinos were obtained from numerous discussions with local people, and by Wildlife Rangers investigating specific reports. Only reports backed by good descriptions of the rhino or its signs were accepted from local people. The rhino is of sufficient interest to people throughout Sabah (due to the high value of the horns) that the presence

of this species seems to be known to at least someone, whenever they occur. This factor, combined with their obvious rarity, allowed a minimum estimate of numbers to be made for the whole of Sabah.

Much information was obtained on the location and, often, the size of elephant herds, both from written FD(WS) reports and from talking to local people. Direct observations, by Faunal Survey teams, of elephants in the Segaliud-Lokan, Kretam and Silabukan areas agreed with the main features of such reports made by other people in the same areas. Reliable herd size estimates of greater than about five individuals could not be made from measuring tracks.

Estimates of the total Sabah elephant population were made, therefore, by combining available post-1978 records of sightings of groups and solitary males. Without a detailed long-term study, the relative importance of accounting for the same groups twice and of missing groups totally cannot be assessed.

The number of tembadau in Sabah was estimated in the same way, except that these animals are much less often seen than elephants and there are fewer estimates of group size, so the overall estimate is correspondingly less accurate. Reports of feral cattle and cattle/tembadau hybrids were distinguished by asking informants to describe the animals that they had seen. As is the case with elephants, small groups periodically merge to form big groups. Reports of the larger groups only were used in making the total estimate which, even allowing for double-counting, is believed to be a minimum.

Estimates of the average population densities of clouded leopard and honey bear in extensive tracts of dipterocarp forest habitat were made by combining the results of appropriate intensive and extensive surveys (as described in Section 4.2.1.). No estimates were made for the whole State.

3.3.2. Primates

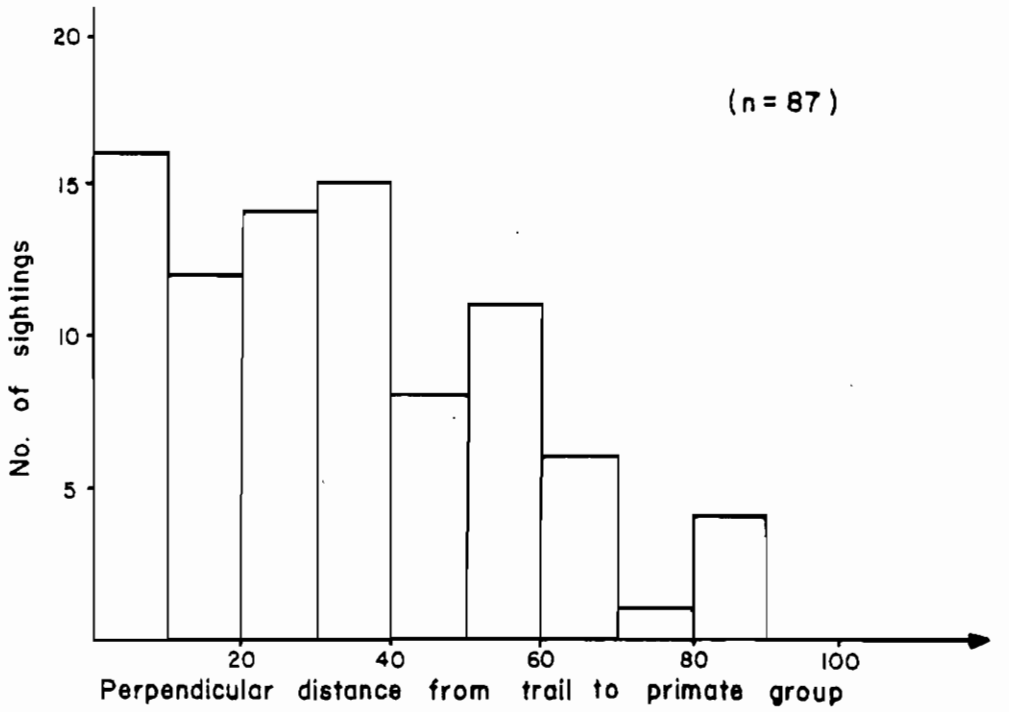
Diurnal primates, excluding the proboscis monkey and silvered leaf monkey, were detected commonly enough on some intensive surveys to use a line transect method for population density estimates. These estimates were the most accurate obtained using Faunal Survey data, and allowed realistic comparison between sites.

The basic principle behind the method was to count the number of primate groups encountered while walking along a trail. The area surveyed is calculated by multiplying the total length of trail walked by the width of a strip of habitat on either side of the trail within which all groups present were detected. Techniques have been developed to calculate the appropriate strip width by estimating the likelihood of detecting groups at increasing distances from the trail or observer.

The most accurate method of calculating strip width is the so-called "Emlen Method". For this, the distance is measured between the path and a detected group. By plotting a large number of these sighting distances it is possible to show a high number of detections near to the trail which corresponds to 100% probability of detecting a group within that distance from the trail. The effective strip width is calculated by finding the distance Xm. on either side of the trail, beyond which the number of sightings of groups exactly compensates for the number of group less than Xm. away that are undetected. This method depends on a strip within which there was 100% detection of groups being recorded, which is not the case for the data collected during this survey (Figure 2a).

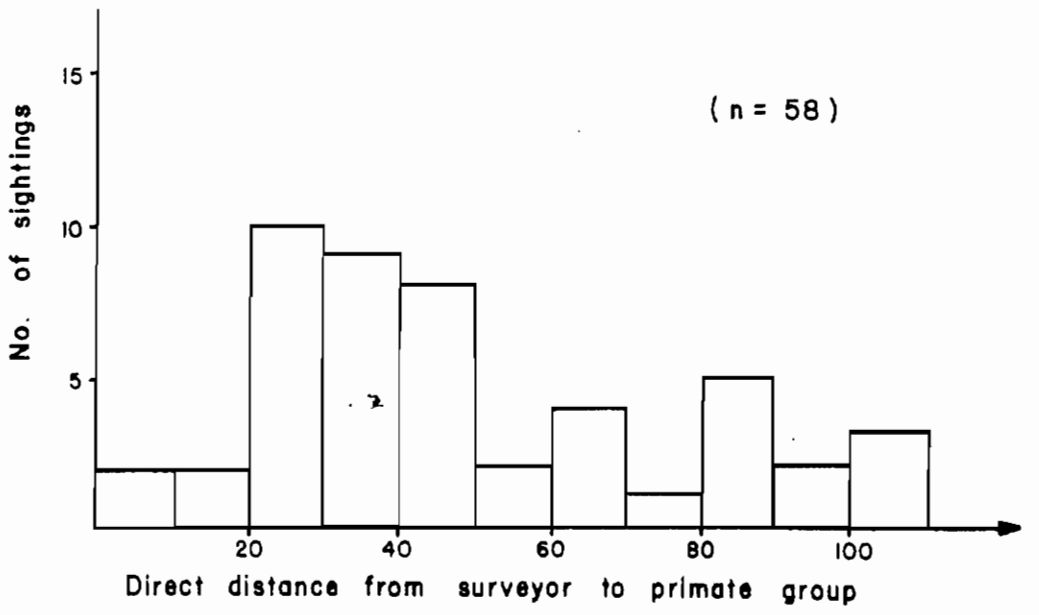
A larger sample size would have improved the accuracy of the calculations of effective strip width, but so few primates were observed during intensive surveys (mean: 6.6 groups/survey) and some species (notably macaques) were seen extremely rarely, that a very prolonged survey would be required. This was incompatible with the need to survey a large number of areas for many species. The "King Method" was used instead of the Emlen Method, in which the effective strip width is cal-

Figure 2a



It is not possible to calculate the 100% detection distance, nor Xm, from the above histogram because there is no indication that within a given distance of the trail all groups present will be seen.

Figure 2b



From the data shown on this histogram, an effective strip width, on one side of trail was calculated to be 39.6m.

culated using a decreased detectability with distance between the primate group and the observer. Observer-to-group detection distances were summed from six survey sites (Figure 2b) and the effective strip width on one side of the trail was 39.6 m. A strip width of 80 m. would be used in density calculations, since primates are detected on both sides of the trail.

There were various biases influencing the likelihood of detecting primates during surveys. A major factor is the dispersion of groups, which may be influenced greatly by the dispersion of trees fruiting at the time of the survey. This was compensated for to a certain extent by combining the results of several surveys in one habitat type to give an average. Other factors include the time of day and the behaviour of the animals. Some species were cryptic either at all sites or only in areas where hunting was common. Primates may often detect the surveyor before they are detected by him. It was not possible with the data available to compensate for such biases and no efforts were made to improve the accuracy of estimating the effective strip width at each site. A strip width of 80 m. was used throughout for calculations of population density. This gave results for population densities in different areas which correspond closely with subjective impressions gained during the survey. Further evidence for reliability of this method, given inherent biases and small sample sizes, comes from comparing population density estimates calculated from Faunal Survey data with those made by other researchers. The orang-utan densities at Bole Kecil and Kawag in 1980 corresponded to those of MacKinnon (16) for the same area in 1969. Red leaf monkey population density estimated for Sepilok also corresponded well with known home range size of this species in the same area. Finally, the densities of grey leaf monkeys in areas where they were common were similar to estimates made by Rodman (17) in similar forest at Kutai, Kalimantan.

Gibbons call loudly and frequently from fixed territories. By plotting all the calls heard in an area

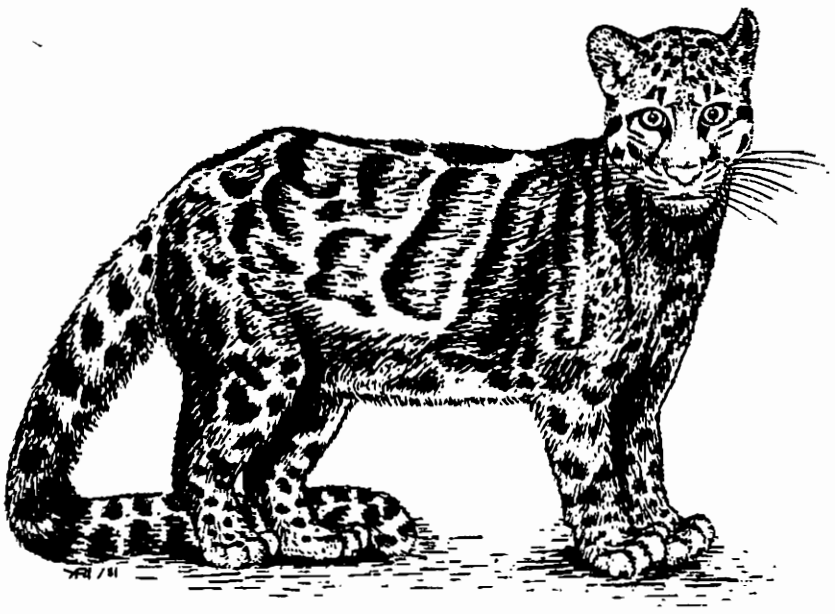
during the course of an intensive survey it was possible to estimate the minimum number of these animals in a known area. Variables such as weather may affect calling frequency, but over a period of five or more days, most individuals are expected to call. To plot the location of calling gibbons, compass bearings were taken from measured points on the trail. The distance to the calling gibbon was estimated where possible, or a cross bearing taken from another point for more accurate plotting of calls. To assess the size of the area sampled, a 500 m. strip on either side of the trail was used, since all groups calling within this distance should be heard. Any groups whose calls were located within the area half-way inside this sample area were counted as half-groups, while groups calling outside the area were ignored. This method of estimating abundance is suitable only for gibbons and also for argus pheasants.

3.3.3. Other mammals and birds

It was not possible to estimate the absolute abundance or population densities of species other than those described in the fore-going discussions. By recording the number of observations (sightings or other signs) of each species for each survey, it was possible to compare the relative abundance of some species between survey sites. A 3-point scale of relative abundance (1, one observation; 2, two to four observations; 3, five or more observations) was used in routine survey reports. Given such small numbers of observations, however, it was decided later that a 2-point estimate of abundance is more appropriate: 1, rare, - one or two observations; 2, common, - more than two observations. Also, 0 is used to indicate that a species is present, but the number of observations probably do not reflect its relative abundance, such as is the case with small and nocturnal mammals (see Appendix 3).

No attempts were made to estimate the relative abundance of birds at intensive surveys sites, other than argus pheasants (described above) and hornbills, which are conspicuous enough to be detected readily by sightings or calls.

4. THE RESULTS



Clouded Leopard

4.1. INTRODUCTION

The basic results of the Faunal Survey are tabulated in Appendices 2-6.

The results are interpreted and discussed more fully in the following sections. The ecology, distribution and abundance of certain species is outlined in The Status of Mammal and Bird Species (Section 4.2). The species distribution maps included in this section are based on Faunal Survey data, with some older (pre-1978) records where precise location information is available. Logging, agriculture and hunting are discussed with reference to wildlife in Section 4.3.

4.2. THE STATUS OF MAMMAL AND BIRD SPECIES

Mammals and birds are discussed under the four headings of: Endangered, Vulnerable and Rare Mammals (definitions conforming to the I.U.C.N. Survival Service Commission definitions; see Appendix 2), Primates, Other Mammals and Birds.

4.2.1. Endangered, Vulnerable and Rare Mammals

(1) THE SUMATRAN or TWO-HORNED ASIATIC RHINOCEROS
(Dicerorhinus sumatrensis)
Family: Rhinocerotidae
Order: Perissodactyla

The one-horned Asiatic rhinoceros (Rhinoceros sundaicus) has not been recorded in Borneo and there is no evidence that it ever existed on the island. The tapir (Tapirus indicus) did once occur in Borneo, possibly until recently. No good evidence was obtained during the Faunal Survey of this species being seen within living memory. All three-toed footprints measured during the Faunal Survey conform in width and shape with those expected of the Sumatran rhino. Five informants who have obtained clear

views of rhinos in three separate areas (Silabukan, Kretam, Sugut) stated independently that the rhinos bore two horns. In this report, we assume that all forms of evidence - verbal information, written reports and footprints - are of the Sumatran rhino (Dicerorhinus sumatrensis).

Ecology

The Sumatran rhino is active mainly around dawn, dusk and at night-time. It lives alone for most of the time, but sometimes travels in pairs and the Faunal Survey received several independent reports of two and three rhinos being seen together in the Silabukan area.

In West Malaysian habitat (18) similar to that in which most of Sabah's rhinos exist, the diet consists predominantly of the leaves and twigs of woody saplings. In a 3,500 ha. study area in primary upland-highland dipterocarp forest, 97% of rhino food plants are woody saplings. Among 321 plants eaten by rhinos, there were more than 147 species and 48 plant families. About 75% of food consumed is mature leaves and 20% small stems. A little fallen fruit is eaten.

It is not clear whether the Sumatran rhino is able to tolerate a diverse array of food plants, and could exist on a diet of much lower diversity if necessary, or whether this rhino selects a diverse diet out of necessity. The success of conservation measures for this species depends partly on which of the two possibilities is true, given that logging causes a great reduction in the diversity of rhino food plants.

One environmental factor which in Sabah appears to be of great importance to rhinos is the availability of mineral salts for consumption, in the form of natural salt-water springs, salt licks, "mud volcanoes" or sea water. The past and present distribution of rhinos in Sabah is correlated closely with the distribution of such salt sources and is not correlated with habitat type except insofar as rhinos are now absent from areas where there has been long-standing human activity. Of 25 accurate and independent records of rhinos obtained during the Faunal Survey, the median straight-line distance of

the rhino from the nearest known salt source was 5½ km. (range 0-14 km). The mineral sought by the rhinos might be sodium, but there are other possibilities (see Map 10).

Several aspects of rhino behaviour suggest that they endeavour at all times to avoid becoming hot. They obviously tend to stay in undisturbed forests, away from recently logged forest and only return after the tree canopy has begun to grow over. They appear to follow and cross streams very frequently. During the day-time, they spend much time resting in mud wallows (which they maintain by gouging soil with their horns) or on ridge tops which catch the breeze.

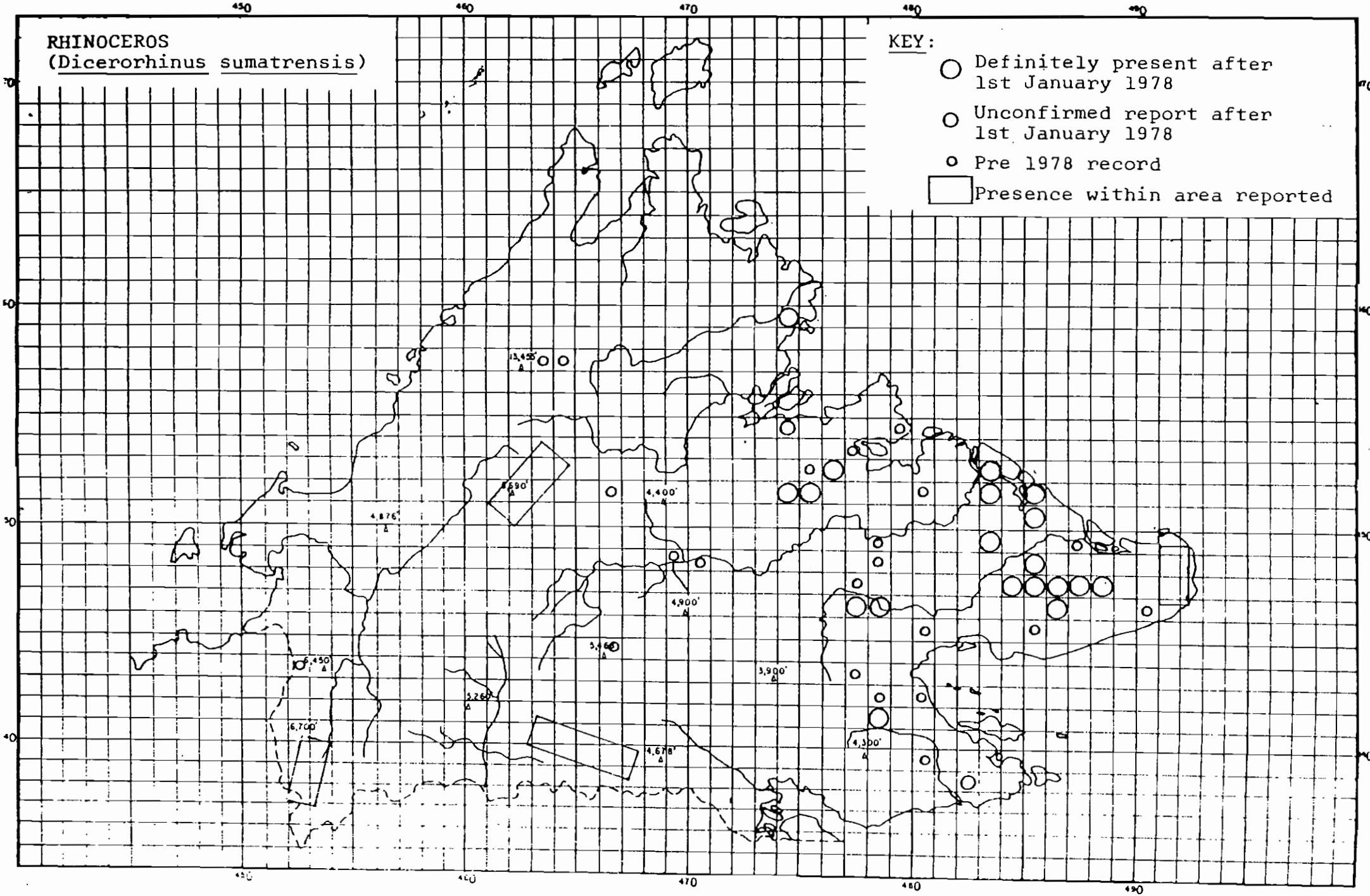
The rhino in Sabah is renowned for fleeing from human disturbance and staying inside forest cover. Reports by people encountering rhinos indicate that they do not tend to flee from man any more than do other ungulates. The scarcity of sightings is a result of rarity and absence from areas disturbed by man, and not of "shyness".

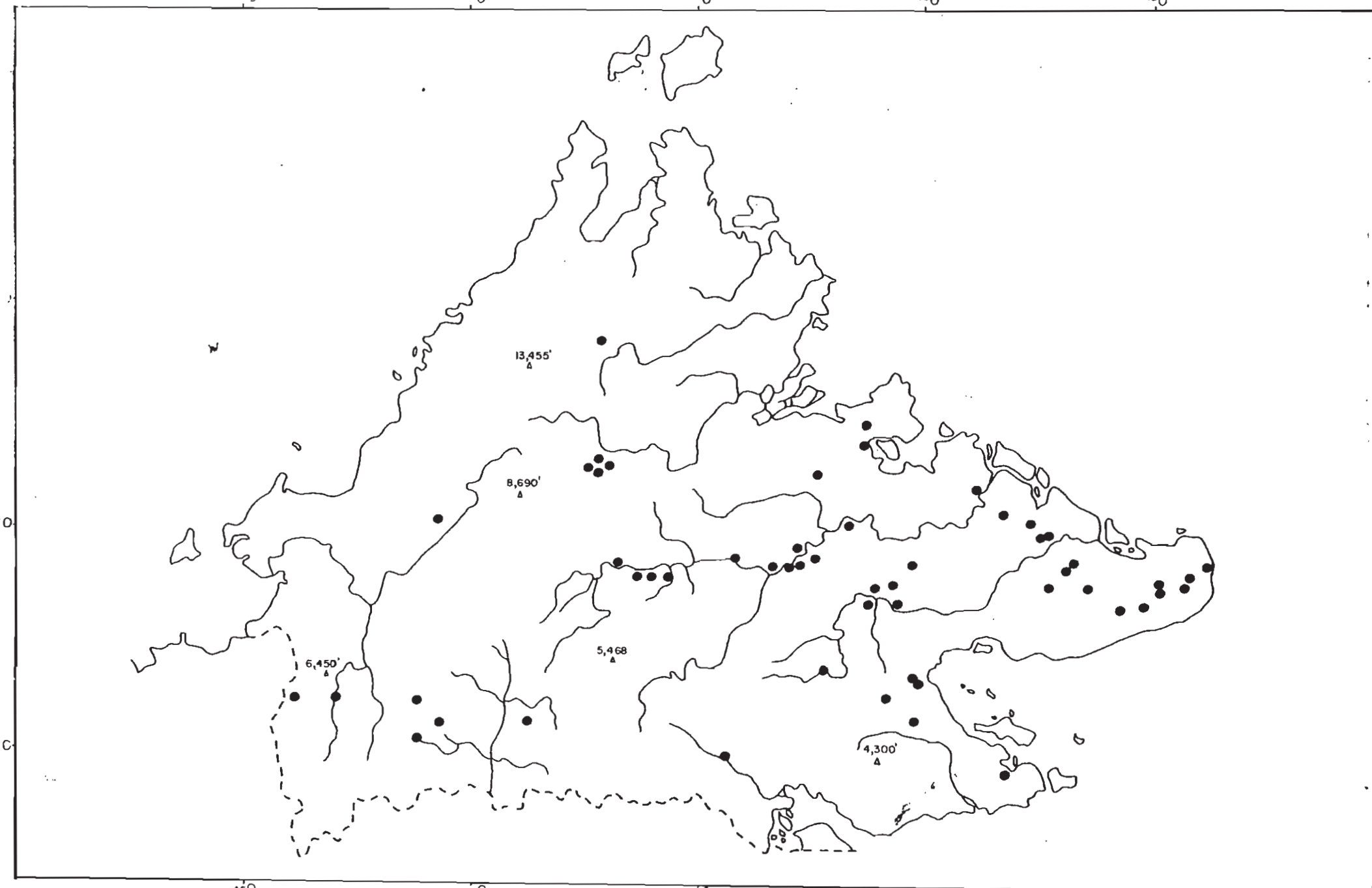
Throughout South-east Asia, this rhino species lives mainly in primary forest. In Sabah there are rhinos currently living either entirely or mainly in logged lowland and upland dipterocarp forest, as well as primary forest. There are salt sources in all such logged forest.

Distribution and Abundance

It appears that rhinos no longer exist in the western parts of Sabah. The last reliable record from the Maligan Range dates from the mid 1960's, although there is one more recent unconfirmed report from Ulu Padas in the south-western corner of Sabah. There are no records from the Crocker Range. It is possible that a very few remain in the remote central part of Kinabalu National Park, but the lack of any reports for the past twenty years suggests not. Human disturbance, largely in the form of hunting is probably the factor which has resulted in no rhinos occurring in these areas.

There is only one place north of the Labuk River from which there are recent, reliable reports. This is the uninhabited, largely logged over area in the Lower


RHINOCEROS
(Dicerorhinus sumatrensis)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
Presence within area reported
450
460
470
480
490
50
40
30
13,455'
4,400'
4,876'
4,900'
5,460'
5,450'
5,260'
6,700'
4,678'
3,900'
4,300'



MAP 10. DISTRIBUTION OF NATURAL SALT SOURCES

Sugut, the last record dating from 1979. The best access point to this area is widely believed by the people of the Sugut River to be haunted and they prefer not to stay overnight. There can be only a very few here, possibly only one rhino.

There are several reports from the Trus Madi Range, but the latest date from the 1960's, when at least two were killed there. Since that time, there has been a tendency for hill-dwelling people to move down to the new roads, and logging has started only recently. The Faunal Survey did not cover this Range, so it is possible that a few rhinos remain.

The largest unexplored region of Sabah is the Kuamut Highlands. The region is uninhabited, although in the nineteenth century Murut people lived along some of the rivers near the Kalimantan border. Logging has occurred only in the northern and eastern parts. This region may contain rhinos.

The eastern lowlands and uplands contain most of Sabah's rhinos. Danum Valley, in the headwaters of the Segama River, is believed to contain rhinos, but there is no definite evidence. East of a line between the mouths of the Labuk and Kalabakan Rivers, there are rhinos in at least five separate areas. The Silabukan area, in the middle of the Dent Peninsula is the most important rhino area. Preliminary surveys suggest that at least 7 and possibly 12 or more rhinos survive here. There were at least two young rhinos using this area during the Faunal Survey (although one was subsequently killed), and this is the only known breeding population in Borneo. There are other rhinos scattered in several other parts of eastern Sabah, now being opened up or due to be opened up for agriculture.

There are at least 15 rhinos in Sabah and the actual number is more likely to be about 30. More than half the total Sabah population, however, has almost no chance of contributing to the species' survival if they remain isolated from each other as they are now.

There is no reliable information on the area of

forest required by one rhino. Studies in a montane habitat in northern Sumatra suggest that one individual ranges in an area of at least 40-50 sq. km. (19,20). One Iban man who has worked in the Silabukan area since the 1940's claims to be able to recognise the tracks of one particular rhino by the right hind foot being bent outwards. If his claims are reliable then the rhino must live in an area of at least 90 sq. km.

Approximate rhino population densities are as follows:-

(1) 1 rhino/20 sq. km. in primary montane forest with 5 known salt licks, northern Sumatra (20).

(2) 1 rhino/40 sq. km. in primary upland dipterocarp forest with no known salt licks in Peninsular Malaysia (18).

(3) (Preliminary surveys only), 1 rhino/30-60 sq. km. in lowland-upland dipterocarp forest, about one third logged, with five known salt sources in Silabukan, Sabah.

(2) TEMBADAU or BANTENG (Bos javanicus)
Family: Bovidae
Order: Artiodactyla

In some areas, reports from local people and hunters indicate that at least some of the "Tembadau" are cross-breeds with feral cattle, or even pure feral domestic cattle. These animals are not considered in the following discussions.

Ecology

The banteng, or tembadau as it is generally known throughout Sabah, is a species of wild cattle which was formerly distributed throughout much of South-east Asia. In Sabah, tembadau live mainly but not exclusively on flat or gently sloping terrain. Primarily, they graze on grasses and herbs, but they also browse on bushes and small trees. In Tawau, Bali Cattle (a domesticated form of the Tembadau originating from Bali) take more browse than other forms of domestic cattle and put on weight more quickly. Tembadau depended on man in many areas in the

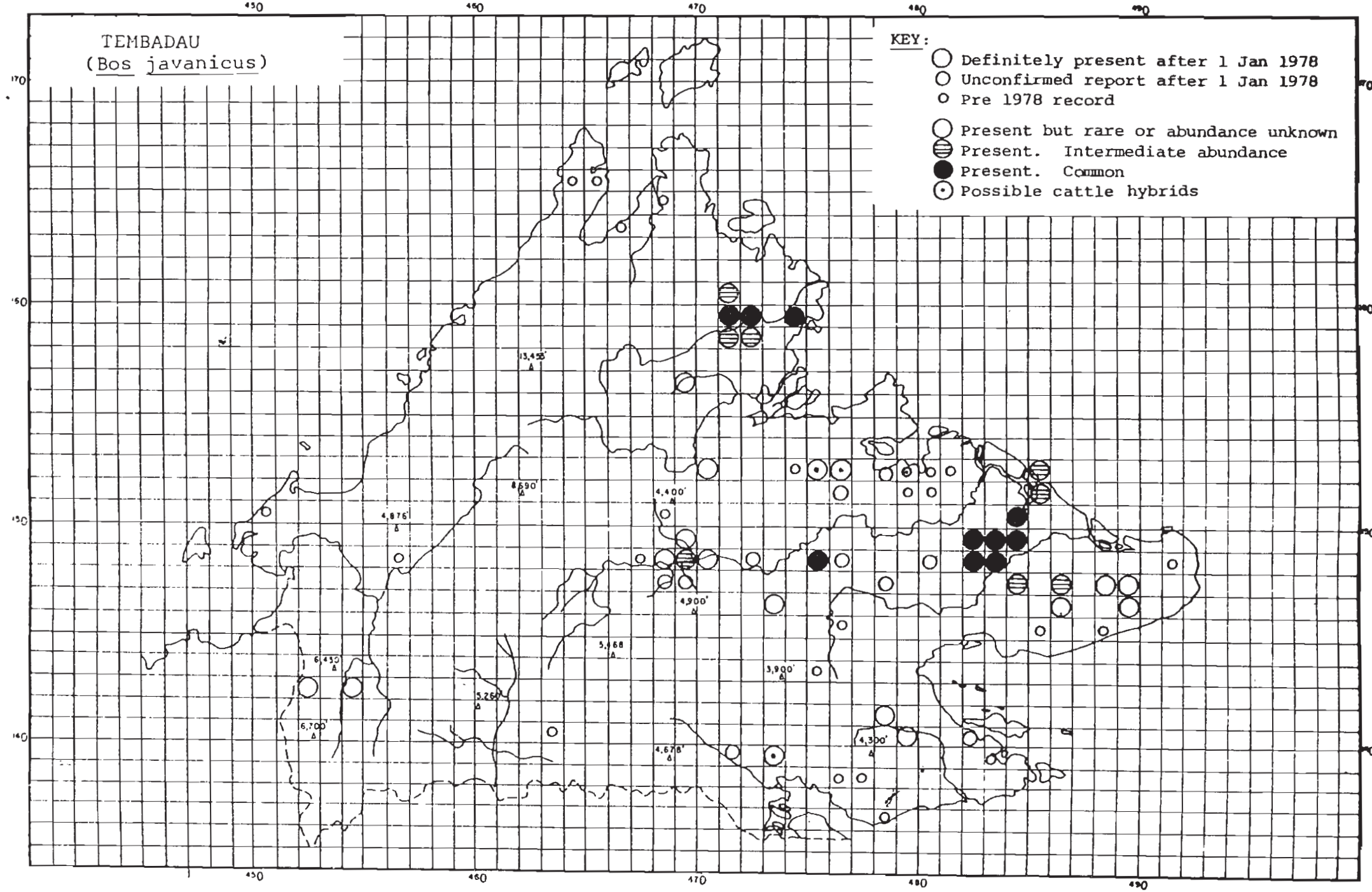
past, living on the grasses and other secondary growth left after cultivated areas had been abandoned. In Sabah, they visit all kinds of natural salt sources to obtain supplementary salt. In the Maligan Range, domestic cattle were observed licking the ash after Murut people had burned the vegetation prior to planting hill rice; possibly, tembadau benefited formerly in this way from the activity of shifting cultivators.

In Sabah today, adult female and young tembadau generally live in groups of 2 to 7 or more, sometimes accompanied by one adult bull. In at least three areas, they still congregate into herds of 30-40. Some bulls live alone and associate with the herds for brief periods.

Distribution and Abundance

In the past, tembadau were distributed throughout most of Sabah (for example, 21,22 and the British North Borneo Herald through the late nineteenth and early twentieth centuries). During the twentieth century, the widespread use of guns (particularly during and after World War 2), probably coupled with a decrease in the extent of shifting cultivation being practised in more remote areas, has led to a significant reduction in distribution. Now, tembadau are common only in parts of the eastern lowlands and there are small numbers scattered throughout the more hilly central areas of Sabah. Evidence was found in only one part of the western hill ranges of small numbers of surviving tembadau (Maligan Range).

Three areas where herds of 30-40 have been seen recently are Kretam, Bukit Kumbaun (south side of Lower Sugut) and between the Paitan and Sugut Rivers. Equally large concentrations of tembadau probably occur in the Labian and Kinabatangan Lowlands and between the middle reaches of the Tingkayu and Kalumpang Rivers. The latter two areas have been subjected to much hunting, however, over the past 15 years. If all recent records of tembadau are combined and herd size is estimated from local observers' reports in multiples of 5 (minimum of 5, maximum of 40), then a total figure of at least 300 is obtained with


TEMBADAU
(Bos javanicus)
KEY:
Definitely present after 1 Jan 1978
Unconfirmed report after 1 Jan 1978
Pre 1978 record
Present but rare or abundance unknown
Present. Intermediate abundance
Present. Common
Possible cattle hybrids
450
460
470
480
490
170
150
130
140
13,455'
8,690'
4,876'
4,400'
4,900'
5,168'
6,430'
5,260'
6,700'
3,900'
4,300'
4,678'

conservative estimates. A more generous estimate, rounding up figures for little-known areas gives a figure of 550. In the absence of better information, our estimate is that there are at least 300-550 tembadau in Sabah.

(3) ELEPHANT (Elephas maximus)
Family: Elephantidae
Order: Proboscidae

Ecology

As is the case elsewhere in Asia, elephants in Sabah feed mainly on monocotyledonous plants - palms, grasses, bamboos, bananas - supplemented with herbs, shrubs, and the leaves or bark of some trees. In Peninsular Malaysia, palms and grasses constitute about 75% of the diet, and a comparison of the amount eaten with the amount available in the environment indicates that grasses are the most preferred food (23). Clearly, primary dipterocarp forest is not an ideal habitat for the elephants, because the major food types are rare and patchily distributed.

In Sabah, elephants visit natural salt sources. The presence of these salt sources appears to exert a considerable influence on the ranging behaviour of elephants.

As in Peninsular Malaysia, the basic unit of elephant social organisation in Sabah appears to be the "family unit" consisting of one or more related females with their immature offspring, totalling about 3-12 individuals. These family units travel and feed alone for some of the time but periodically group together to form herds of up to 50, occasionally in some areas (according to unconfirmed reports) up to 100. Adult bulls are encountered alone, singly or in groups of 2 or 3, and sometimes in the vicinity of/or accompanying family units of female/young herds.

There is some evidence from Peninsular Malaysia that female/young herds travel more slowly and have smaller ranges in secondary dipterocarp forest than in primary forest. In both habitat types, solitary males seem to have smaller ranges than female/young herds (23). Elephants travel substantial distances out of forest only

during or immediately after periods of heavy rainfall. They feed in open areas such as roadsides and plantations after dusk, except on cloudy, cool days when they may come out of the forest as early as 1500 hours.

Distribution and Abundance

Elephants are restricted in Borneo to the north-east part of the island. Their present distribution in Sabah can now be fairly accurately demarcated. Periodic reports of elephants apparently outside the usual species range towards the western periphery appear to be of solitary bulls or small herds making temporary excursions.

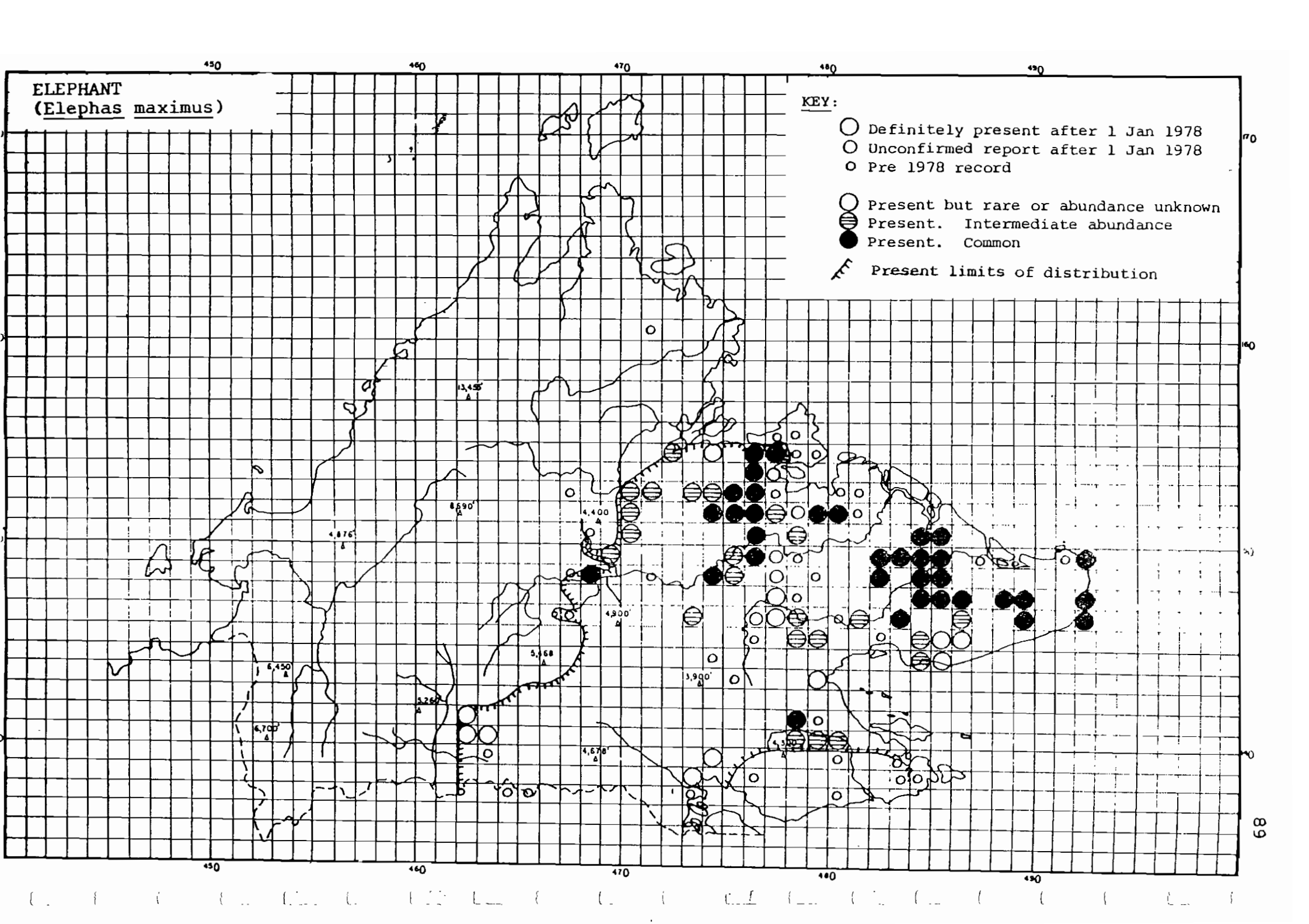
The species range has declined with the spread of large-scale agriculture and elephants are now absent from the Sandakan area and the south-eastern part of Sabah where such agricultural development started in the early years of this century.

During the period 1952-56, signs of elephants were found by at least two reliable Forest Department informants far outside the usual species range, between Paitan and Pantai Boring. No-one who actually saw these elephants can be traced but the reported tracks indicated the presence of two adults. Extensive enquiries by the Faunal Survey throughout the region revealed that no local people have encountered elephants north of the Labuk River. The most plausible explanation is that two elephants wandered far from the main population and either died there or returned in the late 1950's. The importance of this record is that it indicates that there is no physical barrier totally preventing the movement of elephants into the extensive lowland area north of the Labuk River.

There are at least three possible explanations which may account for the strange distribution on elephants in Borneo:-

(1) Elephants were introduced to Borneo by man in recent times

It is recorded that some elephants were released by the Sultan of Sulu in the eighteenth century on the east coast of Sabah (24). The possibility that native


ELEPHANT
(Elephas maximus)
KEY:
Definitely present after 1 Jan 1978
Unconfirmed report after 1 Jan 1978
Pre 1978 record
Present but rare or abundance unknown
Present. Intermediate abundance
Present. Common
Present limits of distribution
450
460
470
480
490
170
160
150
13,455'
8,690'
4,876'
4,400'
4,900'
5,168'
6,450'
3,900'
3,260'
6,700'
4,678'

elephants were present before this time is unresolved. A single fossil molar tooth of Elephas maximus has been identified from a cave in Brunei (25), but it is conceivable that this was brought to Borneo by man. Ivory was imported into China from Borneo (among many other places) by Arab traders in the middle ages (24) but it is possible that this ivory was obtained from traders in Borneo. Tame elephants were seen in Brunei by Portugese explorers in 1521, but again these may have been imported (24).

(2) Elephants were once more widely distributed in Borneo but were exterminated by man

Hunting peoples have existed in Borneo for at least 35,000 years (26). In Sabah, elephants are distributed only in those areas where there has been little or no human settlement until the twentieth century. Given that elephants would have existed at low population densities and come into conflict with man by eating cultivated crops, it is possible that over a period of thousands of years, hunting people could have exterminated elephants from extensive areas. Until 1957, a man named Linsanad, who was believed to use special charms, lived in Tongud (Ulu Kinabatangan) and sometimes led small parties of men armed with spears to kill crop-raiding elephants. Rhinos, which are more difficult to find or approach than elephants, have been exterminated throughout most of Borneo by men using spears.

(3) Elephants are limited by the availability of one or more minerals in the environment

The availability of various minerals in Borneo soils is patchy and low in many areas. Several studies in North America and Africa have indicated that large mammals, including elephants, visit particular localities to obtain sodium salts. Apart from topographical factors and the possibility that elephants have been exterminated in Borneo by man, the distribution of elephants in Sabah, especially female/young herds, is correlated closely with the distribution of known salt sources.

The distribution of adult bull elephants in Sabah is somewhat more widespread than that of the female/young herds. Bulls also traverse more hilly terrain and unlike

female/young herds, commonly venture into gardens where they eat bananas, papayas, maize and the bark of terap trees (Artocarpus sp.).

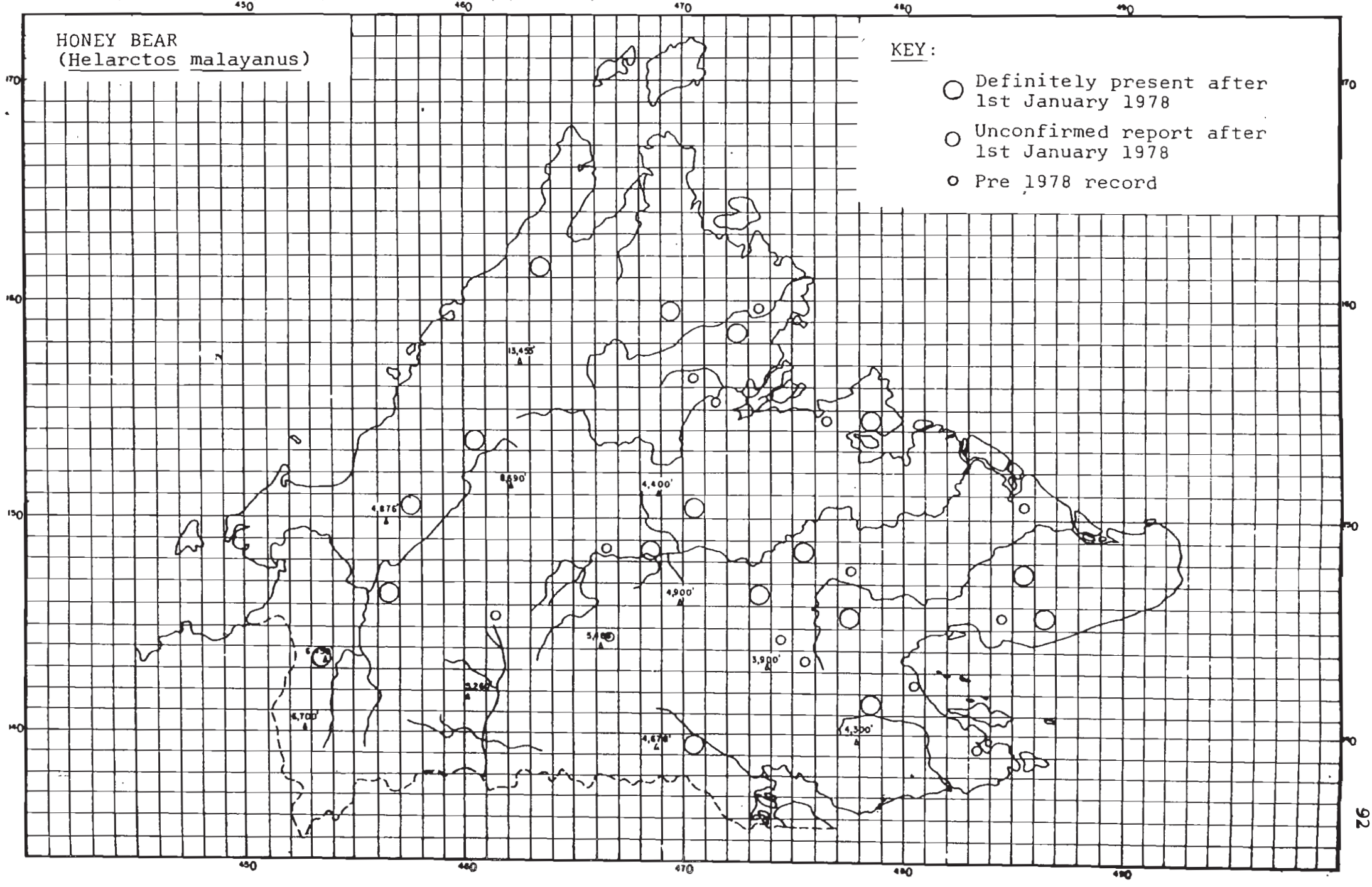
The number of elephants in Sabah has been estimated by more than one Forest Department officer as about 2,000 (earliest estimate, 1949), and more recently as 500-2,000 (27). A minimum estimate, derived by combining definite post 1978 records of herds and a conservative estimate for unknown forested areas, is 450 individuals. A more realistic estimate, which does not assume that all individuals are detected in known areas and makes a more generous estimate for unknown areas, is about 1,000 individuals. There are about 10,000 sq. km. of lowland secondary forest within the present range of the Sabah elephant population. If Olivier's estimate of elephant population density as one elephant in 555 ha. (23) is taken, there would be 1,800 elephants in this habitat, and about 2,000 in the whole of Sabah. A group of up to 40 elephants was ranging within an area of about 280 sq. km. to the west of Sandakan in 1980, indicating a population density of about one elephant in 700 ha. The area contains at least three salt sources and has long been known to support "many" elephants.

Without a more detailed investigation, we can only support the Forest Department estimate of 500-2,000 and state that the best guess from available information is around 1,000 individuals. Note that this estimate includes both adults and young.

(4) HONEY BEAR (Helarctos malayanus)
Family: Ursidae
Order: Carnivora

Ecology

The contents of bee's nests and termites appear to form a substantial part of the diet, with other small animals and fruits. It is said in Sabah that bears eat large quantities of the hard seeds of the Fagaceae family. They travel mainly on the ground at night-time, but sometimes during day-light. They sleep in the forks of large branches. The presence of honey bears in an area is


HONEY BEAR
(Helarctos malayanus)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,890'
4,876'
4,400'
4,900'
3,900'
4,300'
4,678'
6,700'

usually detected by claw marks in the trunks of medium-sized trees, but distinctive footprints may be seen on soft ground or fresh signs of feeding.

Distribution and Abundance

The honey bear is distributed widely throughout the dipterocarp and lower montane forests of Sabah, but is common nowhere. Individuals were seen only twice during the Faunal Survey and fresh signs three times; old claw marks were found in six survey areas. Nine of these eleven records were in primary forest, two in old logged dipterocarp forest. Estimates of abundance can only be crude. Assuming that approximately 1 sq. km. was investigated on thirteen of the surveys in primary dipterocarp forest and that if bears were present at the time, fresh evidence would have been seen, then 3 bears were present in 13 sq. km. From this, it is assumed that honey bears exist at an average population density of about one individual in 4 sq. km. in primary dipterocarp forest in Sabah. Consideration of this species' diet would suggest that they exist at lower population densities in montane forests.

(5) CLOUDED LEOPARD (Neofelis nebulosa)
Family: Felidae
Order: Carnivora

The clouded leopard is Borneo's largest known wild felid. In Sabah, its presence is usually detected by footprints or by chance sightings of the animal resting along the branch of a tall tree or travelling across open gaps in the forest. Throughout Sabah, the call of the red giant flying squirrel is attributed by some indigenous people to the clouded leopard. It seems likely that clouded leopards do sometimes make a similar call, a powerful "boop! .....boop!", which is heard at night or late on cloudy afternoons. Reports of "clouded leopards" based on calls cannot be trusted. Clouded leopards are also confused by many Orang Sungai, Kadazans and Muruts with an imaginary "ghost tiger" (mondou) which is believed to be able to change form. Furthermore, some hunters report the tracks of feral dogs and binturong (whose claw marks are

visible in the tracks) as clouded leopard. Similarly, sightings of small felids (wild cats) and even civets, especially the tangalung, are sometimes reported as clouded leopard. During the Faunal Survey, only observed tracks and detailed descriptions by known reliable people were accepted as evidence of this species.

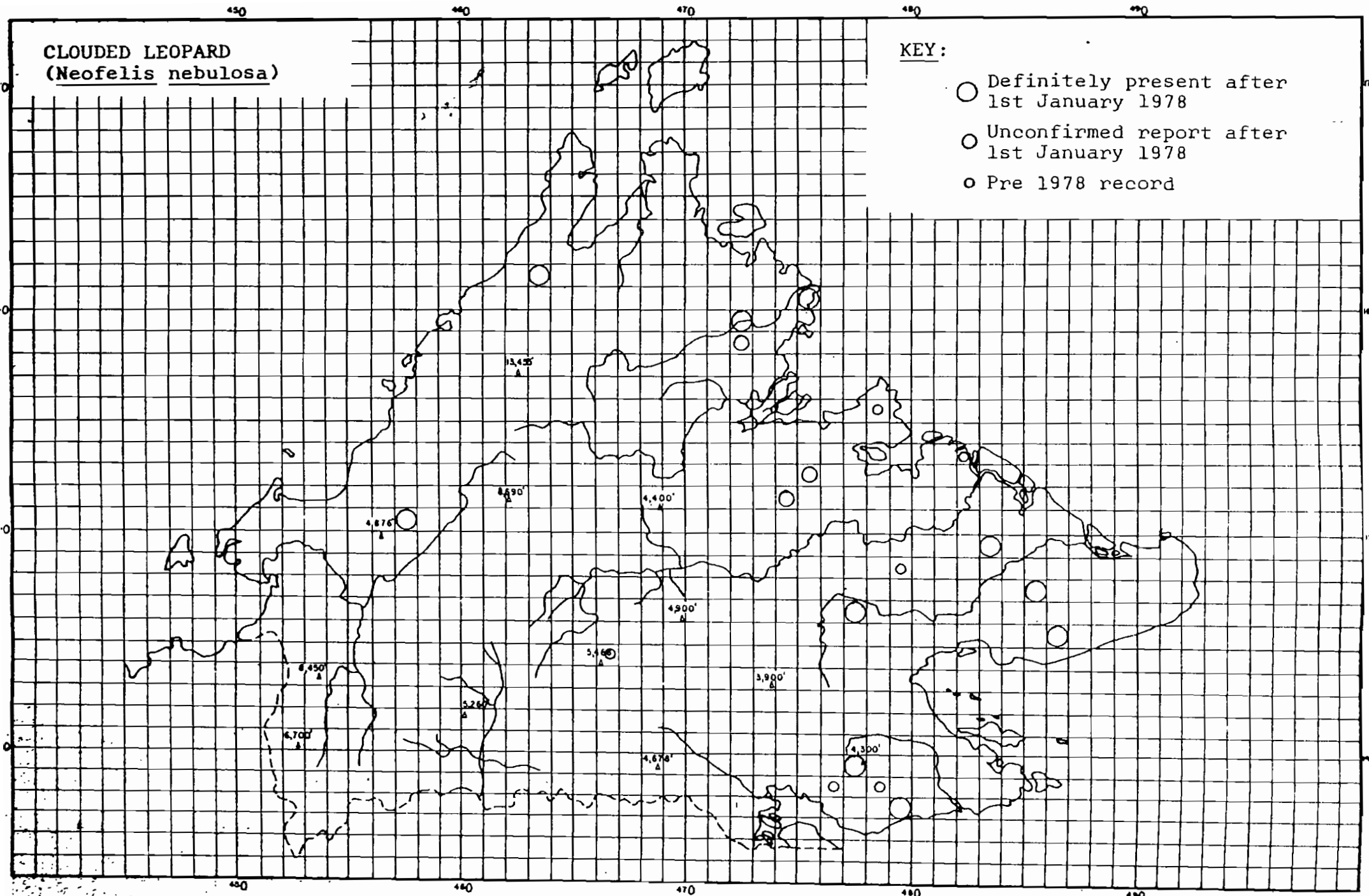
Six informants claimed to have seen large, totally black leopards in Sabah. These could have been binturong, or dark forms of the clouded leopard or bay cat. There is only a very remote possibility that the leopard (Panthera pardus) exists in Sabah.

Ecology

Clouded leopards hunt at night-time and in Sabah are generally seen on the ground except when resting during the day-time in tall trees. Food includes mousedeer, young bearded pigs, young deer, rodents and monkeys. It is widely believed that clouded leopards often eat only the head from their prey, and leave the body uneaten. The freshly-killed headless body of a larger mousedeer was found once during the Faunal Survey, but the cause of death could not be ascertained.

Distribution and Abundance

Clouded leopards are distributed widely in Sabah, with Faunal Survey records from sea level to about 3,500 feet, and both in primary and secondary forests. There are three records from places adjacent to mangrove/nipah and in at least one case (Terusan Sugut), the clouded leopard must have swum and travelled through mangrove. Several local people have seen a clouded leopard here, and believe that it follows bearded pigs which periodically swim to the island. The average density of clouded leopard populations was estimated from extensive surveys done over wide areas on earth roads, both in logged forest and forest due to be logged soon. It is assumed that one sq. km. was covered adequately on each such that a clouded leopard would have been detected if present by tracks or sighting. Three records in twelve such areas suggest population densities of the order of one individual in 4 sq. km. All areas were less than 1,500 feet altitude


CLOUDED LEOPARD
(Neofelis nebulosa)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
13,435'
4,400'
4,900'
3,900'
4,300'
6,450'
6,700'
4,678'

(median about 400 feet), and primary and secondary habitats are combined. Little can be said of variation in density with habitat, but it is likely to be correlated most closely with population densities of prey animals. We would expect lower densities with increasing altitude and steepness, but we do not know how logging would affect clouded leopard food supply.

4.2.2. Primates

The diurnal primates are a group of relatively conspicuous arboreal mammals and all species were surveyed using a similar survey technique. Because they constitute the majority of the biomass of mammalian herbivores in the forest trees, their population densities are indicative of the conditions prevailing in the forest. This feature, coupled with their widespread distribution within Sabah, means that their population densities are indicative of the relative abundance of food trees or the amount of hunting in different areas.

(1) ORANG-UTAN (Pongo pygmaeus)

The orang-utan occurs only in Sumatra and Borneo, and is becoming increasingly rare throughout its range. The Bornean race, Pongo pygmaeus pygmaeus, is the largest primate in Sabah, with adult females weighing 30-50 kg. and adult males up to twice as much.

Ecology

The social system is flexible. Orang-utans are most frequently seen travelling singly, or as mothers with their dependant infants or groups of two individuals often consisting of juveniles and/or subadults. Very rarely, temporary groups of 5 animals or more may associate at large food sources.

This species is frugivorous and large, succulent fruits, such as wild figs, durians, rambutans, langsats etc., are preferred foods. Seasonal depressions in fruit supply, however, force orang-utans to take a wide range of foods, including young leaves and the bark of trees

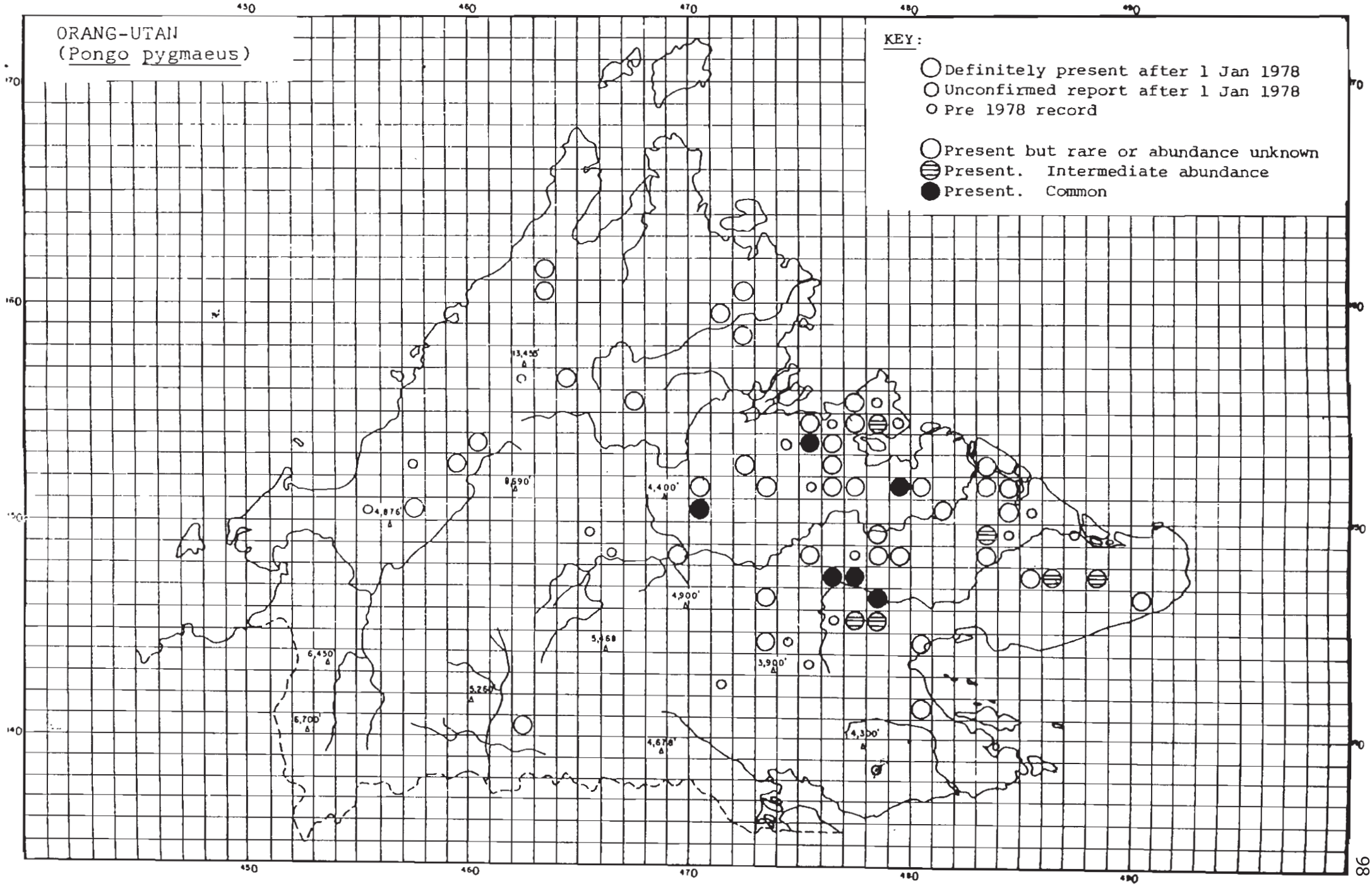
and lianas. Since their main foods are in the trees, orang-utans spend much of their time in the middle and upper storeys of the forest canopy. They may descend to the ground to travel, however and adult males, especially, spend a large part of their time on the ground because they are too heavy to travel arboreally.

The ranging pattern is flexible, but two basic patterns have been recorded. In Lokan (Sabah) and Kutai (Kalimantan), females have relatively stable home ranges of about 30 ha. which are overlapped by the larger home ranges of adult males. In Segama (Sabah) and Ketambe (Sumatra), all individuals have much larger, greatly overlapping and less stable home ranges. Each night, orang-utans build a nest, in which they sleep, by entwining branches to form a platform. Occasionally, "day nests" are built on which to rest.

Distribution and Abundance

The orang-utan has been reported from various habitats throughout Sabah, including dipterocarp forests, montane forests, peat swamp forests and coastal swamp forests and in nipah. They occur in logged forests in some areas, where they are forced to travel on the ground, and there is one report of an individual travelling through a tree plantation.

Although the presence of nests was used to assess whether orang-utans occurred in an area population densities were computed only from sightings of individuals. From the survey data the most striking feature was that the orang-utan population is concentrated in the eastern part of Sabah, especially the lowlands and Segama uplands. The highest population densities, of 2.02 and 2.9 individuals/km^2 were at the lowland sites of Kunkun and Bole Kecil respectively. The latter figure is very high, even higher than estimates made in the same area by MacKinnon in 1970, and is probably a result of individuals being forced to immigrate from the nearby logged forests. The figure for Kunkun tallies with that of Horr's estimates for very similar habitat in the Lokan area. This is a useful estimate for orang-utan population densities in


ORANG-UTAN
(Pongo pygmaeus)
KEY:
Definitely present after 1 Jan 1978
Unconfirmed report after 1 Jan 1978
Pre 1978 record
Present but rare or abundance unknown
Present. Intermediate abundance
Present. Common
450
460
470
480
490
170
160
150
140
13,455'
8,590'
4,876'
4,400'
4,900'
5,468'
3,900'
6,450'
5,700'
5,250'
4,678'
4,300'

primary forests in flat, lowland areas of Sabah with alluvial soils.

Altitude-related factors have a marked effect on orang-utans and population densities decrease for relatively small increases in elevation. In the Segama Uplands, at Kawag (1,200 feet a.s.l.), a density of approximately one individual/km^2 was calculated, which agrees with MacKinnon's estimates in the same area. Above 2,000 feet, they were scarce and appeared to range over large areas in search of food, so that no absolute population density estimates could be made. Extensive ranging for food would explain the unusual record of an orang-utan at 8,000 feet on Mt. Kinabalu in vegetation which can hardly supply sufficient foods year-round and why there are very few records of orang-utans above 4,000 feet.

It is inappropriate to give a total population estimate for Sabah until surveys have been conducted in areas which were not visited during the Faunal Survey. For the purposes of discussion, however, a rough estimate can be made of the minimum population size if the unlogged area is considered; Table 6 summarises the calculations. Although there are at least 4,000 orang-utans in Sabah, habitat loss is occuring at a fast rate and there is an annual mortality of at least 20 individuals as a result of human disturbance.

(2) GIBBON (Hylobates muelleri)

Gibbons are widespread in the forests of South-east Asia. There are two species in Borneo and the species in Sabah, Hylobates muelleri, is endemic to the island. These lesser apes weigh about 5 kg. in adulthood and there is no difference in size between the sexes. Their coat colours are variable. They are adapted to a wholly arboreal life and have very long forelimbs to allow them to swing through trees.

Ecology

Gibbons live in family groups of about 4 individuals, including an adult male, an adult female and their progeny. The group occupies a territory of about 30 ha. which is

TABLE 6

Forest Reserve	Primary forest area (kilometre^2)	Estimated population density	Estimated No. of orang-utans
Dermakot	34		
Tangkulap	166		
Malua	233	2 individuals /kilometre^2	1,556
Segaliud-Lokan	272		
Lamag	67		
Bangkulap	6		
	778		
Ulu Segama	1,866		
Ulu Segama ext.	102		
Tingkayu	15	1 individual /kilometre^2	1,994
Binuang-Tingkayu	11		
	1,994		
Kuamut	984		
Silabukan	158	0.2 individual /kilometre^2	310
Lumerau	283		
Sg. Tongod	125		
	1,550		

These data suggest that there are at least 4,000 orang-utans in Sabah.

The populations which may occur in logged areas and the highlands cannot be accounted for at this stage due to a lack of information.

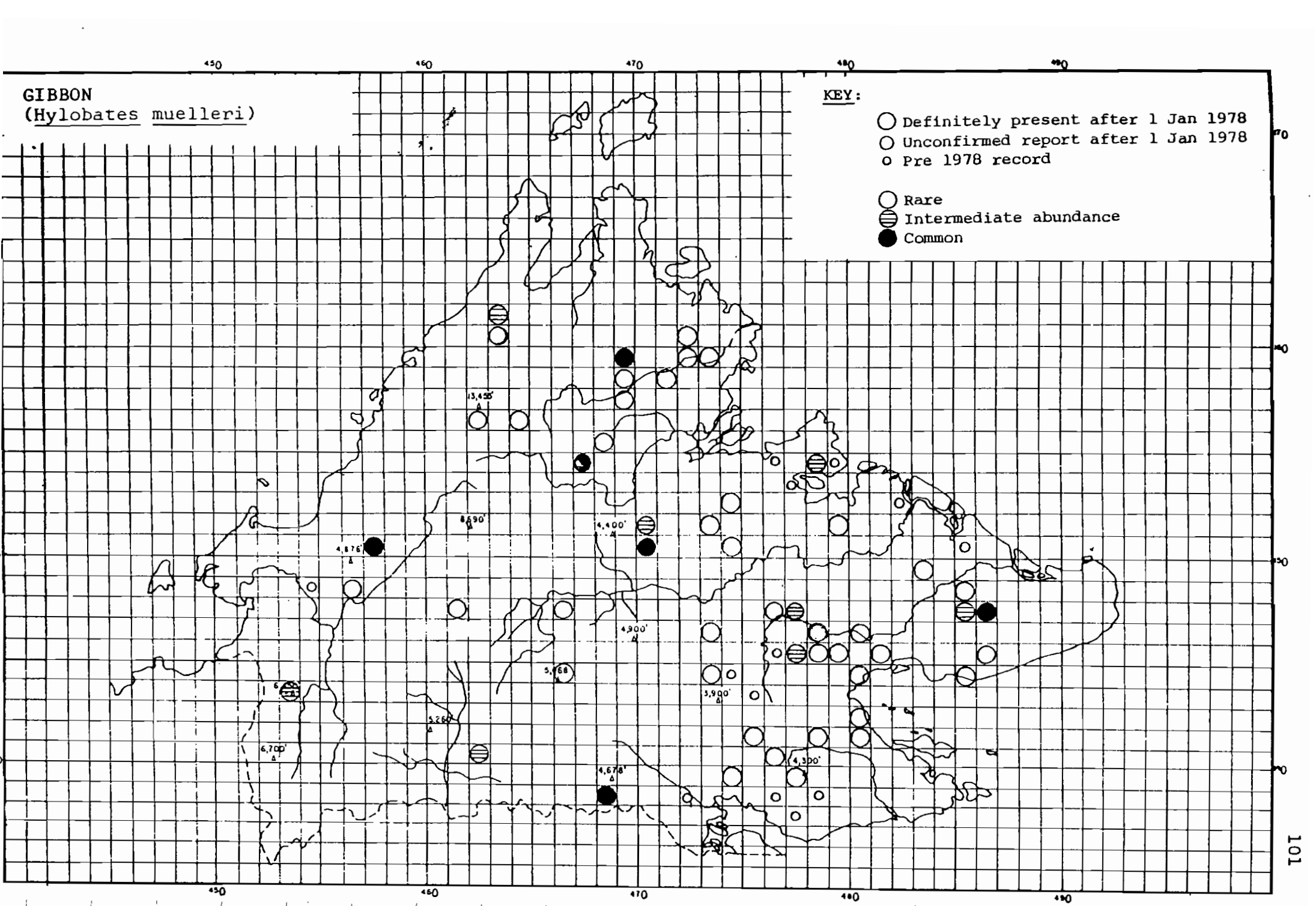

GIBBON
(Hylobates muelleri)
KEY:
Definitely present after 1 Jan 1978
Unconfirmed report after 1 Jan 1978
Pre 1978 record
Rare
Intermediate abundance
Common
450
460
470
480
490
13,455'
8,690'
4,400'
4,876'
4,900'
5,168
3,900'
5,260'
6,700'
4,300'
4,678'

TABLE 7

Abundance of gibbon groups at all survey sites in pristine habitat.

Altitudinal Zone	Estimated number of groups / square kilometre						MEAN
LOWLAND (below 500')	1.5	4.3	2.9	4.3			3.2
UPLAND (500-1500')	2.4	5.7	2.5	2.5	3.4	3.2	3.2
HIGHLAND (1500-3000')	0.6	+	2.1				0.9
MONTANE (above 3000')	3.1	1.7					2.4

+ signifies presence, but no estimate of abundance possible.

All the data are arranged to give estimates of survey sites in ascending order of altitude.

fiercely defended against intrusions by any other gibbons. The territorial boundary is advertised on most days by loud calls. The feeding behaviour is characterised by a strong preference for small succulent fruits, such as varieties of the fig, rambutan and langsat families. They also feed on young leaves and, to a lesser extent, on insects.

Distribution and Abundance

Gibbons are common over most of Sabah. They are abundant in the lowland forests and are found up to about 5,000' on Mt. Kinabalu. They occur in logged forests and were seen once in a tree plantation, but they do not adapt readily to exploited habitats.

The abundance of gibbon groups in different areas was calculated from the number of groups heard calling in a surveyed area. The results are shown in Table 7. Compared to populations of other primates, these results show considerable conformity between survey sites in the same altitudinal zones. Altitude-related factors do not begin to influence gibbon populations until above about 1,500 feet a.s.l. Above the uplands, population densities tend to decline considerably. The surveys in highland areas suffered from rainy weather, so the results may be overly depressed because gibbons tend to call less during rainy periods and some groups in the survey area may have been missed. Studies elsewhere have shown that gibbon densities do decrease with altitude, and this is because the density of their food trees decreases (28). There are, however, pockets of suitable habitat for gibbons at high elevations in areas where the surrounding gibbon density is generally very low, as is exemplified by the high density at Kimanis.

(3) COLOBINES

This sub-family of monkeys is represented by four species in Sabah which all have a common feature: the possession of a saculated stomach for fermenting foods to facilitate digestion of fibrous plant matter that is eaten.

PROBOSCIS MONKEY (Nasalis larvatus)

The proboscis monkey (Nasalis larvatus) is found only in Borneo and is distinct from the other members of the sub-family. All individuals have a characteristic nasal morphology: females have a snub-nose and adult males have a large pendulous nose. There is marked difference in the size of the sexes, males may weigh 20 kg. and females about 10 kg.

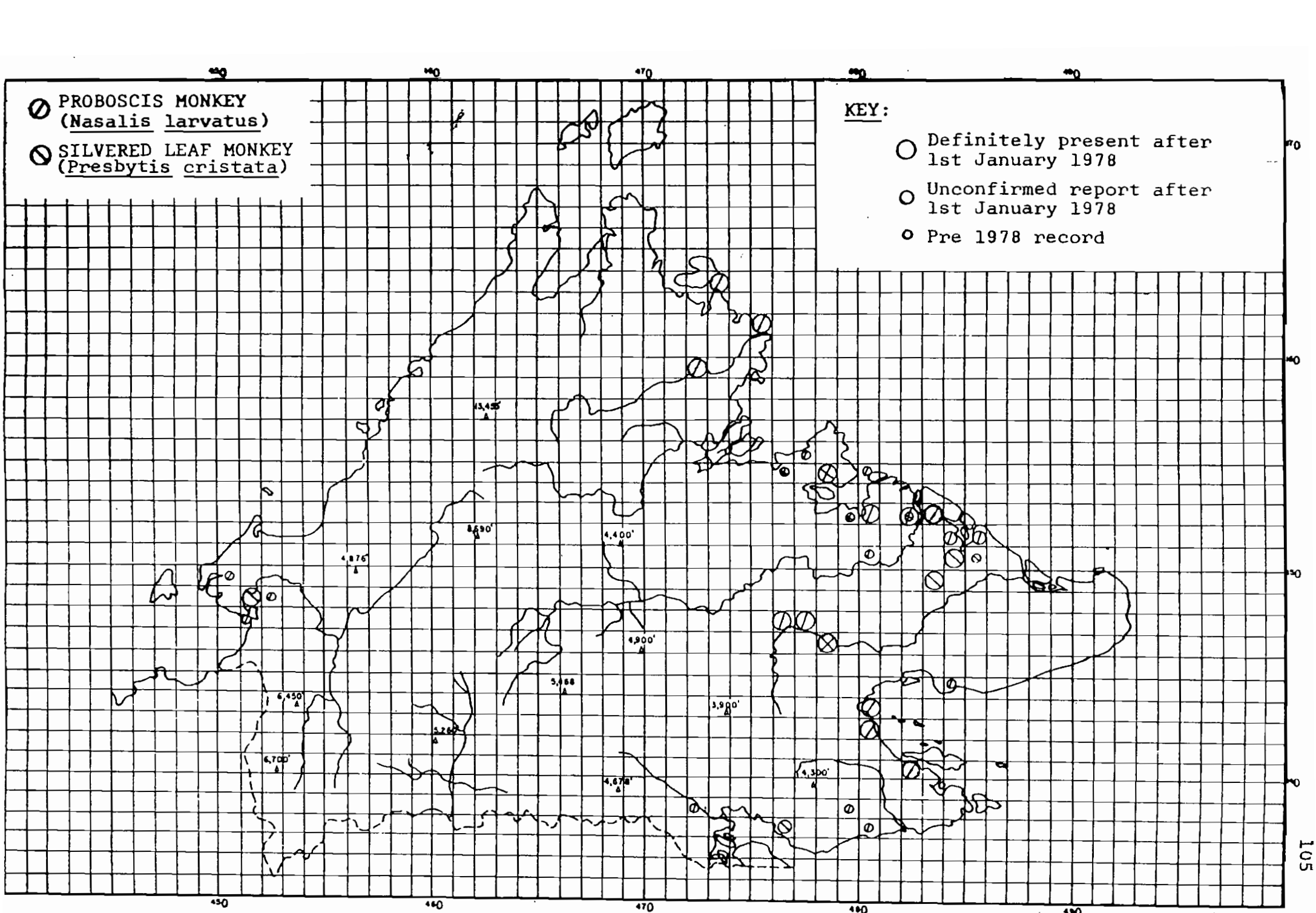
Ecology

Only brief studies have been made of this animal and its ecology is still poorly understood. The social groups vary in size between 10-40 individuals and may contain one or more adult males. The ranging patterns of the species are variable; groups may range 5 km. along river banks upstream from mangrove, but within mangrove, their major habitat, group ranges are probably less extensive. A common feature of ranging behaviour is that groups are always close to large water courses. They are primarily folivorous, with young leaves and shoots making up the majority of the diet.

Distribution and Abundance

This species is distributed along the coastline, especially in the mangroves of the northern part of the Dent Peninsula and Sugut and Paitan Rivers, and is found along the larger rivers as far as 50 km. from the nearest coast on the Segama and Kinabatangan. No data are available to calculate the population size of this species; only qualitative statements can be made. The largest numbers were seen on the Trusan Kinabatangan, near Abai, and around Dewhurst Bay. There may be other areas with dense populations, but more surveys are needed to establish a complete picture.

The most alarming information about the population of this species is that its range seems to be shrinking. There are no recent records of proboscis monkeys in the Klias estuary, the Papar area or around Tawau, all places where they were once present. A formerly abundant population in the Tingkayu has been much reduced. The two


PROBOSCIS MONKEY
(Nasalis larvatus)
SILVERED LEAF MONKEY
(Presbytis cristata)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
13,455'
8,690'
4,400'
4,876'
4,900'
5,168'
6,450'
5,260'
3,900'
6,700'
4,300'
4,674'
450
460
470
480
490
470
460
450

causes of this reduction are the exploitation of mangroves and the hunting of individuals for food and sport. This type of range shrinkage is one of the final stages in a slow process of extinction and a mangrove area is urgently needed for the preservation of this species.

SILVERED LEAF MONKEY (Presbytis cristata)

The silvered leaf monkey (Presbytis cristata) is the least common of the three Presbytis species and is the only representative of the sub-genus Trachypithecus in Borneo. This is a medium sized colobine with females weighing about 6.5 kg. and males being slightly heavier.

Ecology

The ecology of this species has been studied in Peninsular Malaysia. Group sizes vary between 10 to 20 or more individuals and the group composition ranges from all male, to several adult males and females, to single male with several adult females. They are folivorous, with young leaves of mangrove trees being prominent in the diet. They appear to be fairly adaptable, however, and feed on seeds and flowers or even refuse on rubbish dumps in urban areas.

Distribution and Abundance

Silvered leaf monkeys were observed only in coastal habitat in Sabah although they occur in inland areas of Sarawak and can adapt to the urban environments in Peninsular Malaysia. The only report of them in Sabah's inland forests was in logged forest near the coast in 1950's (29)

Species abundance could not be assessed from the few sightings of the Faunal Survey. They were seen in the Klias area of the west coast, in the Sepilok mangrove area and at Dewhurst Bay on the east coast. It appears that this species is even rarer than the proboscis monkey but more surveys are needed in coastal forests.

RED LEAF MONKEY (Presbytis rubicunda)

The red leaf monkey is endemic to Borneo and the Karimata Islands. There are two races of this species in Sabah. A pale race, Presbytis rubicunda chrysea, occurs

on the eastern side of the State, south of the Kinabatangan River and north of the Kalabakan River. The remainder of the State has a darker race, P. rubicunda rubicunda. Individuals of intermediate colouration were seen in Tawau Hills. This monkey weights about 6.3 kg. and there is little difference in size between the sexes.

Ecology

In Sabah red leaf monkeys occur in groups of between 3-10 individuals, of which only one is an adult male. The groups have large home ranges, up to 60 ha. in Sepilok Forest Reserve, but the periphery of the home range is shared with adjacent groups. This species is arboreal, spending most of its time in the lower and middle storeys of the forest, although it will occasionally descend to the ground. The preferred foods are the dry seeds of trees in the laurel, legume and nutmeg families, along with a wide range of other small seeds and young leaves are frequently eaten.

Distribution and Abundance

Red leaf monkeys are distributed throughout the State. They occur in lowland forests and have been heard in montane forest at 6,000 feet a.s.l. on Mt. Kinabalu. They can recolonise logged forest and are known to enter cultivated small-holdings, cocoa and oil palm plantations, but they only remain in such cultivated areas for short periods.

The abundance of the species was calculated from line transect data, summarised in Table 8.

There is a striking degree of variation in group densities between areas. The highest densities of 5.2 groups/km^2 and 4.5 groups/km^2, were in the primary lowland and upland forests of the Segama Forest Reserve. These are similar to MacKinnon's earlier estimates and show that this region is an excellent area for this species as well as the orang-utan. Other areas with moderate abundances were all in the primary forest lowlands and uplands of eastern Sabah, where group densities ranged between 2-3 groups/km^2.

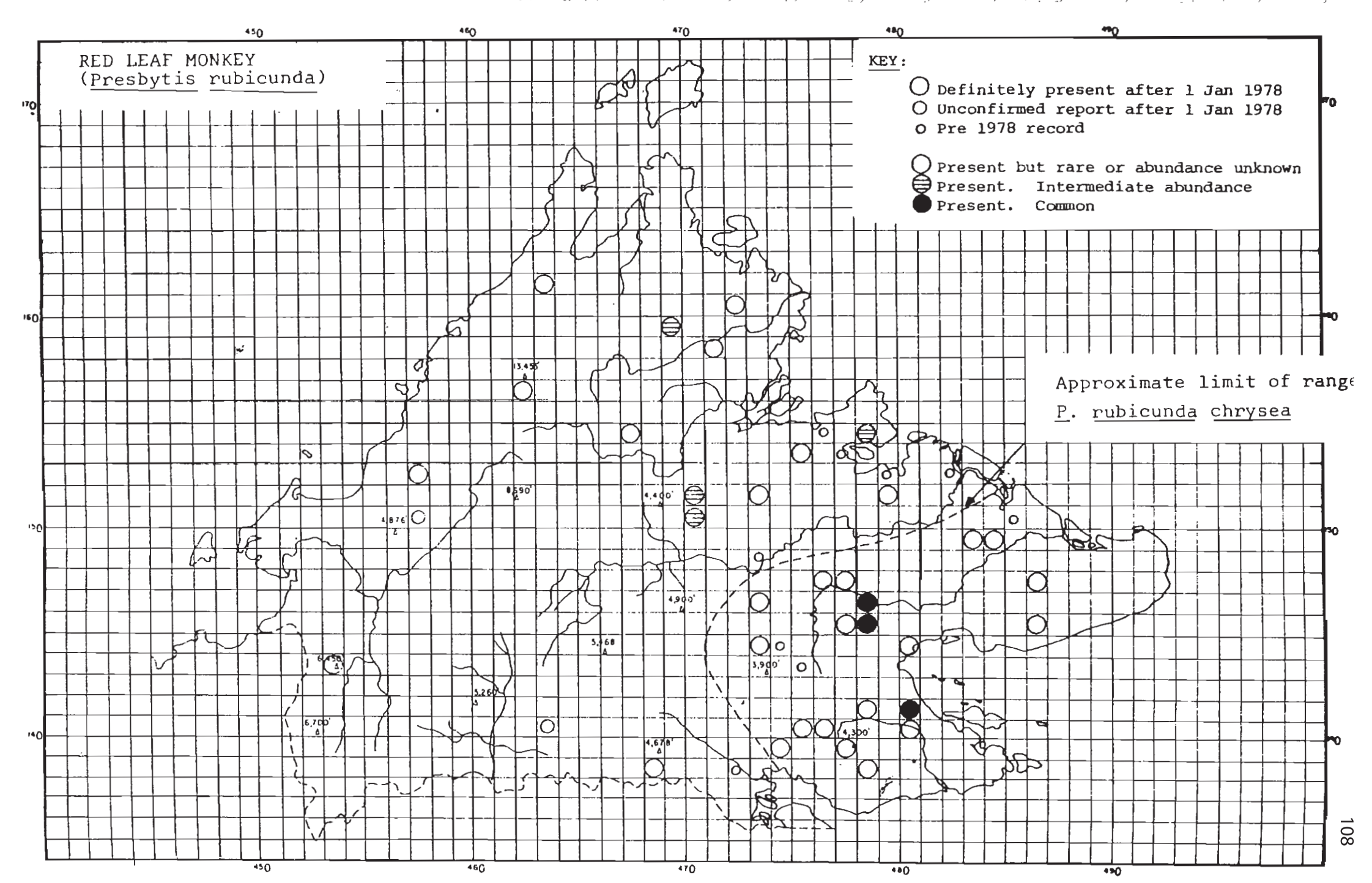

RED LEAF MONKEY
(Presbytis rubicunda)
KEY:
Definitely present after 1 Jan 1978
Unconfirmed report after 1 Jan 1978
Pre 1978 record
Present but rare or abundance unknown
Present. Intermediate abundance
Present. Common
Approximate limit of range
P. rubicunda chrysea
450
460
470
480
490
170
160
150
140
13,455'
8,590'
4,400'
4,876'
4,900'
5,168'
3,900'
5,260'
6,700'
4,678'
4,300'

TABLE 8

Abundance of red leaf monkey groups at all survey sites in pristine habitat.

Altitudinal Zone	Estimated number of groups / square kilometre						MEAN
LOWLAND (below 500')	2.7	2.7	4.5	+			2.5
UPLAND (500-1500')	0.9	1	5.2	-	2.1	+	1.5
HIGHLAND (1500-3000')	-	-	+				
MONTANE (above 3000')	+	5.5					2.8

+ signifies presence, but no estimate of abundance possible.

- signifies no record of the species at this survey site.

All data are arranged to give estimates for survey sites in ascending order of altitude.

Noteworthy exceptions to this trend were the low densities at Kiberibi, perhaps due to the steep topography in that area, and at both primary forest sites in the Dent Peninsula. Population densities on the steeper land of western and central Sabah were all low. Bt. Ibul, with gently sloping terrain, was an exception for the highland sites, with a relatively high density.

GREY LEAF MONKEY (Presbytis hosei)

The grey leaf monkey is endemic to Borneo and is represented by two races in Sabah. The western race, Presbytis hosei hosei, is restricted to the western highlands and, judging from local informants' descriptions, may be separated for part of its boundary with P.h. sabanus, which occupies most of the State, by the Sapulut River. The anatomy and size of this species is very similar to that of the red leaf monkey; adults of both sexes weigh about 6.3 kg. Three independent informants reported having seen a pale phase of this monkey, which mixes freely with the normal grey phase, in the south-eastern part of Sabah (Semporna Lowlands and Tawau Hills). These reports need to be investigated urgently, since much of these regions have been and are being cleared for permanent agriculture.

Ecology

No intensive studies have been done of this species. The groups observed during the Faunal Survey were all small, comprising of 3-13 individuals and having only one adult male in each. Solitary adult individuals were observed on two occasions. The few Sabah feeding records showed that seeds and young leaves were selected as food, and surveys of this species in Kalimantan (17) showed that young leaves are the main part of the diet at some times of the year. A more detailed study is needed before it is possible to accurately describe this species' ecology.

Distribution and Abundance

Grey leaf monkeys occur throughout the State. They have been recorded from sea level up to an elevation of 4,300 feet a.s.l. They adapt to logged forest and old

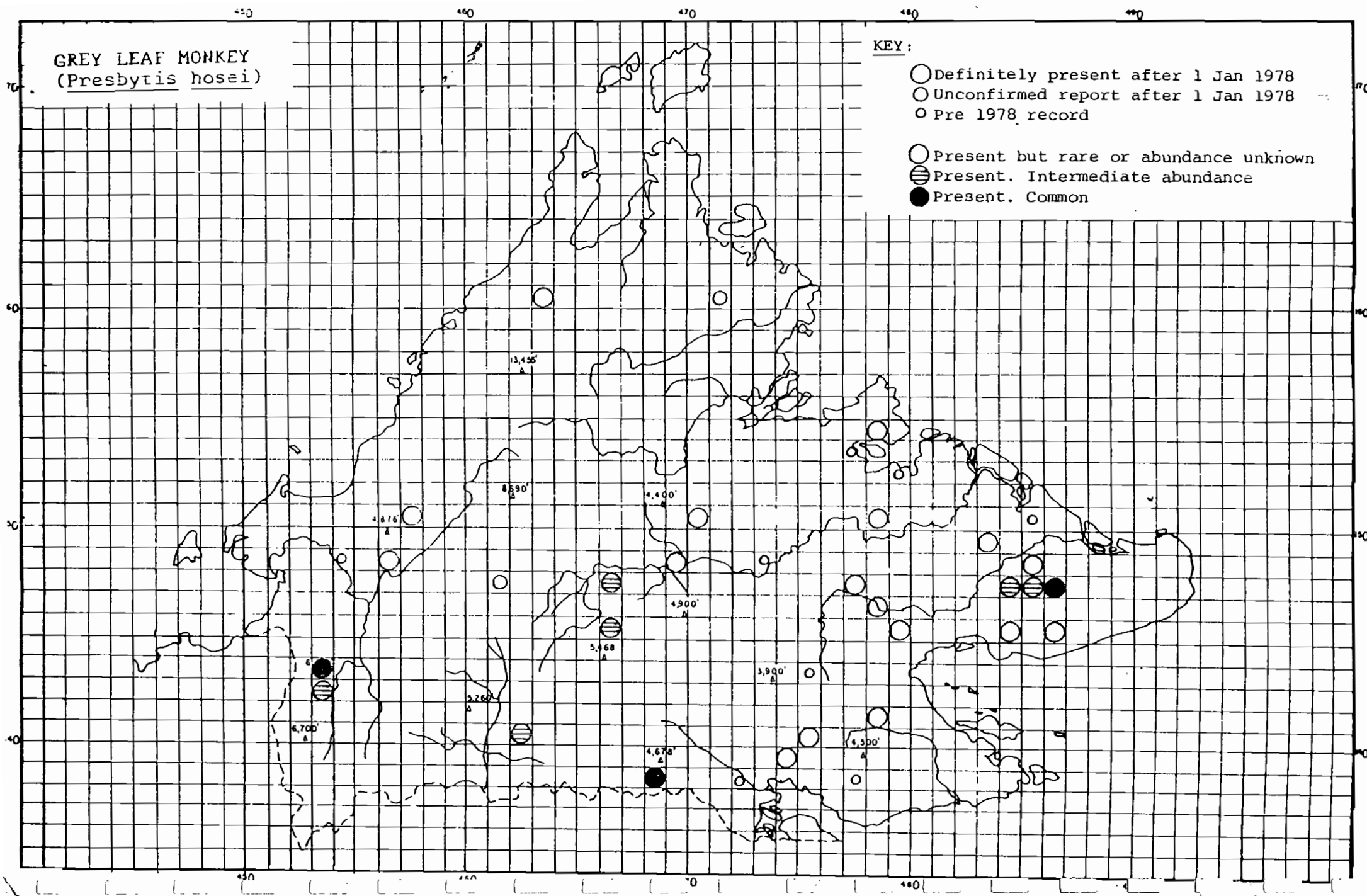

GREY LEAF MONKEY
(Presbytis hosei)
KEY:
Definitely present after 1 Jan 1978
Unconfirmed report after 1 Jan 1978
Pre 1978 record
Present but rare or abundance unknown
Present. Intermediate abundance
Present. Common
13,455'
8,590'
4,400'
4,900'
5,468'
3,900'
6,700'
4,678'
4,300'

TABLE 9

Abundance of grey leaf monkey groups at all survey sites in pristine habitat.

Altitudinal Zone	Estimated number of groups / square kilometre						MEAN
LOWLAND (below 500')	+	+	0.7	4.3			1.3
UPLAND (500-1500')	3.6	+	-	1.9	-	3.4	1.5
HIGHLAND (1500-3000')	+	2.4	-				0.8
MONTANE (above 3000')	1	1.9					1.5

+ signifies presence, but no estimate of abundance possible.

- signifies no record of the species at this survey site.

All data are arranged to give estimates for survey sites in ascending order of altitude.

areas of shifting cultivation, and were recorded feeding in tree plantations.

Abundance estimates are shown in Table 9.

The highest population densities have been recorded in the lowlands and uplands of the Dent Peninsula where there are few red leaf monkeys; densities of 4.25 groups/km^2 and 3.6 groups/km^2 were calculated for the Tabin survey sites respectively. Another upland area with high densities was Samantulong in southern Sabah at the flank of the Kuamut uplands. Moderate densities of about 2 groups/km^2 occurred in the western highlands. Although this species generally appears to be more tolerant of higher altitude forests than the red leaf monkey, population densities tend likewise to decrease with altitude.

(4) MACAQUES

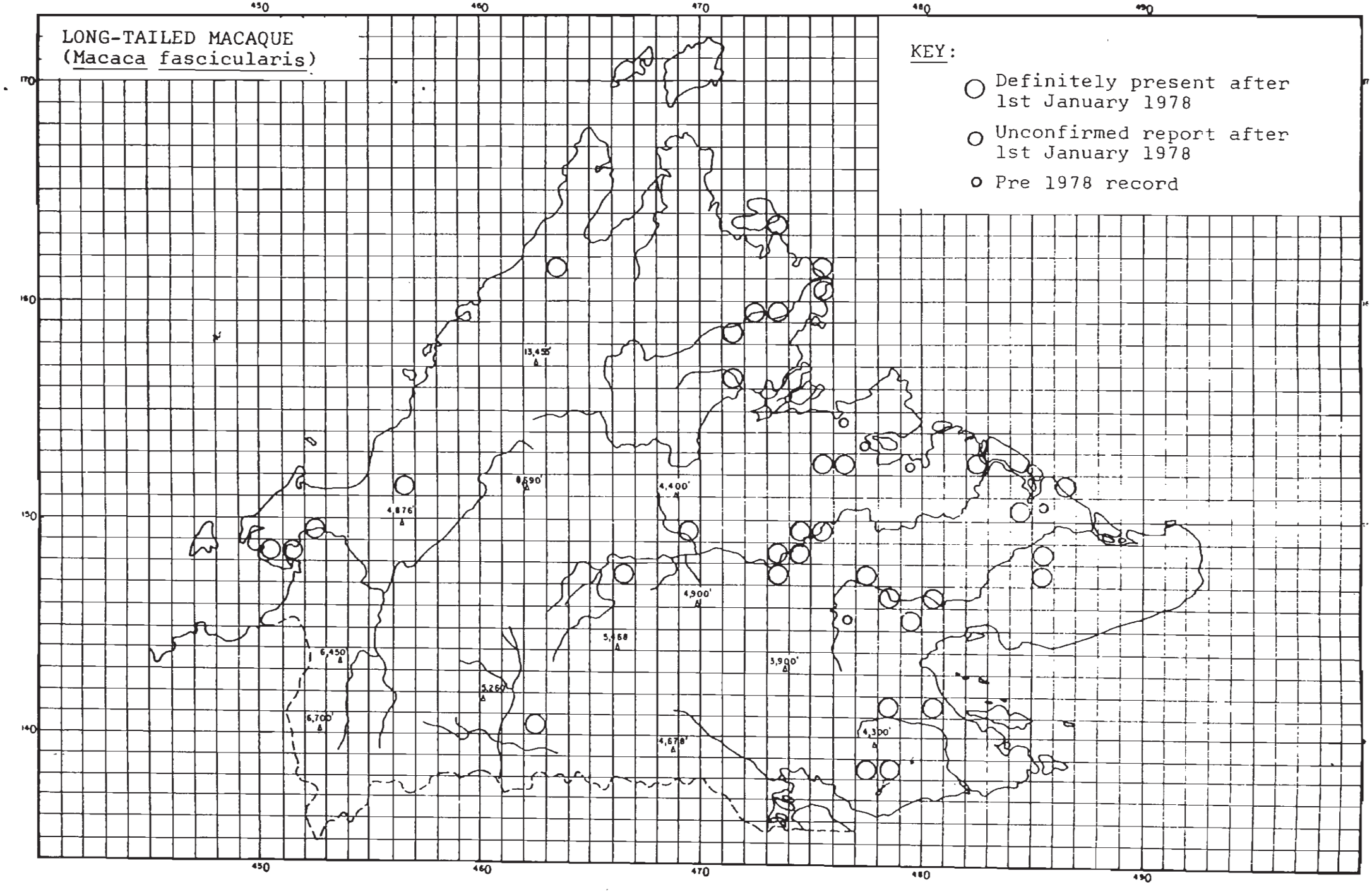
The macaques are ubiquitous in the countries of South-east Asia. They are characterised by having fore and hind limbs of roughly equal length, perhaps as an adaption to terrestrial locomotion, and by the possession of pouches for storing food on the insides of the cheeks.

LONG-TAILED MACAQUE (Macaca fascicularis)

There is probably only one race of this species in Borneo, Macaca fascicularis fascicularis. This monkey is relatively small, adult females weigh about 3.5 kg. and adult males up to 6 kg.

Ecology

They live in groups of about 20 individuals, although group sizes range between 10 and 40 or more individuals. Social interactions are a frequent feature of group activities and the social organisation is flexible, with groups fracturing into small foraging parties during the day. They have an omnivorous diet, eating small animals, fruits, seeds and to a lesser extent foliage and flowers. They readily descend to the ground or ascend tall trees depending on the location of desired resources. The home range area may be as large as 80 ha. for a group of 20 indivi-


LONG-TAILED MACAQUE
(Macaca fascicularis)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,690'
4,876'
4,400'
4,900'
5,468'
3,900'
6,450'
5,260'
6,700'
4,678'
4,300'

Distribution and Abundance

Long-tailed macaques are predominantly animals of coastal and riverine habitats. They occur in mangrove/nipah vegetation and in lowland forest near to rivers and are very rare at altitudes above 1,000 feet a.s.l. The social and dietary flexibility makes it easy for them to adapt to exploited habitats and they may become sufficiently common in cultivated areas to be pests. There is no evidence, however, to suggest that their numbers increase in logged forest. Their preferred riverine habitat is generally little-damaged during logging operations.

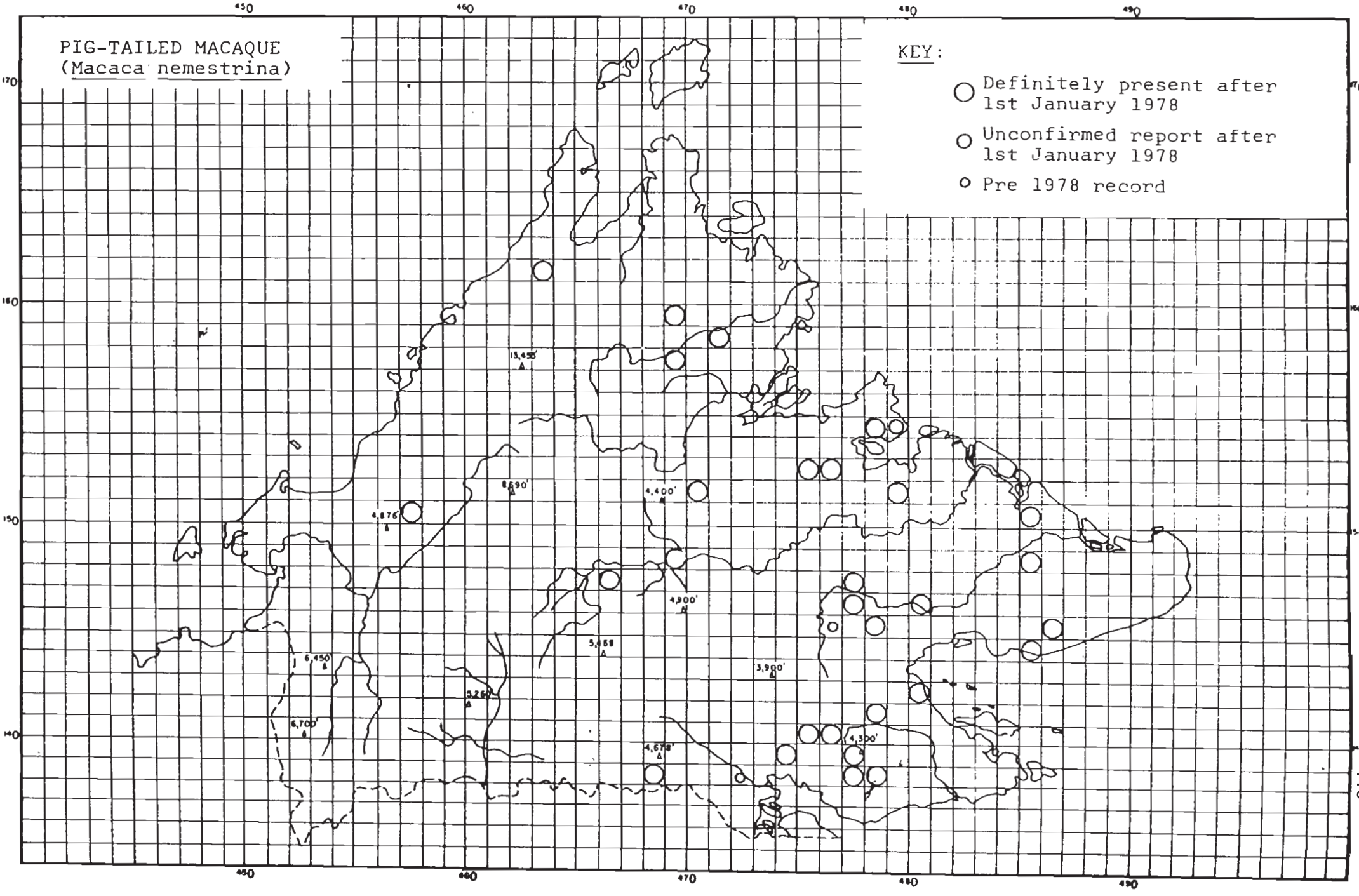
The species range appears to be stable, and may be increasing in some recently cultivated areas. Although they were seen too infrequently to allow calculations of their abundance, it is assumed that this species will remain in most areas of its current range at fairly constant population densities. The main threat to this species' abundance is hunting.

PIG-TAILED MACAQUE (Macaca nemestrina)

The pig-tailed macaque, Macaca nemestrina, is similarly widespread throughout South-east Asia. It is a powerfully built monkey, with a very muscular torso and limbs. Adult females weigh about 7 kg. and adult males are about twice as large.

Ecology

The social structure is flexible in a similar way to the preceeding species; groups of 20 or so individuals are usually seen and these animals commonly sleep in the same night trees together. During the day they may fracture into smaller feeding parties of 5-10 animals and on occasions groups of 100 or more individuals were counted. They are omnivorous, frequently foraging along the ground, particularly for insects, but they obtain most food from trees in the form of fruits, seeds and leaves. They range over much larger areas than do any other monkey species in Sabah.


PIG-TAILED MACAQUE
(Macaca nemestrina)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,690'
4,400'
4,876'
4,900'
5,158'
3,900'
6,450'
5,260'
6,700'
4,678'
4,300'

Distribution and Abundance

This macaque is a monkey of the inland forests. It is found from sea level to at least 4,000 feet a.s.l. in Sabah, but was never observed in mangrove or riverine vegetation. This species adapts to secondary vegetation and was seen in large groups in logged forest. Pig-tailed macaques frequently raid orchards, oil palm and cocoa plantations to feed on fruits, and were seen eating insects in a tree plantation.

Because they range over such a large area, they were infrequently seen and it was not possible to calculate group densities for different areas. By pooling data from different surveys in the same altitudinal zone, however, it was possible to assess the effects of altitude on this species' distribution. Population densities are similar in forests from the lowlands up to 3,000 feet a.s.l. Above 3,000 feet population densities decline.

(5) PROSIMIANS

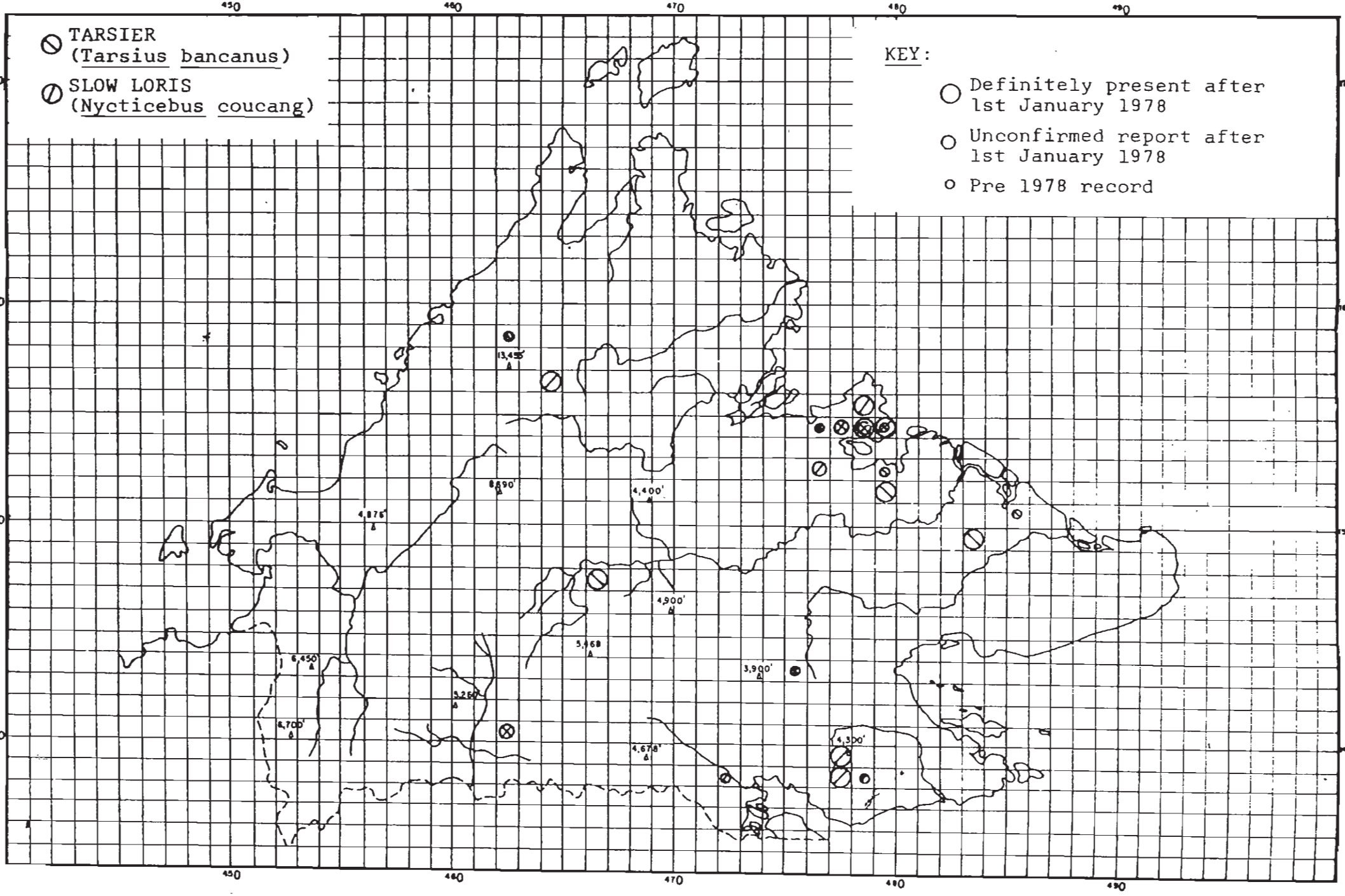
In Sabah there are two small, nocturnal primates which are rarely seen and few data were collected during the Faunal Survey.

TARSIER (Tarsius bancanus)

Tarsiers occur only on some islands of South-east Asia, and the species in Sabah is the smallest of Borneo's primates, weighing 100 g.

They are carnivorous animals, and family groups travel in leaps between the trees and shrubs of the understorey, searching for insects and small vertebrate animals.

They appear to be distributed over most of the State, although there are still big gaps in the known distribution of records. They occur in primary forest, but are more frequently seen in the shrubby vegetation at the edge of primary forest, treefalls and clearings. They have been reported in cultivated small-holdings, but not large plantations. Their abundance appears to be low, but they inhabit some exploited habitats, so are unlikely to become endangered.


TARSIER
(Tarsius bancanus)
SLOW LORIS
(Nycticebus coucang)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,890'
4,400'
4,876'
4,900'
5,168'
6,450'
3,900'
5,250'
6,700'
4,678'
4,300'

SLOW LORIS (Nycticebus coucang)

The Bornean race of the slow loris is the smallest of this species which is widespread in South-east Asia and weighs about 250 g.

Slow lorises travel singly in the trees searching for insects and fruits.

The species was seen at several sites in eastern Sabah and there were many reports of it from western areas. They occur in primary and secondary forest, and were seen in cultivated land near urban areas and 5 km. inside a large cocoa plantation. Capture of individuals of this species for pets is a small drain on the population, and the species appears to be quite secured from major exterminations.

(6) CONCLUSIONS

If the results from the survey are considered for all species, then distinct trends in the primate community structure become apparent. Three species, proboscis monkeys, silvered leaf monkeys and long-tailed macaques are common only in coastal districts and along the larger rivers. They have very little in common with the ecology of the other primate species, although the long-tailed macaque is more flexible in its behaviours, is found more commonly inland and has similarities with the pig-tailed macaque.

Other regions of special importance to Sabah's primates are the eastern lowlands and Segama uplands. These areas are very important for the orang-utan and have high densities of red leaf monkeys. The abundance of the two leaf monkey species is variable, but it is clear that wherever one species is common, the other species is scarce. The highest abundance of grey leaf monkeys was in the Silabukan area. The population densities of gibbons and pig-tailed macaques were relatively consistent in areas of pristine habitat whatever their geographical position.

If all estimates for diurnal primate species are combined, population density and biomass density (that

is, weights of primates) decrease with increasing altitude (Figure 3).

Among the primate species, orang-utans are most severely influenced by altitude-related factors which alter their ecology and population densities. Gibbons are not so drastically affected until altitudes of 1,500 feet a.s.l. are reached, and population densities of leaf monkeys fall off markedly only above 1,500 feet. In the highlands, the abundance of all the primates drops radically, with the possible exception of the pig-tailed macaque. The biomass density figures for the montane habitat are misleadingly high because the small sample is strongly influenced by the high densities of primates at Bt. Ibul. This site had exceptional conditions of topography and vegetation, so was not representative of the majority of montane habitat in Sabah.

Finally, it is instructive to compare the results of the Faunal Survey with those of other studies of primate population densities in South-east Asia. Species are combined into four categories, according to genus (Table 10). Biomass densities were also calculated, based on field observations in Sabah coupled with published data on species in other areas.,

The results (Table 10) show clearly that the population densities of primates in Sabah and Kutai (East Kalimantan) are as much as 50% lower than for other sites in South-east Asia. Orang-utans are concentrated at some places, such as Segama, Kutai and Ketambe (which is the reason they were selected for ecological studies), but otherwise generally at much lower population densities. The densities of gibbon groups are remarkably constant, despite the wide range of areas surveyed, but halve above 3,000 feet a.s.l. With the exception of the Segama region, population densities of leaf monkeys are very much lower in Sabah than anywhere else, as much as 6-9 times lower in some cases. Due to the lack of data on the long-tailed macaques it is misleading to compare their densities, but the pig-tailed macaques seem consistently abundant up to 3,000 feet a.s.l. They are exceptionally common at Ketambe.

Figure 3

Changes in population density of the primate community in Sabah related to changes in altitude.

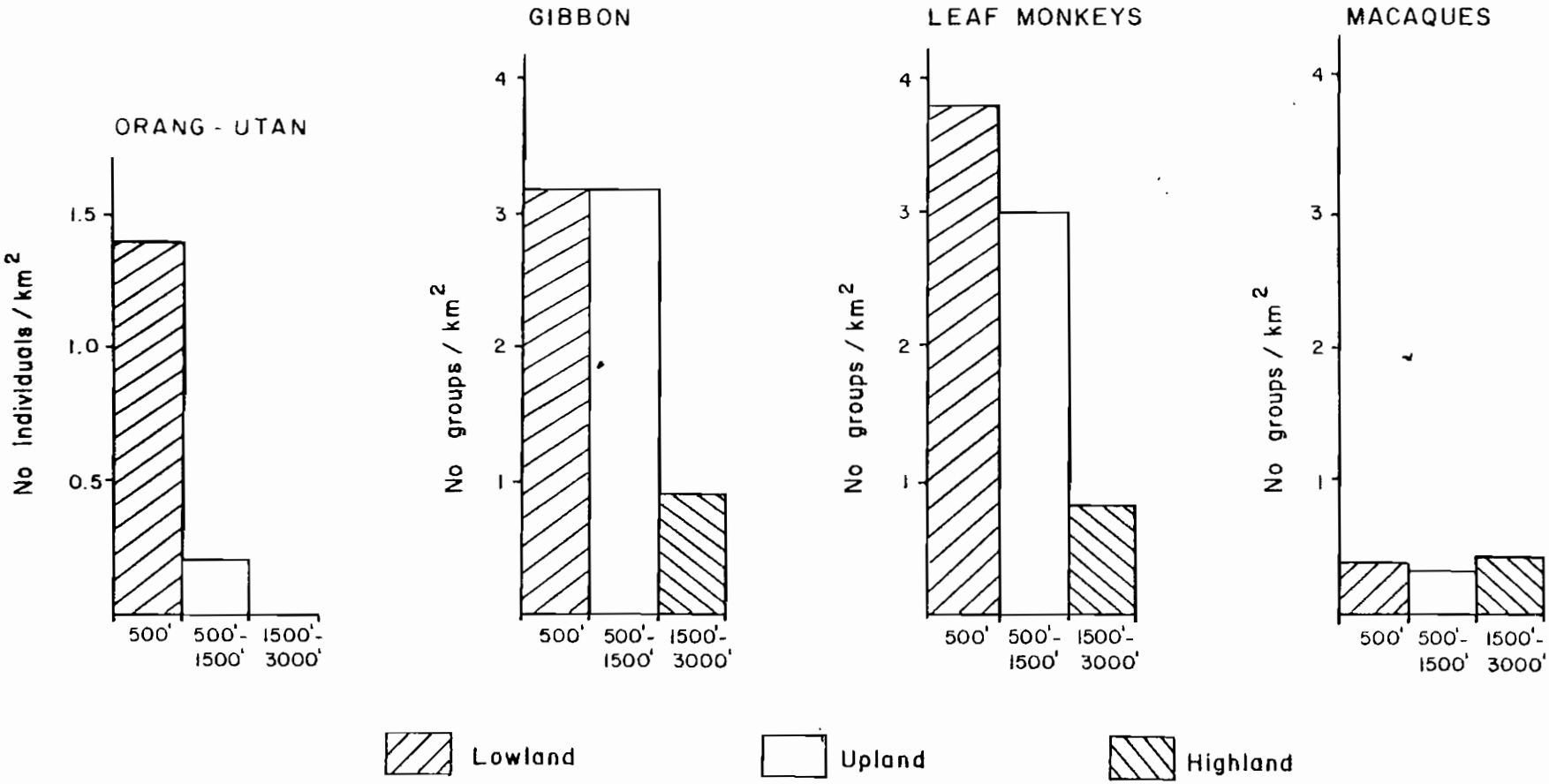


TABLE 10

Biomass density estimates of diurnal primates in South-east Asian primary rain forest habitats (numbers represent kg./km.^{2})

AREA	LOWLAND (below 500')				UPLAND (500-1500')			HIGHLAND (1500-3000')	
	SABAH 4 sites (a)	KALIMANTAN Kutai (b)	W. MALAYSIA 5 sites (c)	W. MALAYSIA K. Lompat (d)	SABAH 6 sites (a)	SABAH Segama (e)	SUMATRA Ketambe (f)	SABAH 3 sites (a)	W. MALAYSIA 4 sites (c)
ORANG-UTAN	38	135	-	-	9	150	140	+	-
GIBBONS	52	58	87++	106++	52	46	175++	14	56++
LEAF MONKEYS	111	78	614	956	90	162	135	24	170
LONG-TAILED MACAQUE	+	19	49	232	37	21	144	-	-
PIG-TAILED MACAQUE	50	42	+	+	44	63	133	56	+
TOTAL (kg./km.^{2})	251	332	750	1294	232	442	727	94	226

Primate weights (in kilograms) assumed in estimating biomass density

	Adult male	Adult female	Sub-adult	Juvenile	Group size	Group weight
Orang-utan	60	40	30	15		
Gibbon (not siamang)	5.5	5.5	3	2	4	16
Leaf monkeys	6.3	6.0	3		7	30
Long-tailed macaque	6	3.5	2		20	60
Pig-tailed macaque	15	7	4		20	140

(a) Faunal Survey data.

(b) reference 17.

(c) Marsh and Wilson, 1981.

(d) Chivers and Davies, 1979.

(e) Chivers, 1980 (pp. 167-190).

(f) Rijksen, 1978.

\+ present, abundance unknown.

\- absent.

++ includes siamang (Hylobates syndactylus).

The lower population densities in northern and east Borneo are possibly attributable, at least in part, to the abundance of dipterocarp trees in this region. This family of trees contributes a negligible amount to the diet of any primate species and high dipterocarp abundance is associated with a low abundance of other tree species. Primate biomass densities might be lower in areas with many dipterocarps due to a lower availability of food trees. Further research is needed to investigate this hypothesis.

4.2.3. Other Mammals

(1) MOONRATS AND TREESHREWS
Order: Insectivora

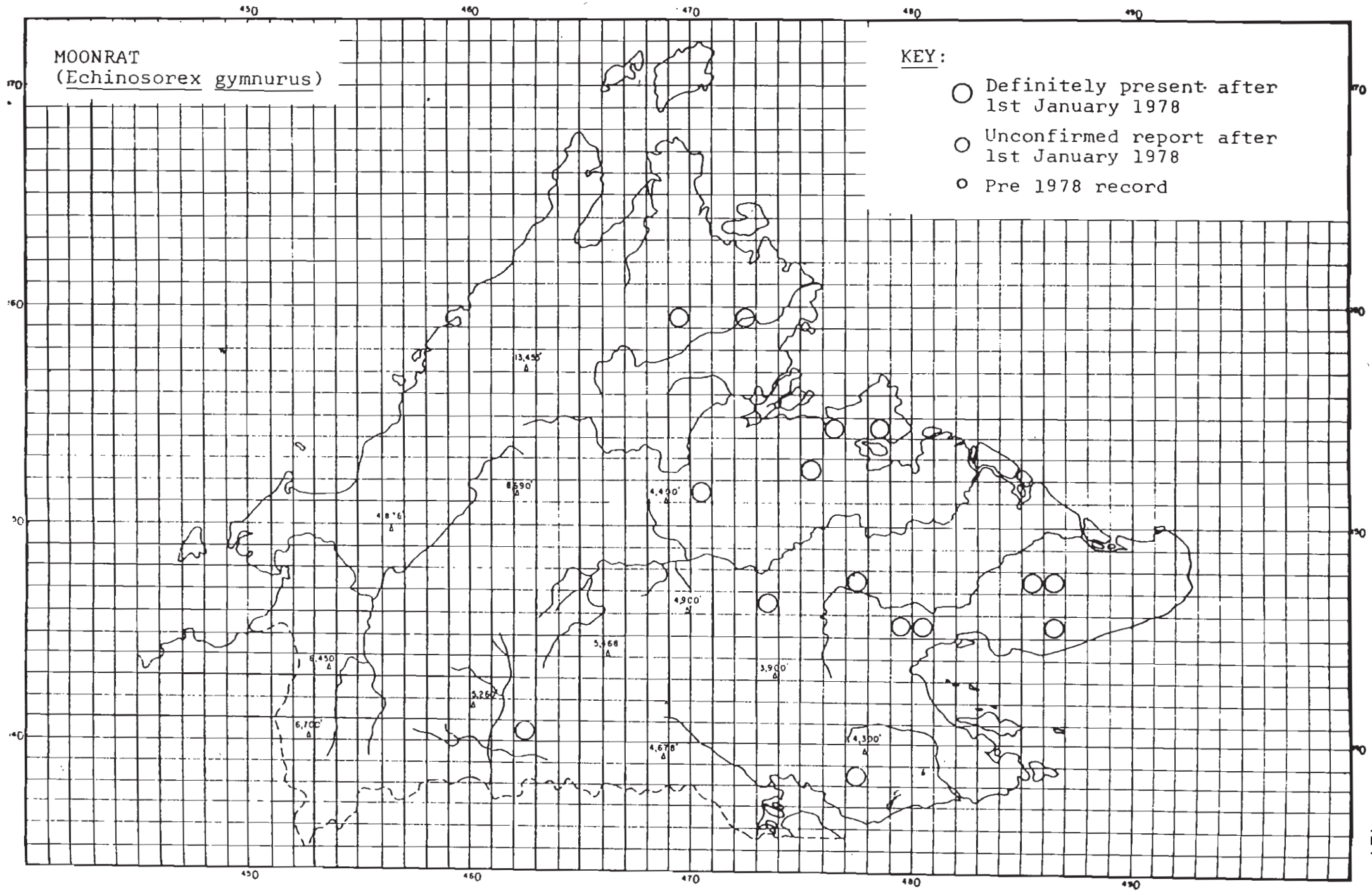
There are three families of insectivores in Sabah: the Moonrats or Gymnures (family Erinaceidae), the Shrews (Soricidae; not considered here) and the Treeshrews (Tupaiidae).

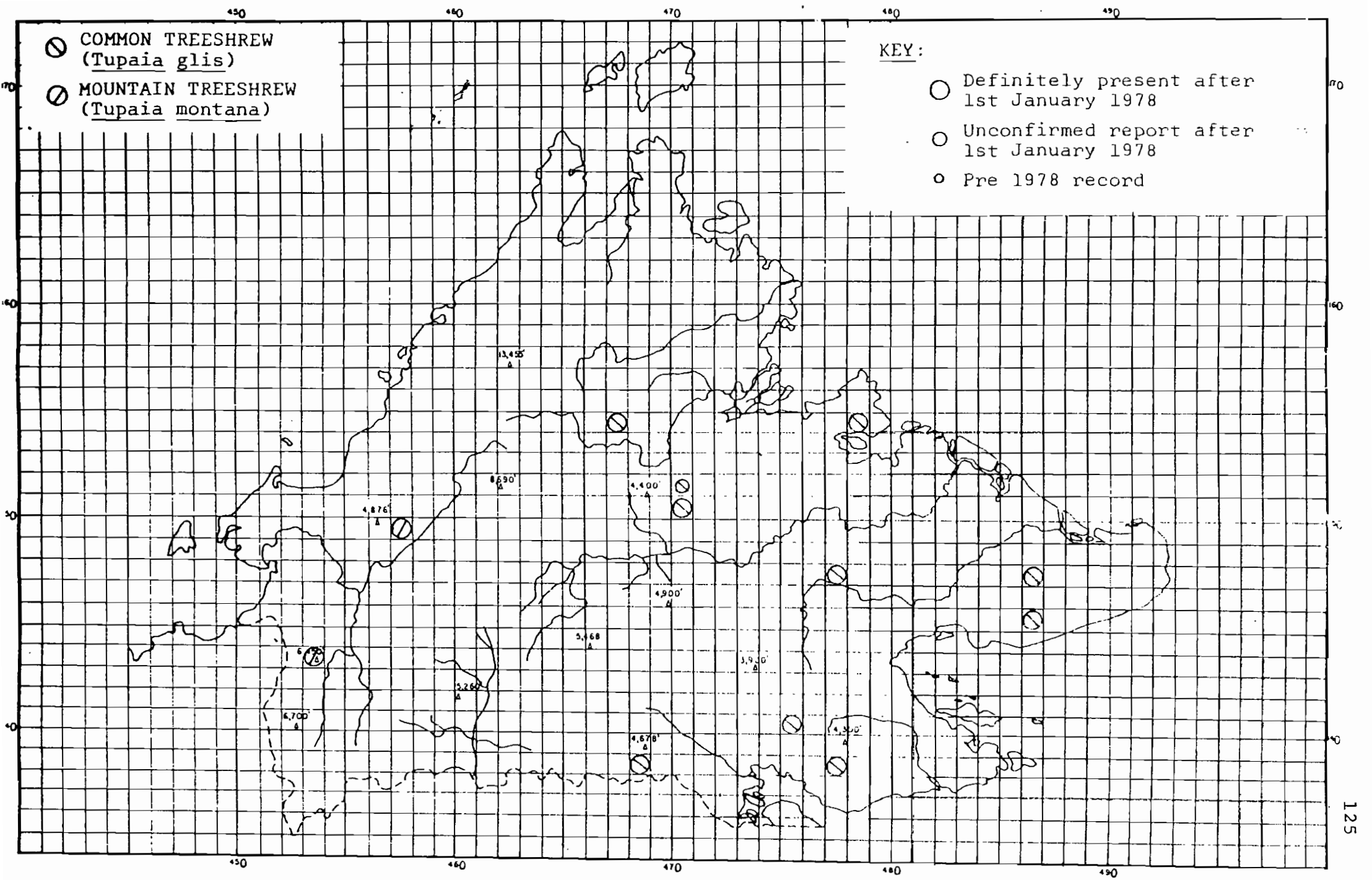
Ecology

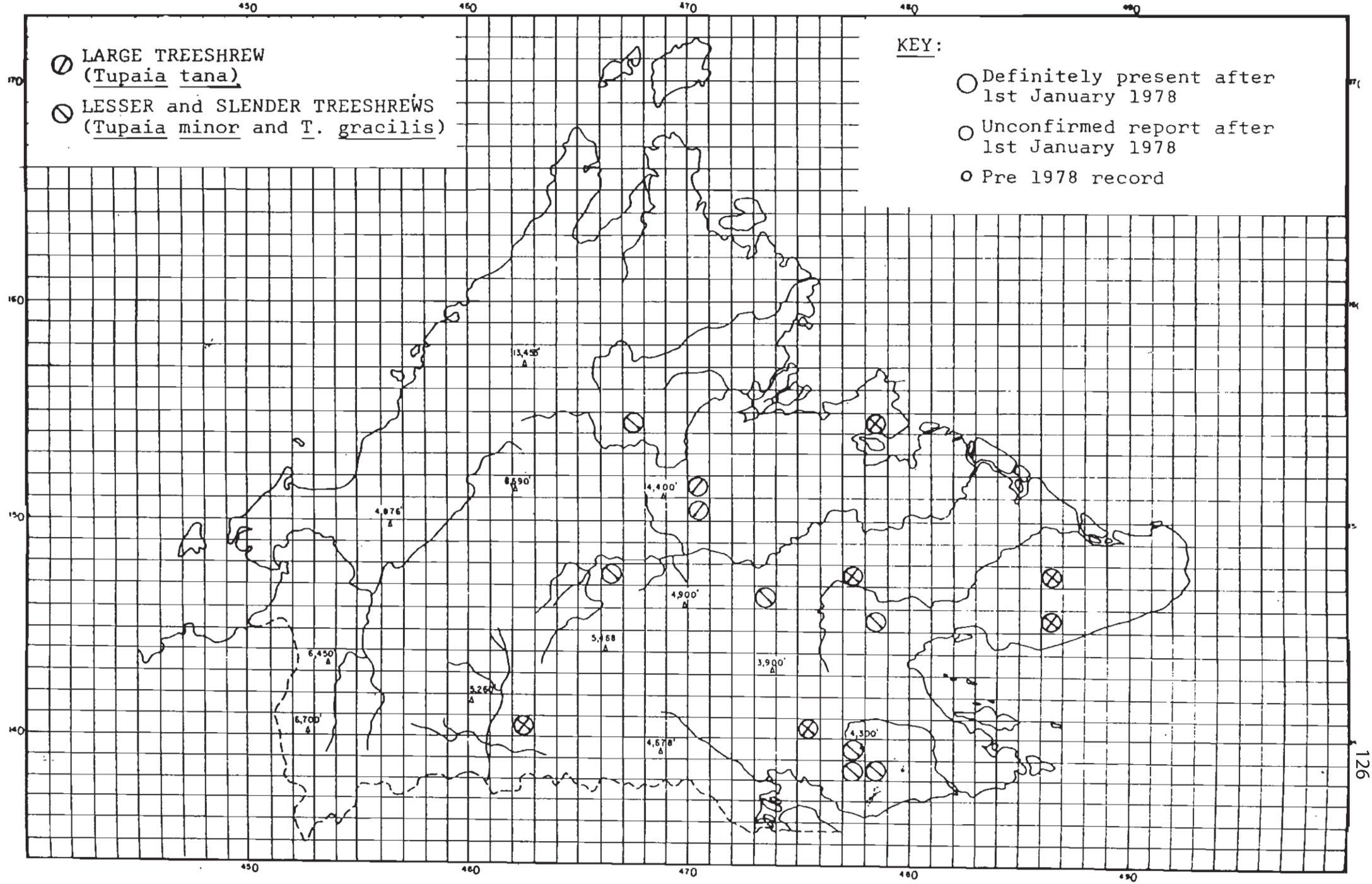
The white-coloured moonrat (Echinosorex gymnurus; up to 40 cm. long, excluding tail) feeds largely on invertebrate animals, especially earthworms from topsoil, leaf litter and rotting wood on the forest floor, and possibly also on small fish and frogs. Moonrats are found usually in damp places, especially near streams, in terrain ranging from flat to steep. In Sabah, they have been recorded only within or near to forest or belukar.

The short-tailed moonrat or lesser gymnure (about 14 cm. long) lives only in montane areas.

Four kinds of treeshrews were recognised during the Faunal Survey. The common treeshrew (Tupaia glis) feeds on the surface of the ground, on fallen branches and trees, and in small trees. About half the food consists of fruits and half of insects and spiders. The mountain treeshrew (T. montata) appears to be similar ecologically to the common treeshrew, replacing it above about 3,000 feet a.s.l. Two treeshrew species - the


MOONRAT
(Echinosorex gymnurus)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,590'
4,490'
4,900'
5,468'
3,900'
6,450'
5,260'
6,100'
4,678'
4,300'


COMMON TREESHREW
(Tupaia glis)
MOUNTAIN TREESHREW
(Tupaia montana)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
13,455'
8,690'
4,400'
4,876'
4,900'
5,468'
3,260'
6,700'
4,678'


LARGE TREESHREW
(Tupaia tana)
LESSER and SLENDER TREESHREWS
(Tupaia minor and T. gracilis)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
13,455'
8,890'
14,400'
4,876'
4,900'
5,468'
6,450'
5,260'
3,900'
6,700'
4,300'
4,678'
450
460
470
480
490
170
160
150
140

lesser (T. minor) and slender (T. gracilis) - are indistinguishable in the field and were counted as one during the Faunal Survey. Observations were made in logged forest (recently and old), forest regenerating after shifting agriculture, forest edge, riverine forest, patches of primary forest with major breaks in the tree canopy, and in cocoa and oil palm plantations. There were no records in deep primary forest. In all cases observed, the treeshrew was in small trees or climbing plants. Food includes small arthropods and fruits. The large treeshrew (T. tana) lives and feeds on the ground and on old fallen trees inside forest cover. It eats arthropods and earthworms from leaf litter and decaying wood.

Distribution and Abundance

The moonrat is distributed widely in Sabah, and although not recorded precisely in the western part, it is known to indigenous people there. Distribution and abundance appear to be influenced mainly by the presence of permanently damp places with earthworms or other suitable food. The short-tailed moonrat is known only from Mount Kinabalu, where it is common, and from Mount Trus Madi. All the treeshrews mentioned above appear to occur where there is suitable habitat.

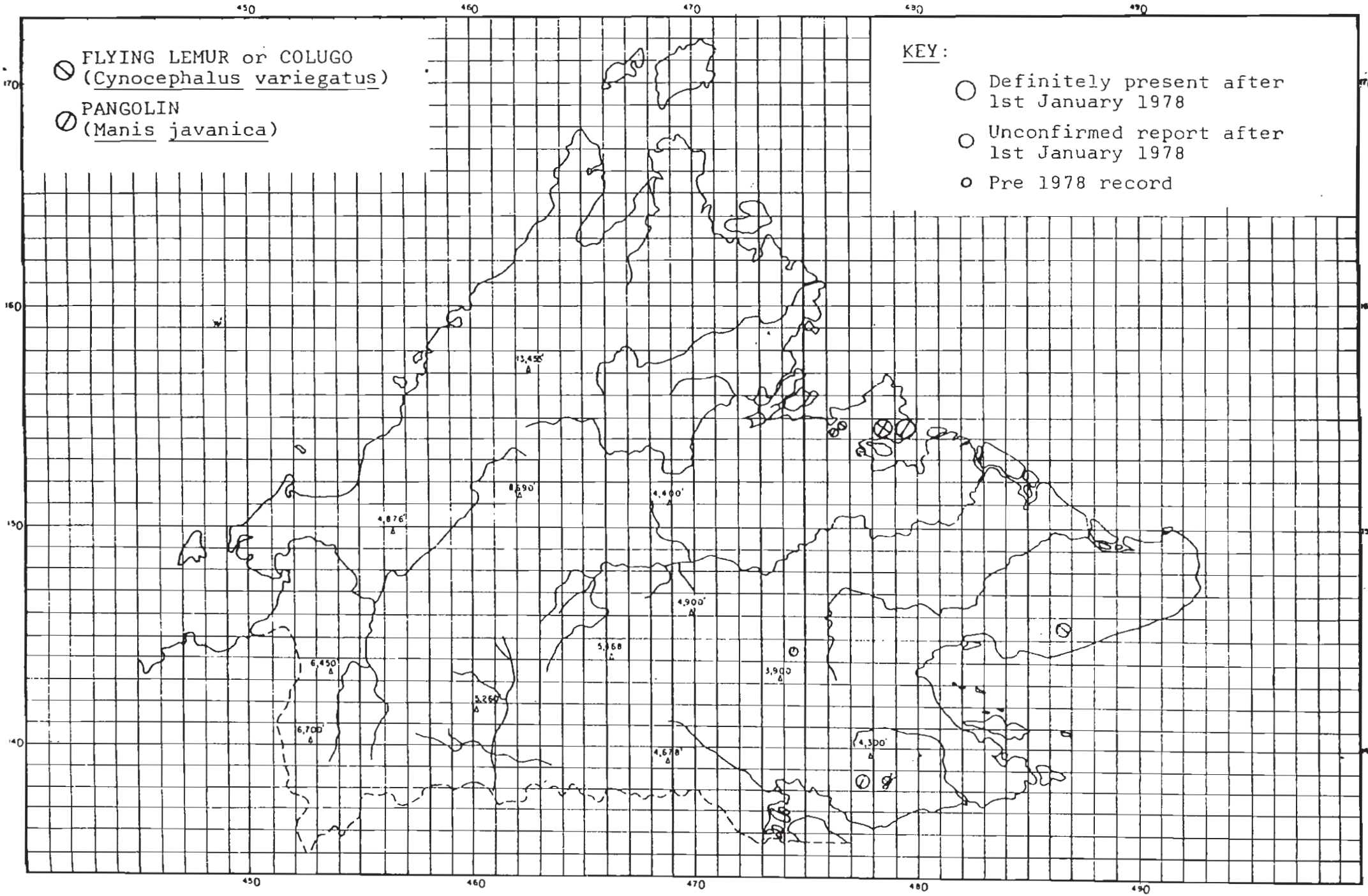
(2) FLYING LEMUR (Cynocephalus variegatus)
Family: Cynocephalidae
Order: Dermoptera

Ecology

The flying lemur or colugo is a nocturnal, gliding mammal about which little is known. It is said to feed largely on leaves, fruits and buds, but its odd, comb-like teeth suggest some dietary specialisation, such as sap from trees.

Distribution and Abundance

The only Faunal Survey records are from Sepilok Forest Reserve and a "probable" record in 20-year old logged forest (Bakapit), although there are previous records from other regions of Sabah. The paucity is due


FLYING LEMUR or COLUGO
(Cynocephalus variegatus)
PANGOLIN
(Manis javanica)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,690'
4,400'
4,876'
4,900'
5,968'
3,900'
6,450'
3,260'
6,700'
4,678'
4,300'

probably to the difficulty in detecting this species and it may prove to be locally common in suitable habitat.

(3) PANGOLIN or SCALY ANTEATER (Manis javanica)
Family: Manidae
Order: Pholidota

Ecology

The Pangolin is nocturnal, and both terrestrial and arboreal. Adults may be 1 m. in length from head to tip of tail. Pangolins live alone except when females are accompanied by infants, which are carried around at the base of the mother's tail. They feed only on ants and termites, both on the ground and in the trees.

Distribution and Abundance

Like many other nocturnal and partially arboreal mammals, this species is seen rarely. The only Faunal Survey sightings were in gardens in the Sandakan area and in Sepilok Forest Reserve. It was reported reliably to be present in the cultivated areas between Tawau and Merotai (to the south-west side of Tawau Hills National Park), and is known to local people throughout Sabah. The pangolin is evidently widely-distributed but can nowhere be reckoned as common. It is not clear whether the species is more common in cultivated areas than in forest, or whether it is merely more often seen in cultivated areas.

(4) SQUIRRELS
Family: Sciuridae
Order: Rodentia

Ecology

Squirrels may be classified into Tree and Ground Squirrels, which are diurnal, and Flying Squirrels, which actually glide and are active mainly at night-time. Broad habitat preferences of the known Sabah species may be summarised as shown in the following table (over page; one flying squirrel, probably Petaurillus sp., has not yet been collected or scientifically described from Sabah).

Type of Squirrel	Favoured Habitats	Number of species known in Sabah
Tree Squirrels	Dipterocarp Forests	6
	Montane Forests	5
	Both Dipterocarp and Montane Forests	2
	Man-made Habitats	1
Ground Squirrels	Dipterocarp Forests	3
	Montane Forests	1
Flying Squirrels	Forest Habitats	10
Total number of species known in Sabah		28

Most tree squirrels rarely travel on the ground, while ground squirrels rarely go higher than tree buttresses or fallen trees. Nine flying squirrel species have been described scientifically from Sabah, but an unknown pigmy flying squirrel (Petaurillus sp.) collected just north of Telupid, but not preserved, was described to the Faunal Survey.

In any one patch of forest, there may be up to six species of tree squirrels. As rough generalisations, the bigger the tree squirrel, the more time it spends higher up in the trees and the more structurally complex the forest, the more species are present.

The giant squirrel spends most of its time in larger trees and specialises in seeds as food. The Callosciurus species of which the black Prevost's squirrel and the common plantain squirrel are most familiar, live in medium-sized trees, eating fruits and insects. All these species also eat some young leaves, bark and sap from trees. Living most of the time in small trees and on the ground of dipterocarp forests are the horse-tailed and Low's squirrel. Both feed on fruits, seeds and arthropods. The pigmy squirrels search for food - which appears to consist largely of lichen, fungi and small arthropods - on the trunks of smaller trees. They move very rapidly from tree to tree by way of climbing plants and slender branches.

Little is known of the other squirrels, although the tufted ground squirrel, which has been reported as occasionally arboreal, was seen eating fallen fruits on a log.

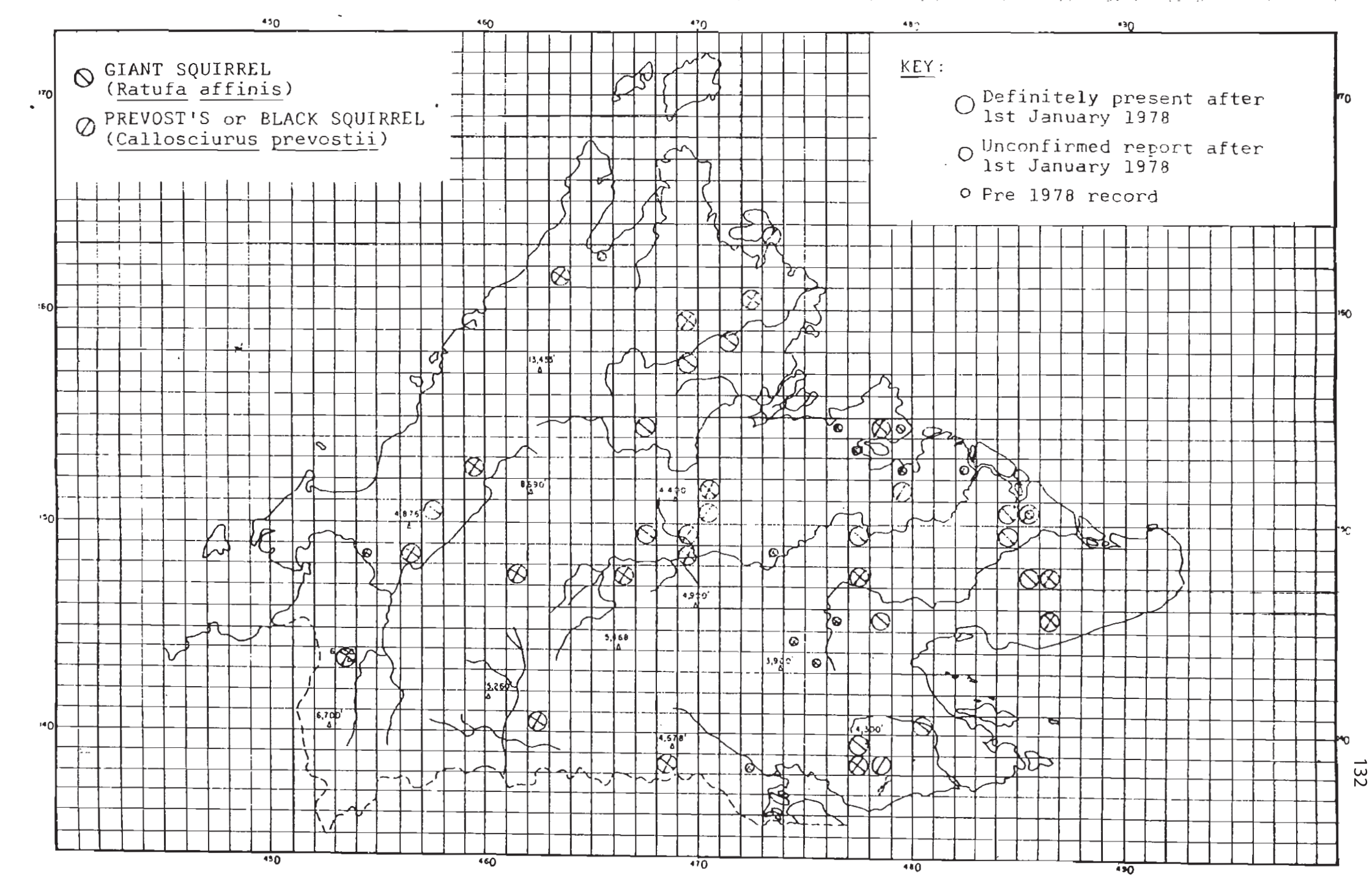
Distribution and Abundance

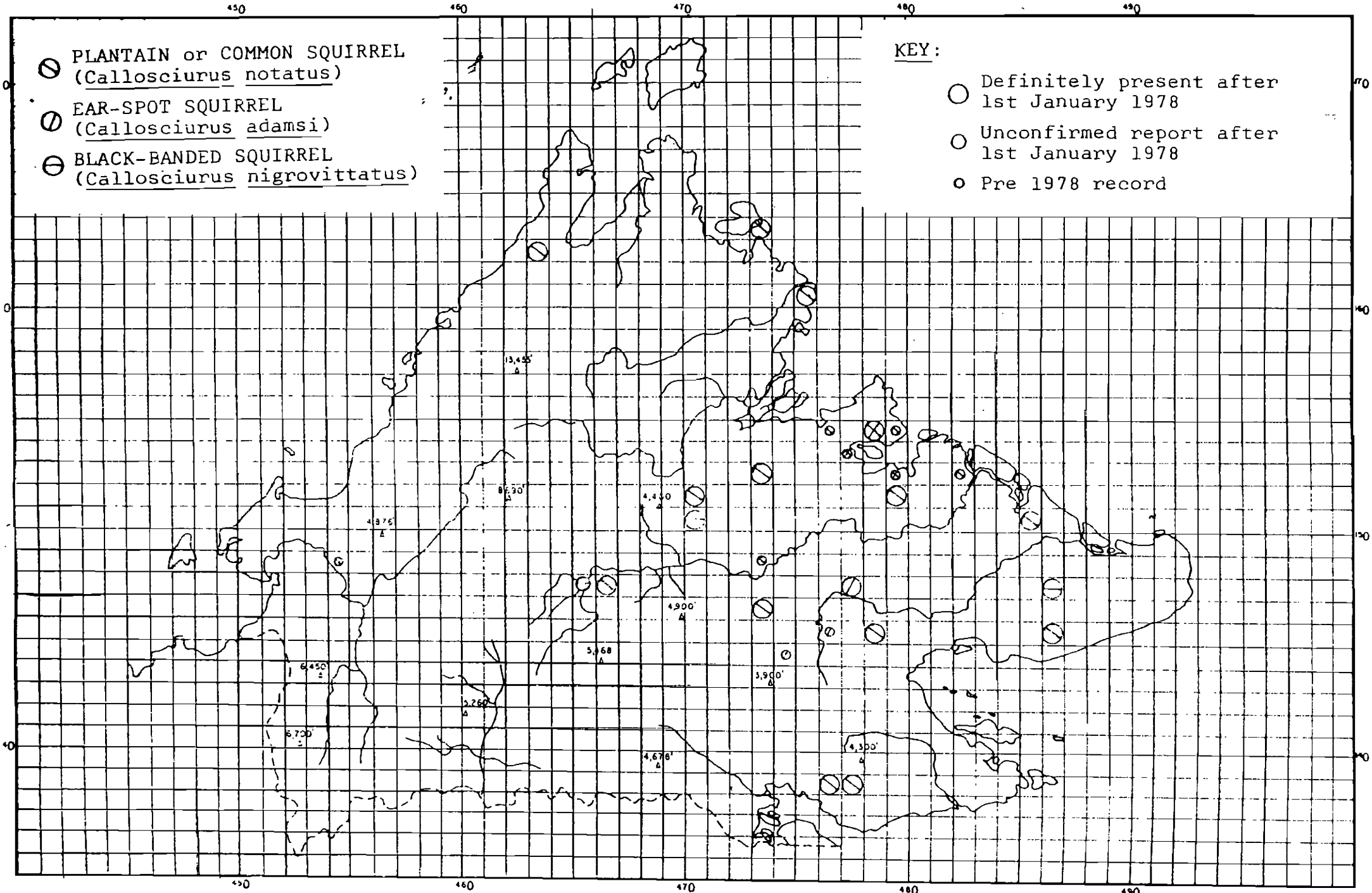
The giant squirrel exists in most areas where there are sufficient medium or large sized trees. This species is most abundant in primary dipterocarp forest at all altitudes, but exists also in lower montane forest and some logged dipterocarp forest. Population density in Peninsular Malaysia (primary lowland dipterocarp forest) was estimated at one individual in 4 ha. but there was also a closely-related species at that site (30).

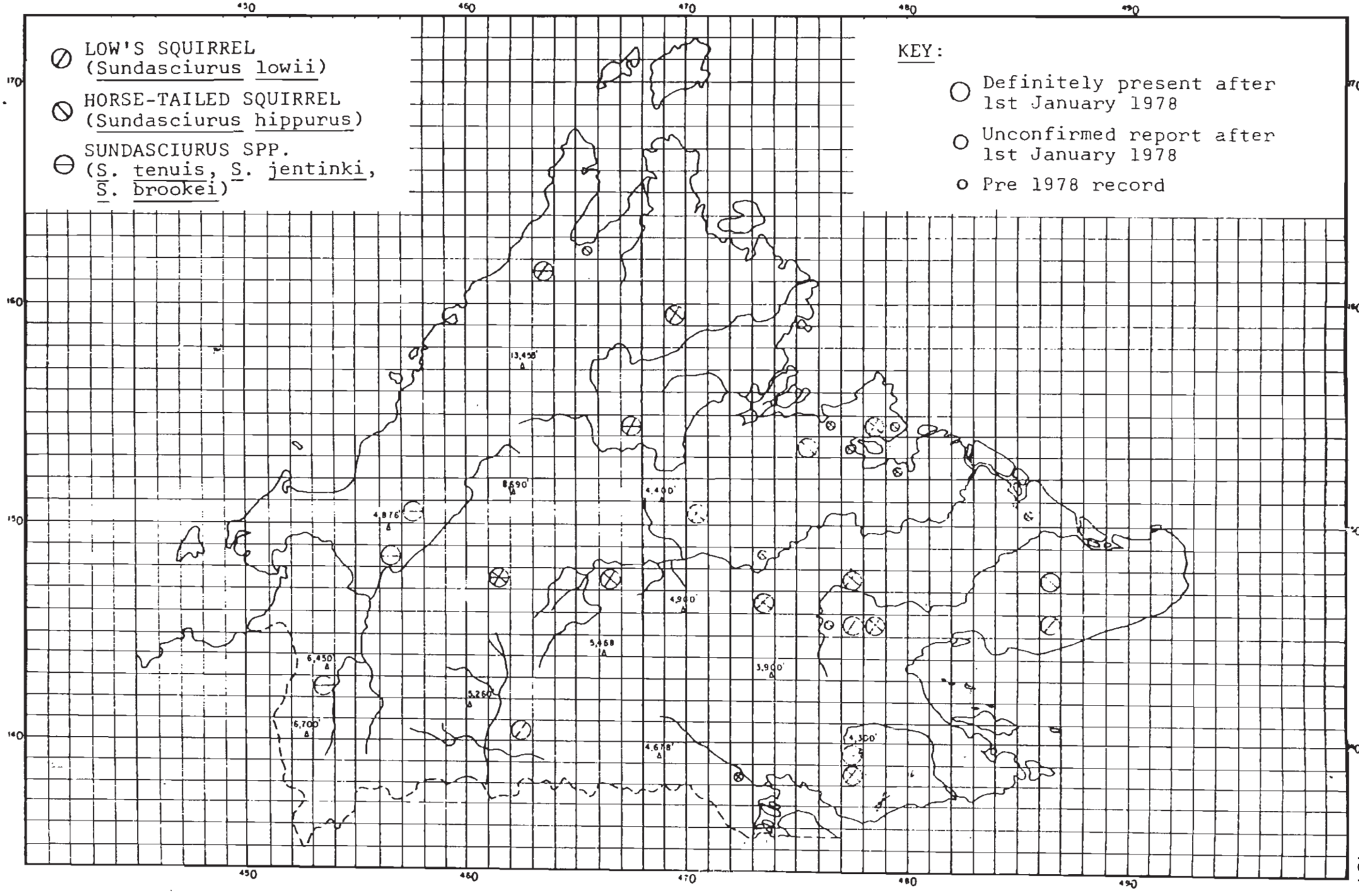
Prevost's squirrel occurs throughout Sabah in primary and logged dipterocarp forest. It raids gardens and plantations for fruit, but does not live entirely in such habitats. Population density of this species was estimated at one site in Peninsular Malaysia (primary lowland dipterocarp forest) at one individual in 2.5 ha., but densities in Sabah appear to be generally lower. The plantain squirrel is known almost entirely from man-made habitats. It can live and reproduce in orchards and monoculture plantations, where it is usually the most serious mammalian pest. Population density in mature cocoa plantation (Bal Estate, Tawau), where numbers are reduced by shooting which has been in operation for many years, was estimated as at least one individual in 1 ha. Formerly, densities were considerably higher. Population density on the edge of primary lowland dipterocarp forest in Peninsular Malaysia was estimated at one squirrel in 0.4 ha. (30).

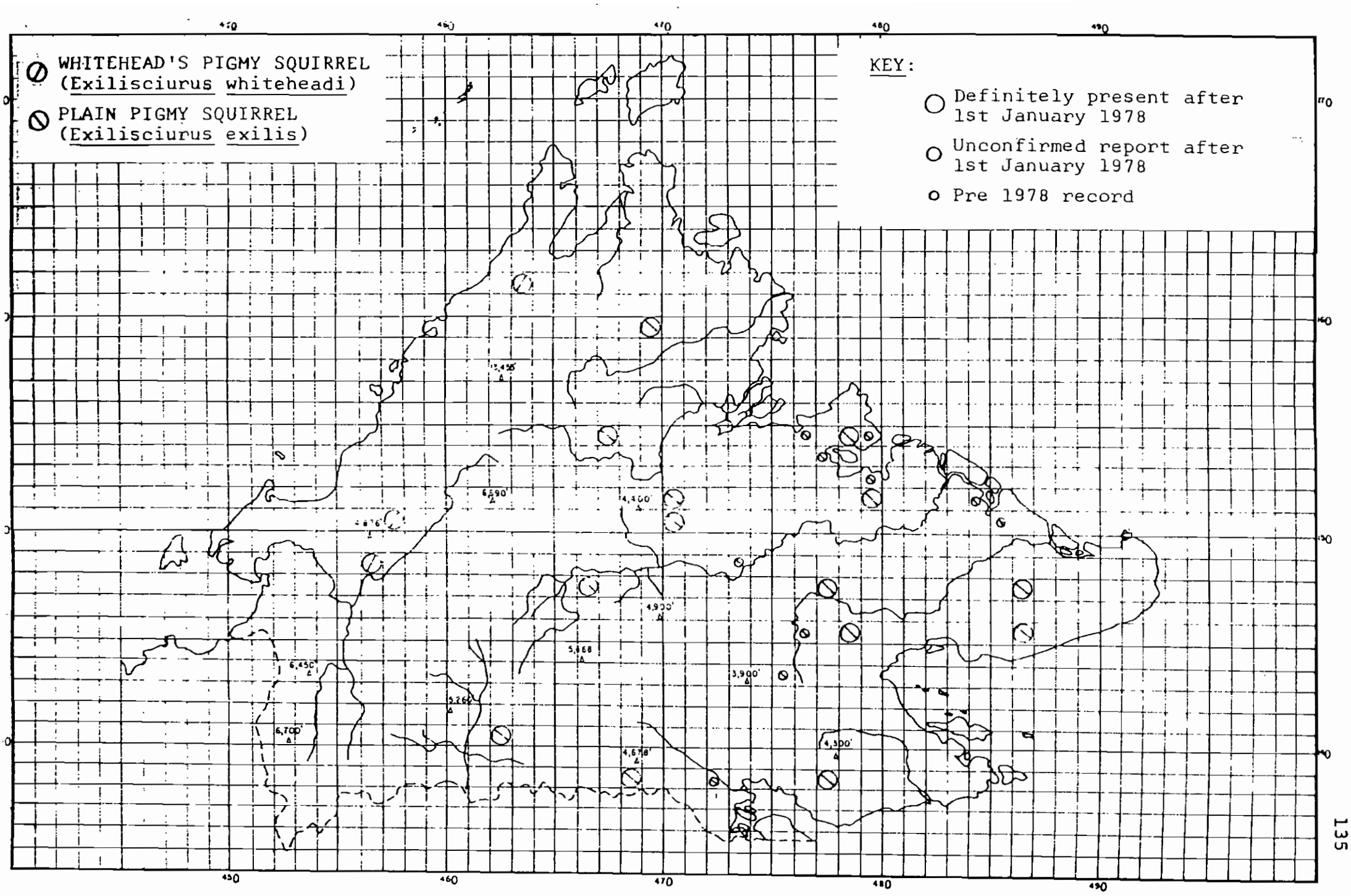
The black-banded and ear-spot squirrels resemble closely the plantain squirrel, but both are rare and patchily distributed mainly in primary forest. The Faunal Survey produced two new locality records for each species.

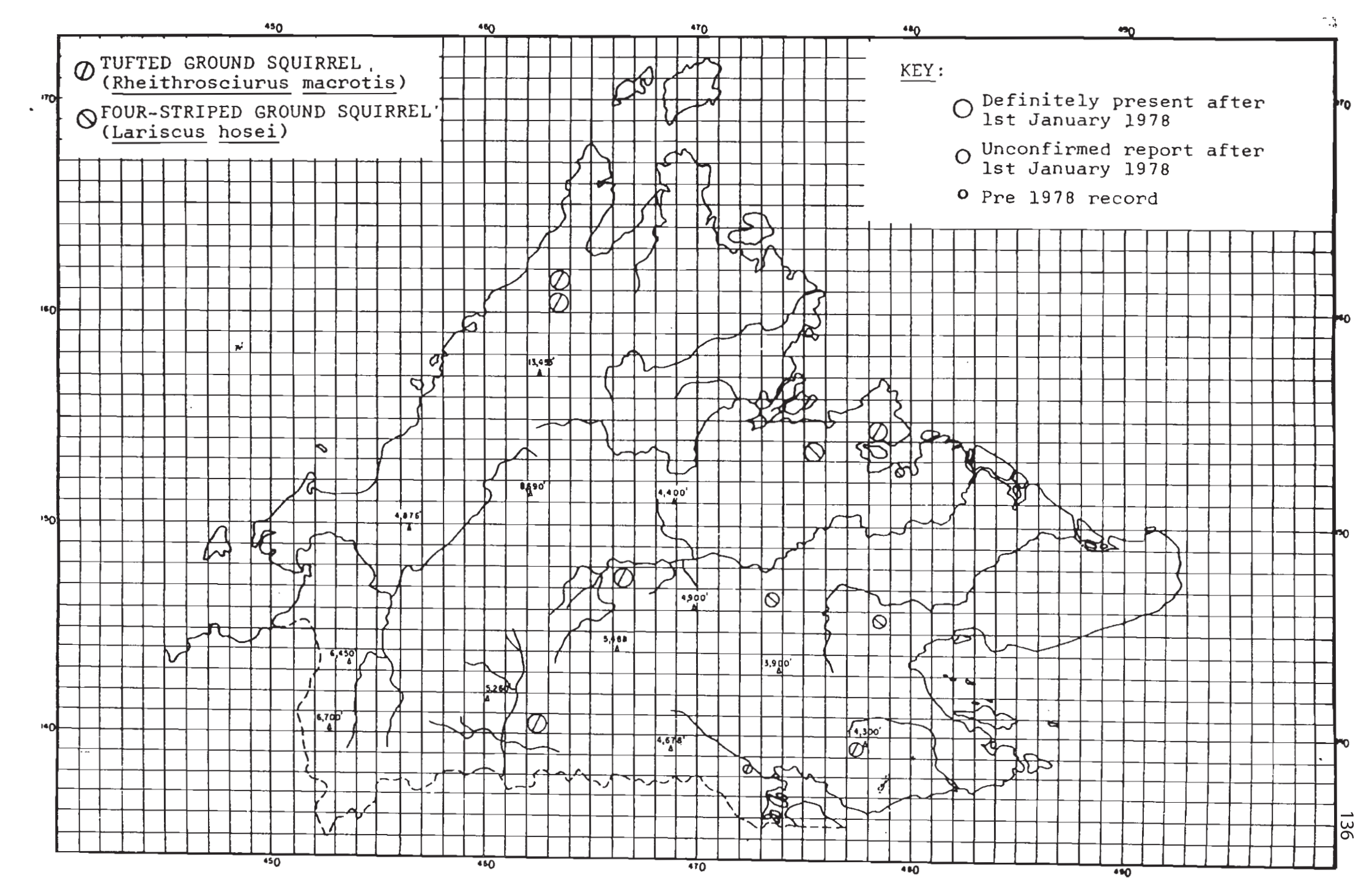
There are no records of the horse-tailed or Low's squirrel from most of western Sabah, but otherwise these

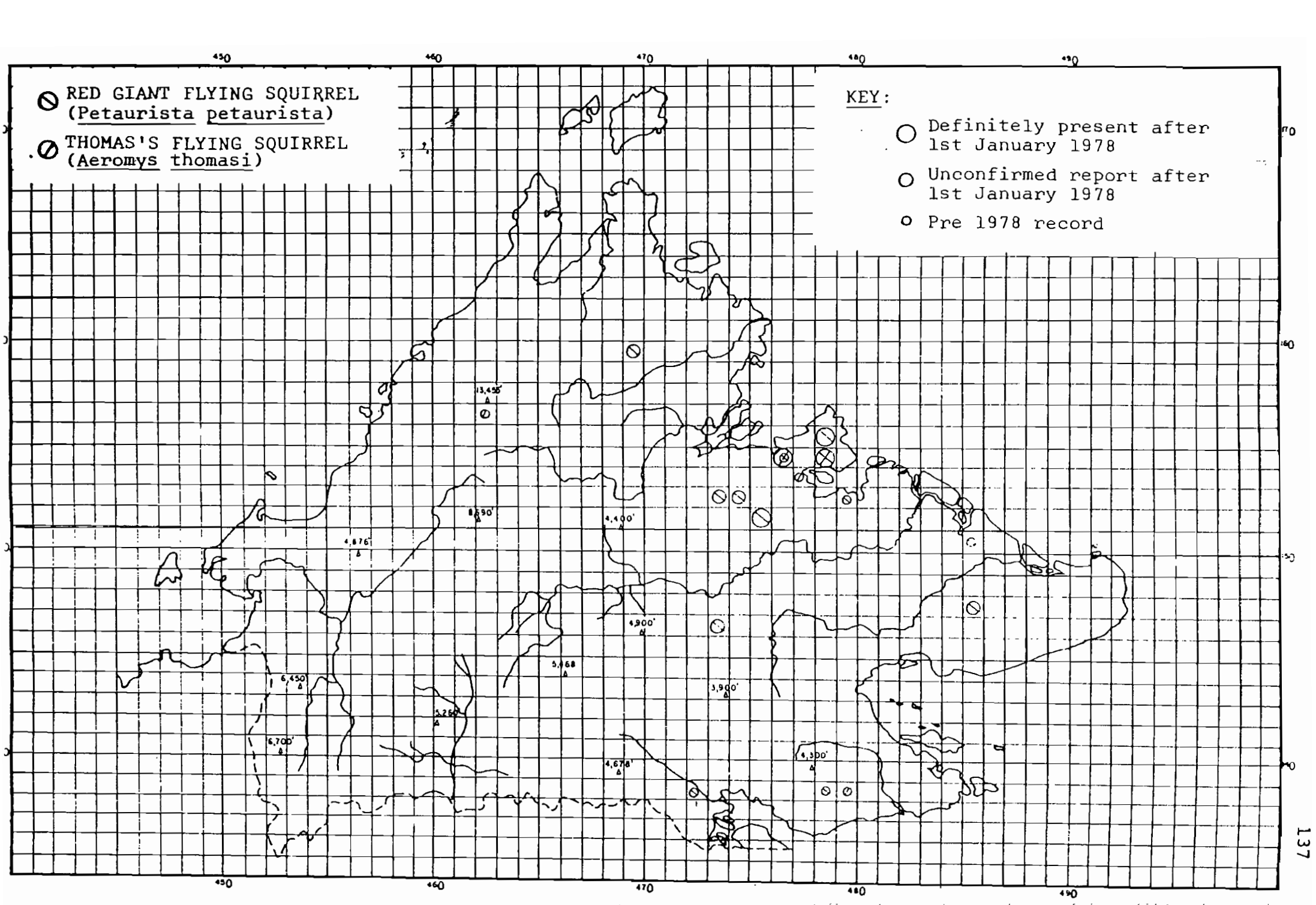

GIANT SQUIRREL
(Ratufa affinis)
PREVOST'S or BLACK SQUIRREL
(Callosciurus prevostii)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,590'
4,875'
4,420'
4,900'
5,168'
3,900'
5,260'
6,700'
4,578'
4,300'


PLANTAIN or COMMON SQUIRREL
(Callosciurus notatus)
EAR-SPOT SQUIRREL
(Callosciurus adamsi)
BLACK-BANDED SQUIRREL
(Callosciurus nigrovittatus)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
13,455'
8,430'
4,440
4,900'
5,168
3,900'
6,450'
5,700'
4,676'
4,300'


LOW'S SQUIRREL
(Sundasciurus lowii)
HORSE-TAILED SQUIRREL
(Sundasciurus hippurus)
SUNDASCIURUS SPP.
(S. tenuis, S. jentinki,
S. brookei)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,690'
4,400'
4,876'
4,900'
5,468'
6,450'
3,900'
5,260'
6,700'
4,678'
4,300'


WHITEHEAD'S PIGMY SQUIRREL
(Exilisciurus whiteheadi)
PLAIN PIGMY SQUIRREL
(Exilisciurus exilis)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
6,450'
6,700'
5,868
4,900'
3,900'
4,300'
4,678'
5,266'
6,590'
4,360'


TUFTED GROUND SQUIRREL
(Rheithrosciurus macrotis)
FOUR-STRIPED GROUND SQUIRREL
(Lariscus hosei)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,890'
4,400'
4,876'
4,900'
5,088'
3,900'
6,450'
5,260'
6,700'
4,300'
4,678'


RED GIANT FLYING SQUIRREL
(Petaurista petaurista)
THOMAS'S FLYING SQUIRREL
(Aeromys thomasi)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
13,455'
8,890'
4,876'
4,100'
4,900'
5,068'
6,450'
5,260'
6,700'
3,900'
4,300'
4,678'

species are distributed widely in primary and old secondary forests. Low's squirrel may be locally abundant but the horse-tailed squirrel was nowhere common.

Small Sundasciurus spp. (species uncertain) were observed in the western hill ranges at 1,800-4,000 feet a.s.l. and in Tawau Hills (3,000 feet a.s.l.). The plain pigmy squirrel occurs throughout Sabah in primary and old logged lowland and upland dipterocarp forests. In the highlands and montane habitats, it is replaced by Whitehead's pigmy squirrel - which has distinctly tufted ears - as low as 1,600 feet a.s.l. at Ulu Losan but usually at higher altitudes. Where present, these squirrels are usually common.

There was one definite and one unconfirmed sight record of the four-striped ground squirrel, indicating that it is as rare as its scarcity in museum collections suggests. Sight records and local information indicate that the spectacular tufted ground squirrel (body length about 34 cm.) occurs throughout Sabah in primary dipterocarp forests. One individual was seen in an area, at Sungai Langut which probably had been cultivated a very long time ago, and is now rich in wild fruit trees such as Dracontomelum, Grewia, Ficus and Durio. Only five individuals were seen during the Faunal Survey, indicating that this is probably the rarest of the diurnal squirrels.

Only two species of flying squirrels were identified during the Faunal Survey - Thomas's (recorded twice) and the red giant (several areas). Unconfirmed records, both sightings and calls, probably of the red giant flying squirrel were obtained in other areas. The apparent rarity of flying squirrels is mainly attributable to the difficulty in detecting them.

(5) PORCUPINES
Family: Hystricidae
Order: Rodentia

Ecology

There are three species of porcupines in Sabah:-

Long-tailed porcupine (Trichys lipura)
Common porcupine (Hystrix brachyura)
Thick-spined porcupine (Thecurus crassispinis)

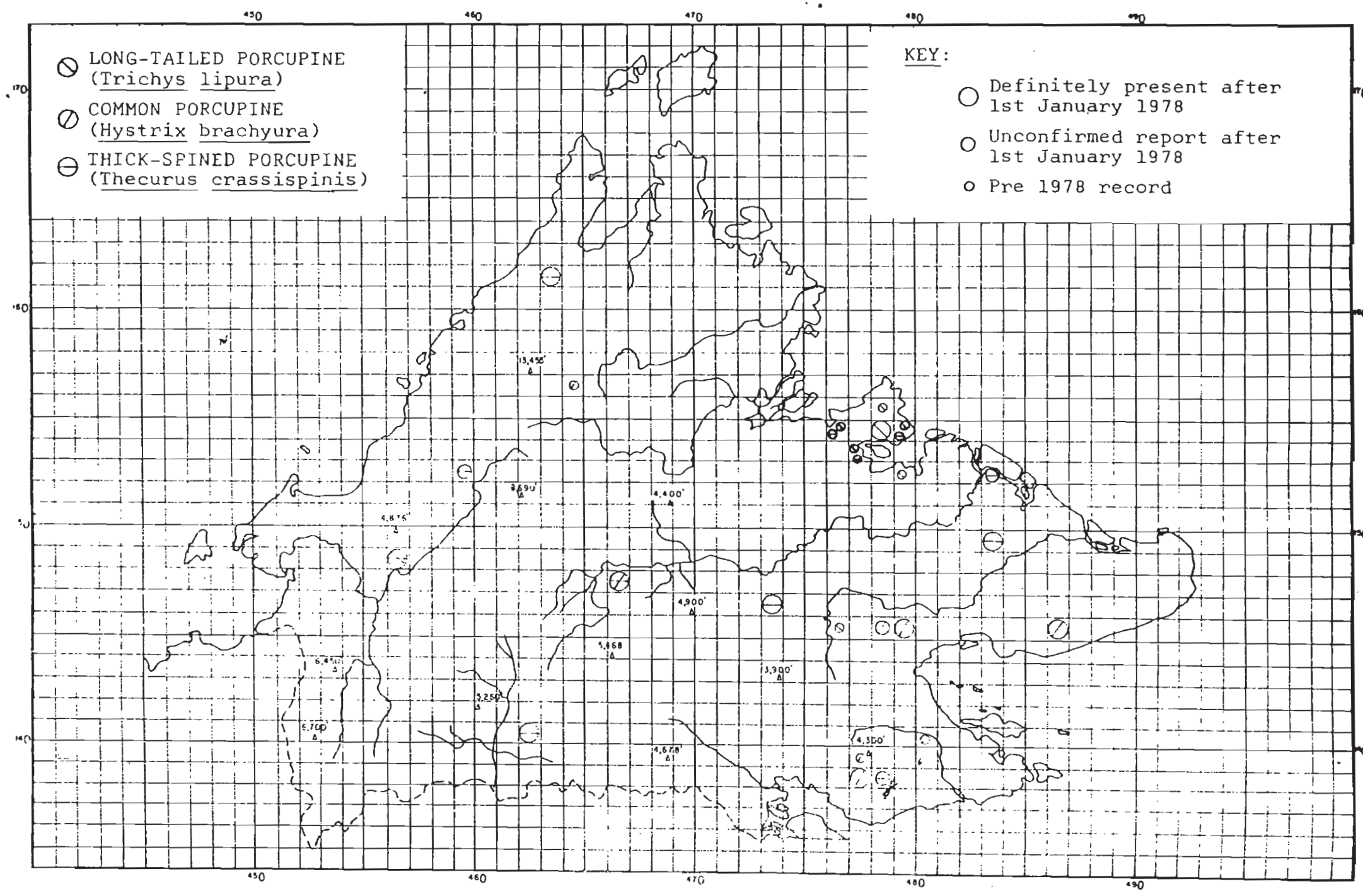
All are nocturnal and terrestrial. Seeds, roots and other vegetative plant material (at or near ground level) form their basic diet. At Sepilok Forest Reserve, a long-tailed porcupine was observed eating belian (Eusideroxylon zwageri) seeds under the parent tree and there is good circumstantial evidence that seeds were being taken elsewhere. In the Crocker Range at 1,800 feet a.s.l., a group of three long-tailed porcupines was seen on a steep hill-side in a thick-stemmed bamboo thicket. It was probably these porcupines which had been eating bamboo shoots, the remains of which were found the following day. At Sepilok, young wild ginger stems were seen eaten, probably by this species.

The common porcupine is the largest of the three species. One was observed in an overgrown, old cultivated area near Pinangah eating the hard seeds of a legume liana. Another was seen leaving an oil palm plantation in which it had evidently been eating oil palm fruits.

The thick-spined porcupine resembles the common porcupine, but has fewer thick, black-and-white spines. The thick-spined porcupine was observed feeding only once, on the seeds of fallen fruits. It may have been this species which had been eating durian seeds in old logged forest at Malubuk. At Gunung Madalon, one was seen in its burrow between the buttresses of a large tree on a hill-side, and large quantities of the discarded remains of Scorodocarpus sp. seeds were scattered nearby.

Distribution and Abundance

The long-tailed porcupine was recorded at only two different places, on opposite sides of Sabah, in flat lowland dipterocarp forest and steep highland dipterocarp forest. It is known to local people throughout Sabah. At Sepilok Forest Reserve, three different individuals of this species were trapped (on three different occasions) in a total trapping area of less than 0.5 ha.


LONG-TAILED PORCUPINE
(Trichys lipura)
COMMON PORCUPINE
(Hystrix brachyura)
THICK-SPINED PORCUPINE
(Thecurus crassispinis)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,458'
8,890'
4,400'
4,900'
5,468
5,300'
5,250'
4,300'
4,678'

The common porcupine is evidently distributed widely throughout Sabah, although there are none from Sabah in museum collections. The limited number of precisely located records available suggest that this species adapts better to man-made habitats than the thick-spined porcupine. The only local informant (an experienced Murut hunter) who distinguished the common and thick-spined porcupine said that one is found in tall, primary forest and the other in old secondary forest, but it was not clear which was which. Both species have been recorded up to about 3,000 feet a.s.l. The thick-spined porcupine is also widely distributed and judging from the relative number of records the more common of the two species.

(6) THE MUSTELIDS (MARTEN, WEASEL, TELEDU, FERRET-BADGER, and OTTERS)
Family: Mustelidae
Order: Carnivora

Yellow-throated Marten	(Martes flavigula)
Malay Weasel	(Mustela nudipes)
Teledu	+(Mydaus javanensis)
Ferret-Badger	(Melogale orientalis)
Hairy-nosed Otter	(Lutra sumatrana)
Smooth Otter	(Lutra perspicillata)
Small-clawed Otter	(Amblonyx cinerea)

+Also known as Tudu, Malay Badger or, incorrectly, skunk.

Ecology

Little is known of these mustelids because they live at low population densities and leave few identifiable signs of their existence. There have been no ecological studies and most information comes from chance sightings and some published works (notably 29).

The yellow-throated marten is active diurnally and searches for food in the trees and on the ground. Food includes all forms of small vertebrate and invertebrate animals, with some fruits and nectar. They may hunt singly, as adult pairs or in family groups. They were

seen in primary dipterocarp forest, logged forest and tree plantation during the Faunal Survey.

All records of the Malay weasel are from or adjacent to forest.

The teledu is normally nocturnal, although one was seen active on a cloudy, damp afternoon. It appears to feed largely by digging into top-soil, eating earthworms, cicada larvae and other invertebrates.

Nothing is known of the ecology of the ferret-badger in Sabah, but a closely-related species on the Asian mainland seems to be similar to the teledu.

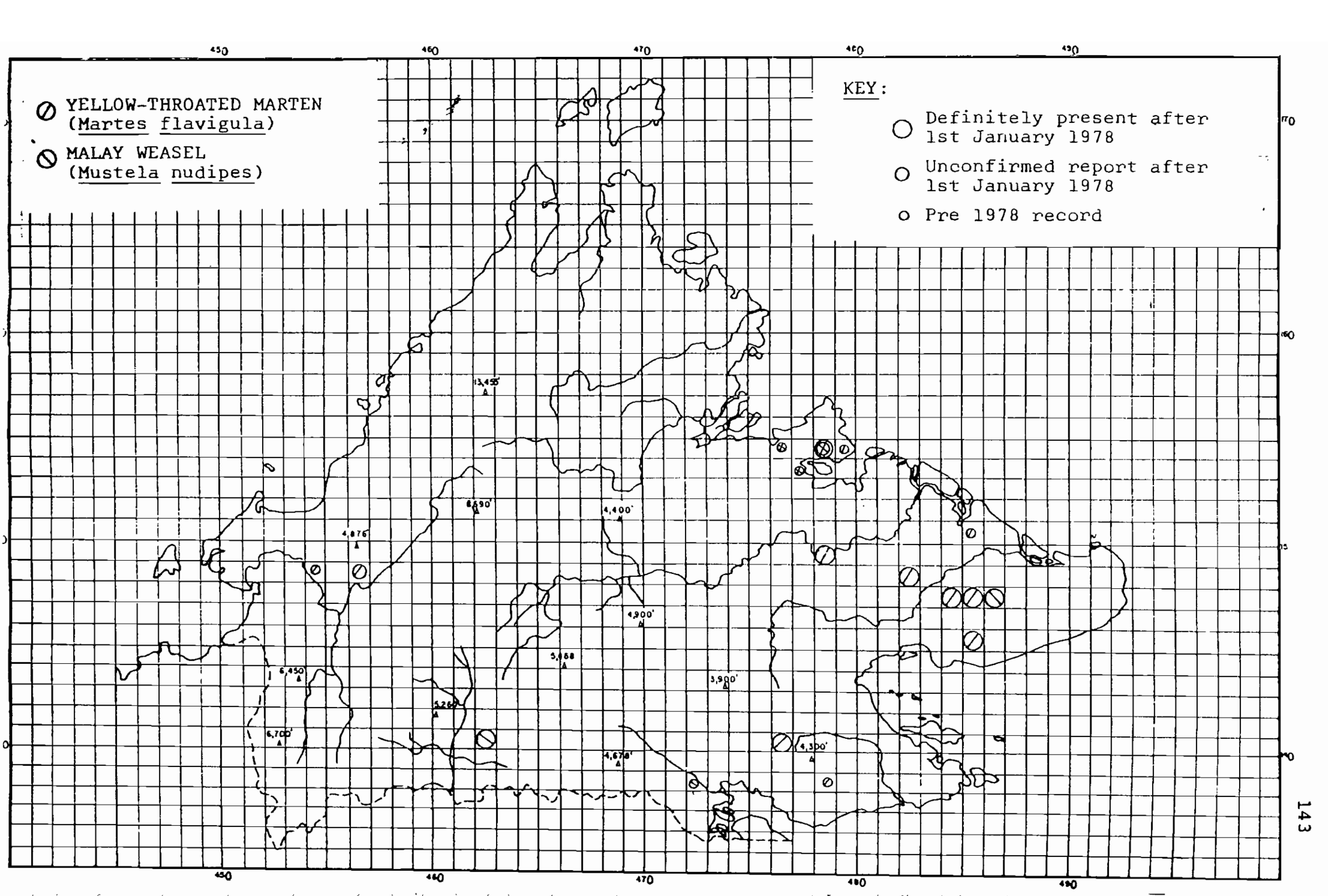
All the otter species live as family groups but in Sabah single adults are often seen foraging alone. The two larger otters (hairy-nosed and smooth) seem to live largely on fish in coastal waters and larger rivers. The small-clawed otter feeds mainly on freshwater and coastal invertebrate animals.

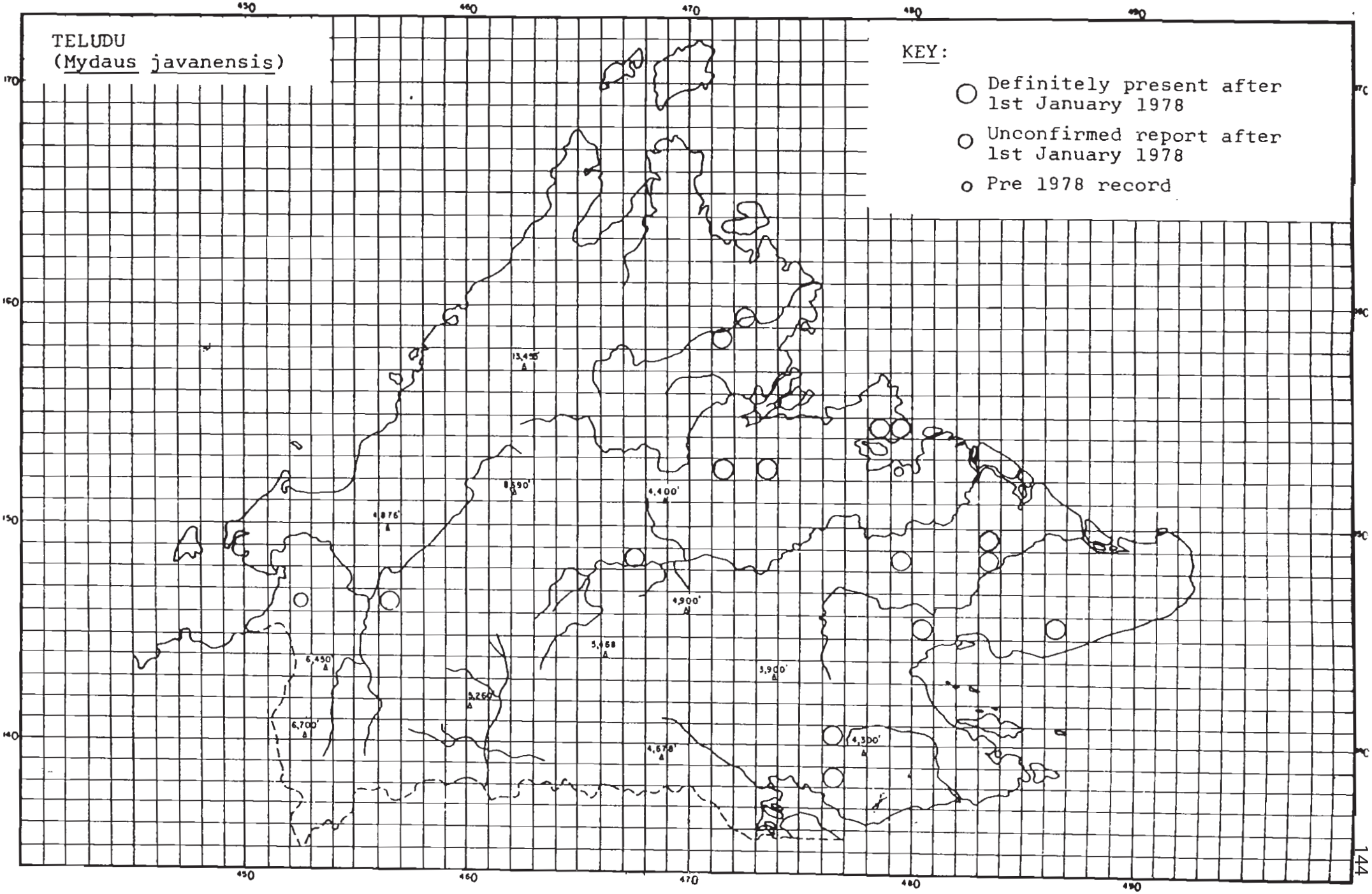
Distribution and Abundance

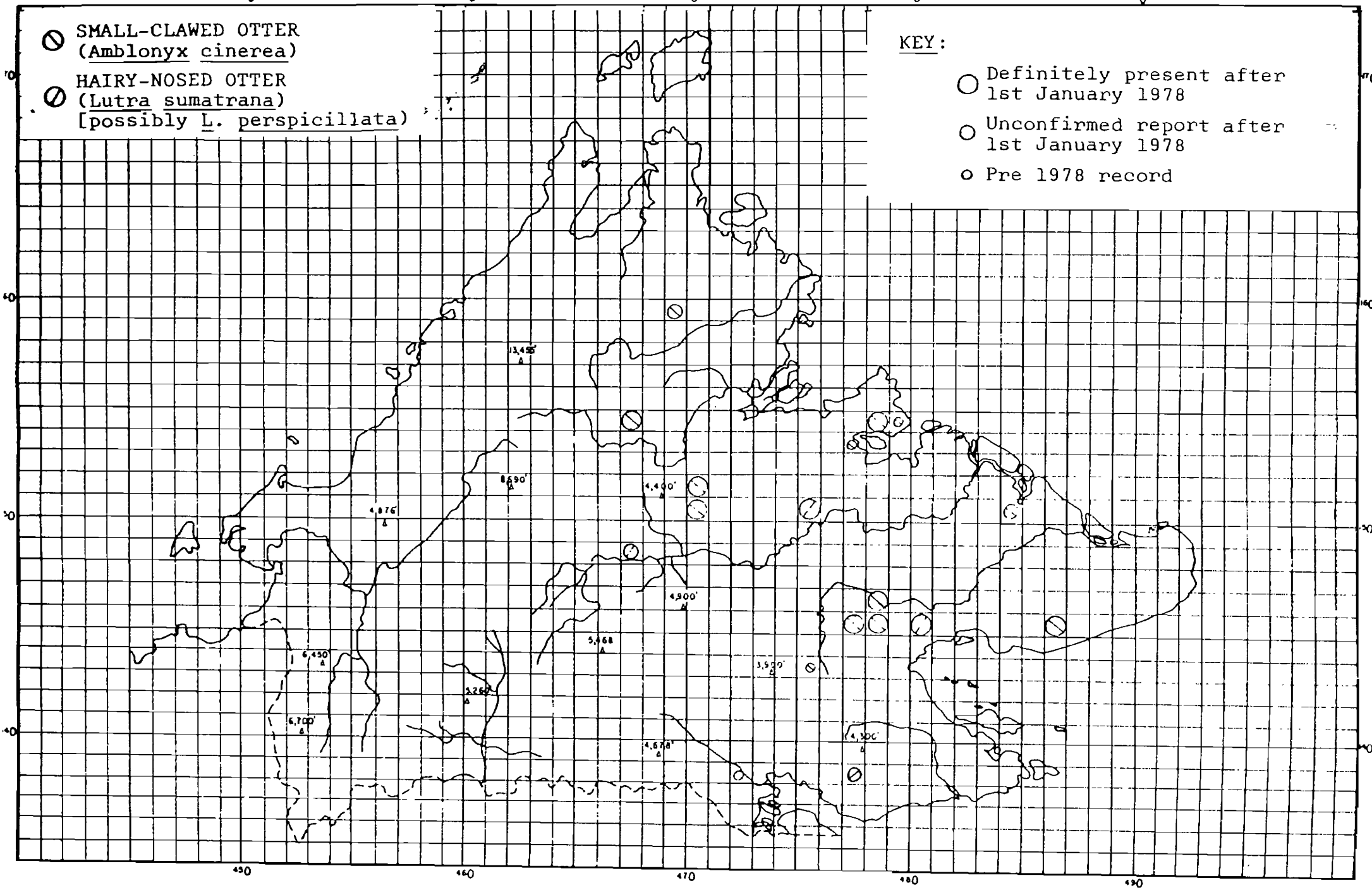
Almost all records of the yellow-throated marten were from eastern Sabah, but the species is known to the indigenous people of the west, and it is evidently widespread and adaptable, being found to an altitude of at least 3,000 feet a.s.l. The Malay weasel is also widely distributed, but more information is needed. It seems to be regarded as a kind of ground squirrel by some people in Sabah.

The teledu may be restricted by altitude or gradient, or some related factor, since the highest record of this species is at 1,000 feet a.s.l. Below this altitude, it was recorded in logged forest, plantations, gardens, roadsides and in one primary forest area (Sepilok).

No ferret-badgers were seen during the Faunal Survey, but it is clear from local people that this species is not restricted either to Mount Kinabalu or to primary forest (as has been recorded previously, (4)) and indeed is possibly more common in the cultivated hilly areas of western Sabah.


YELLOW-THROATED MARTEN
(Martes flavigula)
MALAY WEASEL
(Mustela nudipes)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
13,455'
8,690'
4,876'
4,400'
4,900'
5,168'
6,450'
5,260'
6,700'
3,900'
4,678'
4,300'


TELUDU
(Mydaus javanensis)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,590'
4,400'
4,876'
4,900'
5,468'
6,450'
3,900'
3,260'
6,700'
4,678'
4,300'


SMALL-CLAWED OTTER
(Amblonyx cinerea)
HAIRY-NOSED OTTER
(Lutra sumatrana)
[possibly L. perspicillata)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
13,455'
8,690'
4,400'
4,876'
4,900'
5,668'
6,450'
3,520'
3,260'
6,700'
4,678'
4,300'

Large otters were seen in two places (Pintasan on the middle Kinabatangan River and at Silam) and are reported by local people in the Kinabatangan River as far up as Tongud (reliable) and upper Tawau River (less reliable). The small-clawed otter is more common, and probably occurs wherever there are streams and forest cover.

There is insufficient information to comment on the abundance of any mustelid in Sabah. We do not regard any of them as sufficiently rare or threatened by development to warrant special conservation measures now.

(7) The VIVERRIDS (CIVETS, or MUSANG, and MONGOOSES)
Family: Viverridae
Order: Carnivora

Nine species of civets, or musang as they are known locally, occur in Sabah:-

Tangalung or Malay Civet	(Viverra tangalunga)
Banded Linsang	(Prionodon linsang)
Common Palm Civet	(Paradoxurus hermaphroditus)
Masked Palm Civet	(Paguma larvata)
Binturong	(Arctictis binturong)
Small-toothed Palm Civet	(Arctogalidia trivirgata)
Banded Palm Civet	(Hemigalus derbyanus)
Hose's Civet	(Hemigalus hosei)
Otter Civet	(Cynogale bennetti)

All are nocturnal, but the binturong and small-toothed palm civet are sometimes active also during the day-time. All have some distinctive feature useful for field recognition, but the common and small-toothed palm civets are often difficult to distinguish.

Two species of mongoose are known from Sabah and there is probably a third:-

Short-tailed Mongoose	(Herpestes brachyurus)
Collared Mongoose	(Herpestes semitorquatus)
and possibly *	
Hose's Mongoose	(Herpestes hosei)

Ecology

The tangalung (rather cat-like with black spots and

stripes on a whitish background) hunts only on the ground and feeds predominantly on invertebrate and small vertebrate animals. The banded linsang is the smallest civet, predominantly or wholly carnivorous. The common palm civet is the most commonly seen species. Fruits, orthopterans and beetles form the bulk of its diet. This species forages both on the ground and in the trees. The masked palm civet appears like a large version of the common palm civet and its diet is similar. The binturong is the largest civet and the alternative name of bear-cat is apt. It is probably the animal sometimes mistaken in Sabah for a black leopard. Most sightings in Malaysia are of binturongs feeding on the fruits of strangling fig plants during the day-time, but they also forage on the ground for animal food. This is the only civet in Sabah with a prehensile tail. The small-toothed palm civet appears like a slender, long-tailed version of the common palm civet, and it is more arboreal than the latter. The banded palm civet is a terrestrial species which feeds largely on orthopterans and earthworms, and no plant material. Nothing is known of the ecology of Hose's civet or the otter civet.

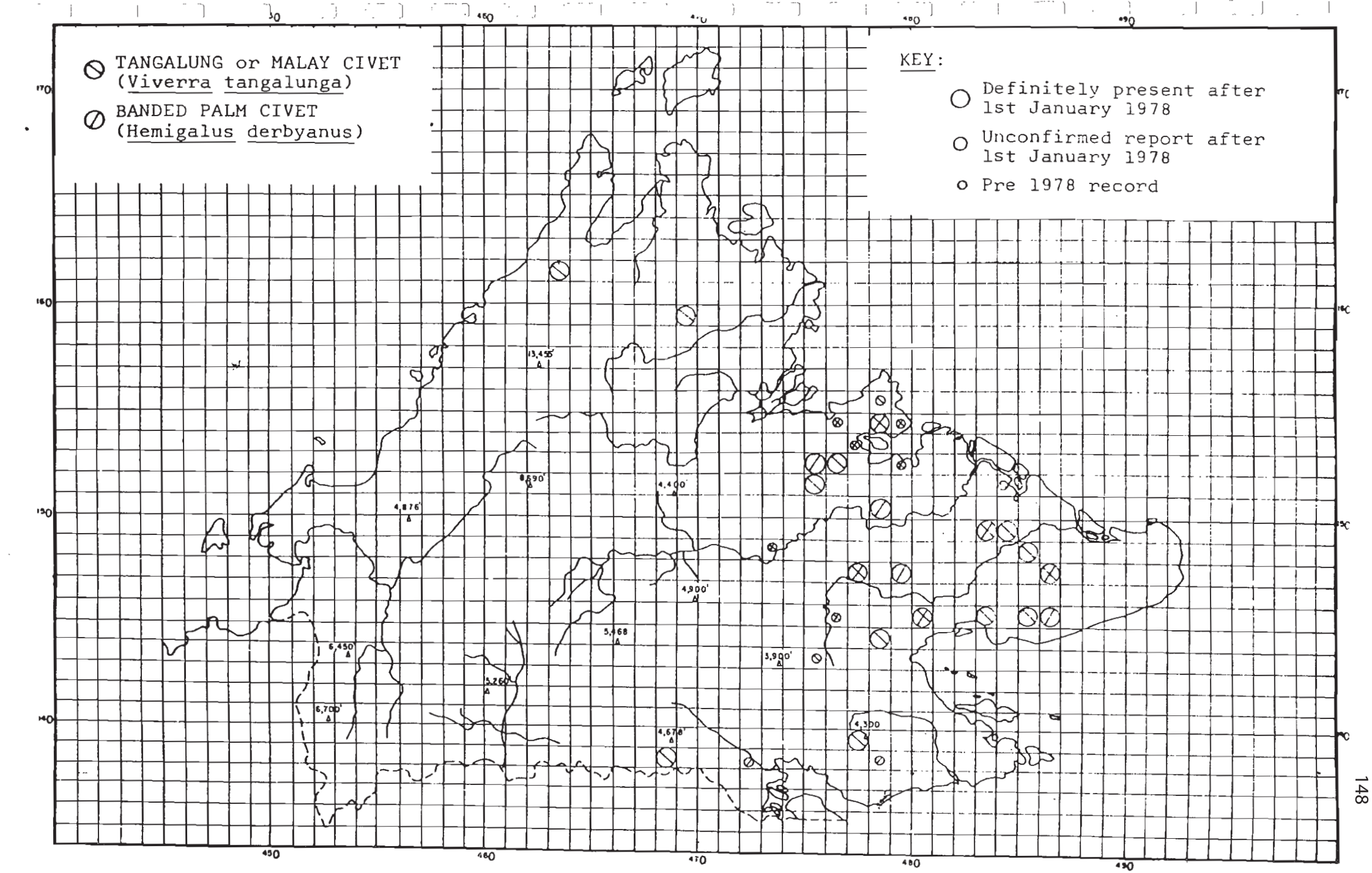
Mongooses are predominantly diurnal and terrestrial, feeding on large invertebrate and small vertebrate animals.

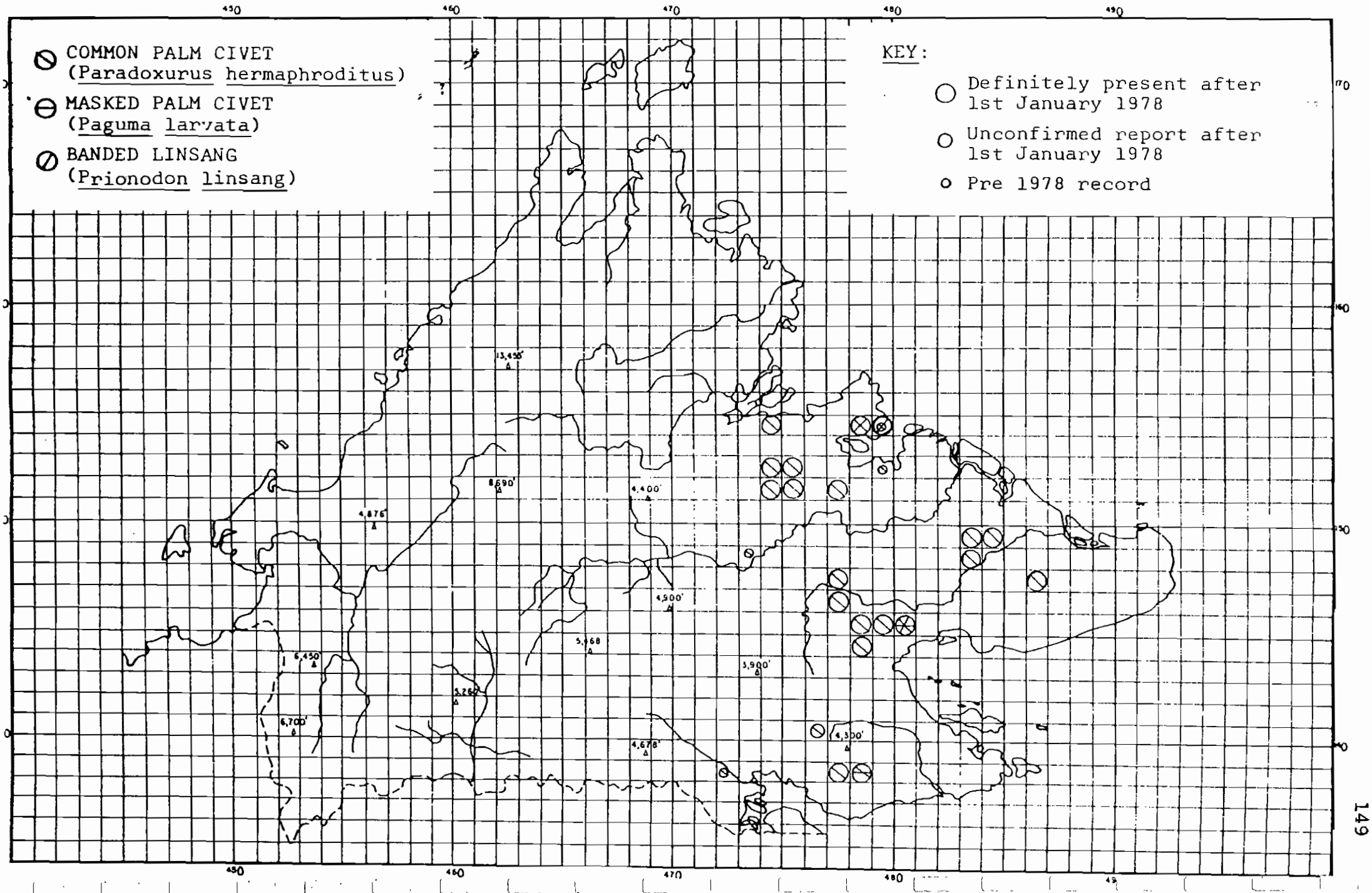
Distribution and Abundance

Faunal Survey records appear to show that the viverrids generally are more abundant in eastern than in western Sabah. This is largely spurious, however, since most viverrid records were obtained from logging roads, which were not surveyed in western Sabah.

All sixteen records of the tangalung were in primary or logged forest up to nearly 3,000 feet a.s.l. The banded linsang was recorded only in three places; in an experimental cocoa plantation under secondary forest, on the outskirts of Sandakan town in a built-up area with adjacent belukar, and in Sepilok Virgin Jungle Reserve.

All records of the common palm civet except one were in exploited habitats or on logging roads through primary forest, at less than 1,000 feet a.s.l. They were


TANGALUNG or MALAY CIVET
(Viverra tangalunga)
BANDED PALM CIVET
(Hemigalus derbyanus)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
13,455'
8,590'
4,400'
4,876'
4,900'
5,468'
6,450'
5,260'
3,900'
6,700'
4,678'
4,300'
450
460
470
480
490
170
160
150
140


COMMON PALM CIVET
(Paradoxurus hermaphroditus)
MASKED PALM CIVET
(Paguma larvata)
BANDED LINSANG
(Prionodon linsang)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
13,455'
8,690'
4,876'
4,400'
4,900'
5,468'
3,900'
6,450'
5,262'
6,700'
4,678'
4,300'
430
440
450
460
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500
510
520
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540
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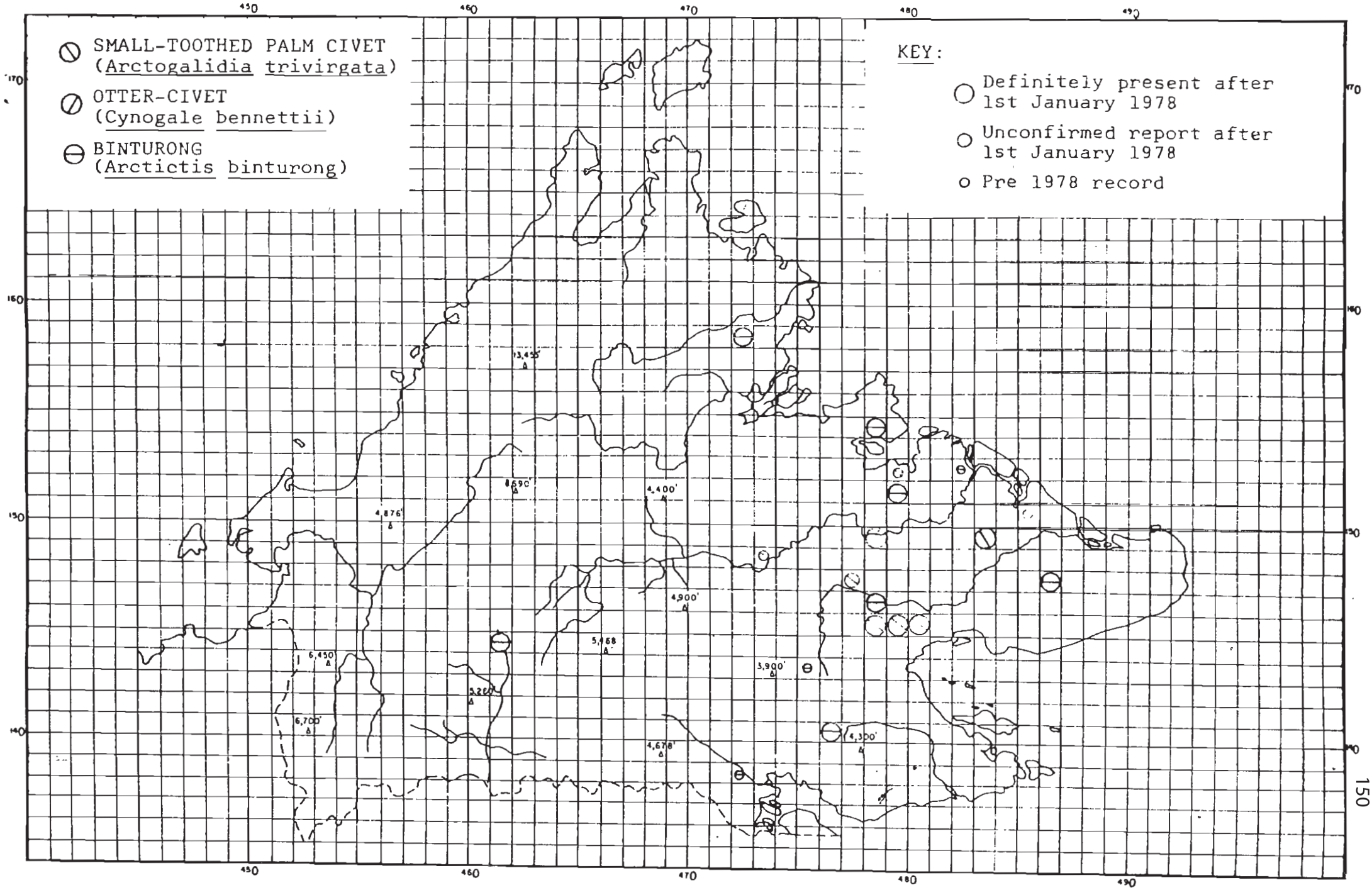
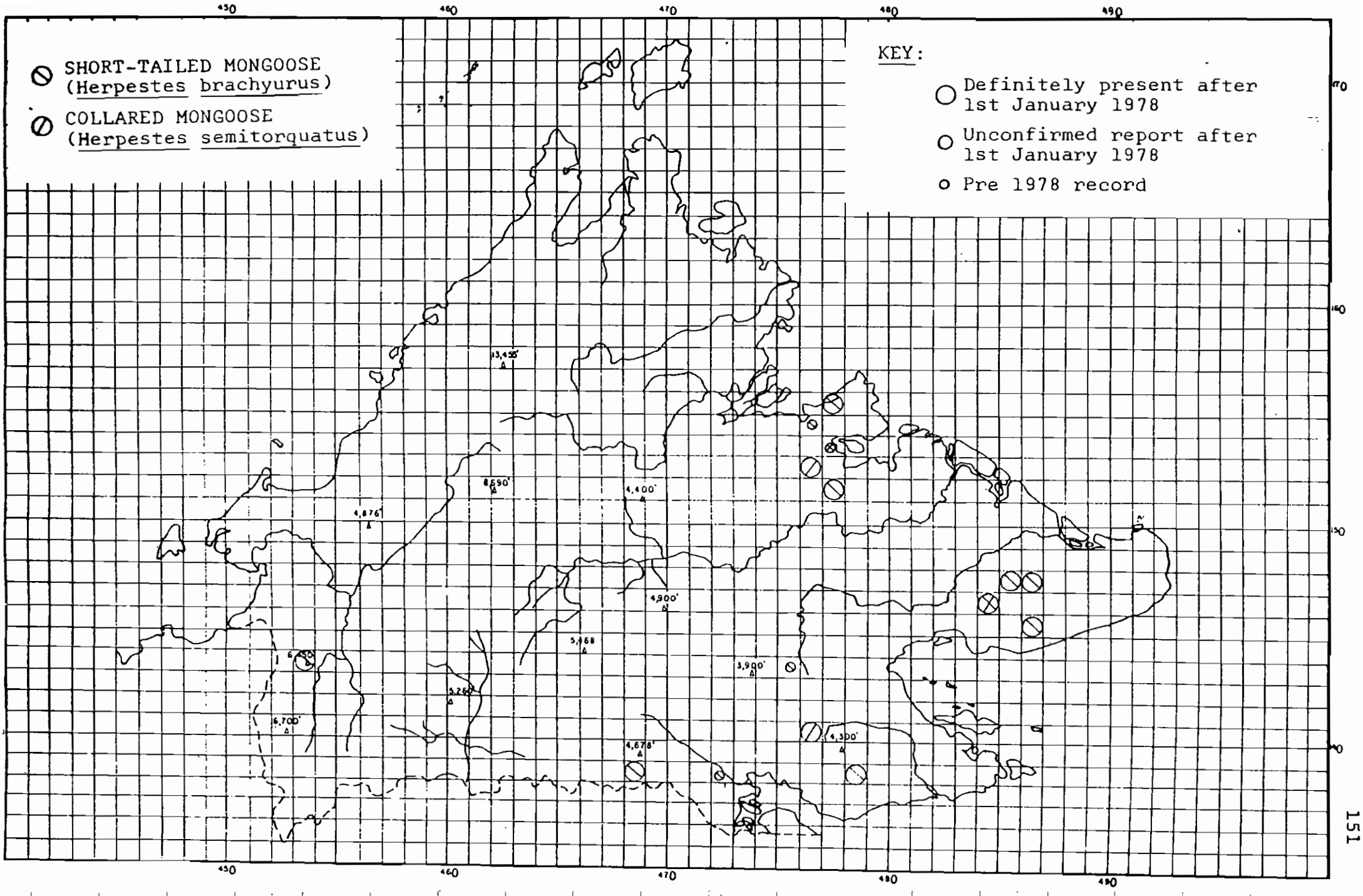

SMALL-TOOTHED PALM CIVET
(Arctogalidia trivirgata)
OTTER-CIVET
(Cynogale bennettii)
BINTURONG
(Arctictis binturong)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,690'
4,876'
4,400'
4,900'
5,468'
6,450'
6,700'
5,280'
3,900'
4,678'
4,300'


SHORT-TAILED MONGOOSE
(Herpestes brachyurus)
COLLARED MONGOOSE
(Herpestes semitorquatus)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
13,455'
8,590'
4,400'
4,876'
4,900'
5,168'
3,900'
6,700'
4,678'
4,300'

seen in small-holdings (eating bananas) and in cocoa plantations (where they eat cocoa fruits); in the forested areas they were usually seen foraging along roadsides for small animals. A sighting of an adult common palm civet with her small young one deep inside a cocoa plantation resting during the day-time indicates that this species breeds in cocoa plantations.

The masked palm civet was detected in only two places, in both cases entering cocoa plantations from adjacent secondary forest. Although the binturong sometimes enters non-forested habitats, it is normally a forest-dwelling species. It is known throughout Sabah but the paucity of records of a rather conspicuous animal indicate that is is nowhere abundant.

The small-toothed palm civet was recorded only from Ulu Segama and Kretam during the Faunal Survey, but it is probably widespread and common in forest, since its rather small size and arboreal habits make it difficult to detect. After the common palm civet, the banded palm civet was the most commonly seen species in the eastern lowland forests, both primary and logged. It is known to the people living in the hilly areas of western Sabah.

The otter civet was recorded definitely only once, on the basis of a photograph of a dead animal taken near Sungai Pin (middle Kinabatangan). Other verbal reports were unconfirmed. No information was collected on Hose's civet. It seems to be confused with the yellow-throated marten, so verbal reports are unreliable.

There were records of the short-tailed and collared mongoose from primary and logged forest, including one at 4,000 feet a.s.l. (short-tailed) and one in Albizzia tree plantation (collared). The short-tailed seems to be the more common, with nine Faunal Survey records, and only three of the collared mongoose. There may be a third species of mongoose in Sabah. In 1966, Mr Anthony Lamb (Sabah Agriculture Department) was given a reddish-coloured mongoose collected in the Tangusu Bay area between the Segama estuary and Tambisan. At Ulu Losan (115° 58'E, 5° 17'N, 1,700 feet a.s.l.) a reddish-coloured

viverrid which could not be identified as any known Sabah species (bigger and more red than the Malay weasel) was seen in October 1980 active at 1215 hours. This anomalous animal is perhaps Herpestes hosei.

There are no estimates of absolute abundance for any viverrid. The tangalung, common and banded palm civets, however, are evidently common. The masked and small-toothed palm civets, binturong and banded linsang appear to be rarer, but this may be partly because all are more arboreal and forest-dwelling species. The otter civet is clearly rare, and Hose's civet has a restricted distribution. Both known mongoose species adapt to man-made habitats.

None of the viverrids are sufficiently rare or threatened by development to require special conservation measures now, but more information is required on the otter civet, Hose's civet and (?) Hose's mongoose.

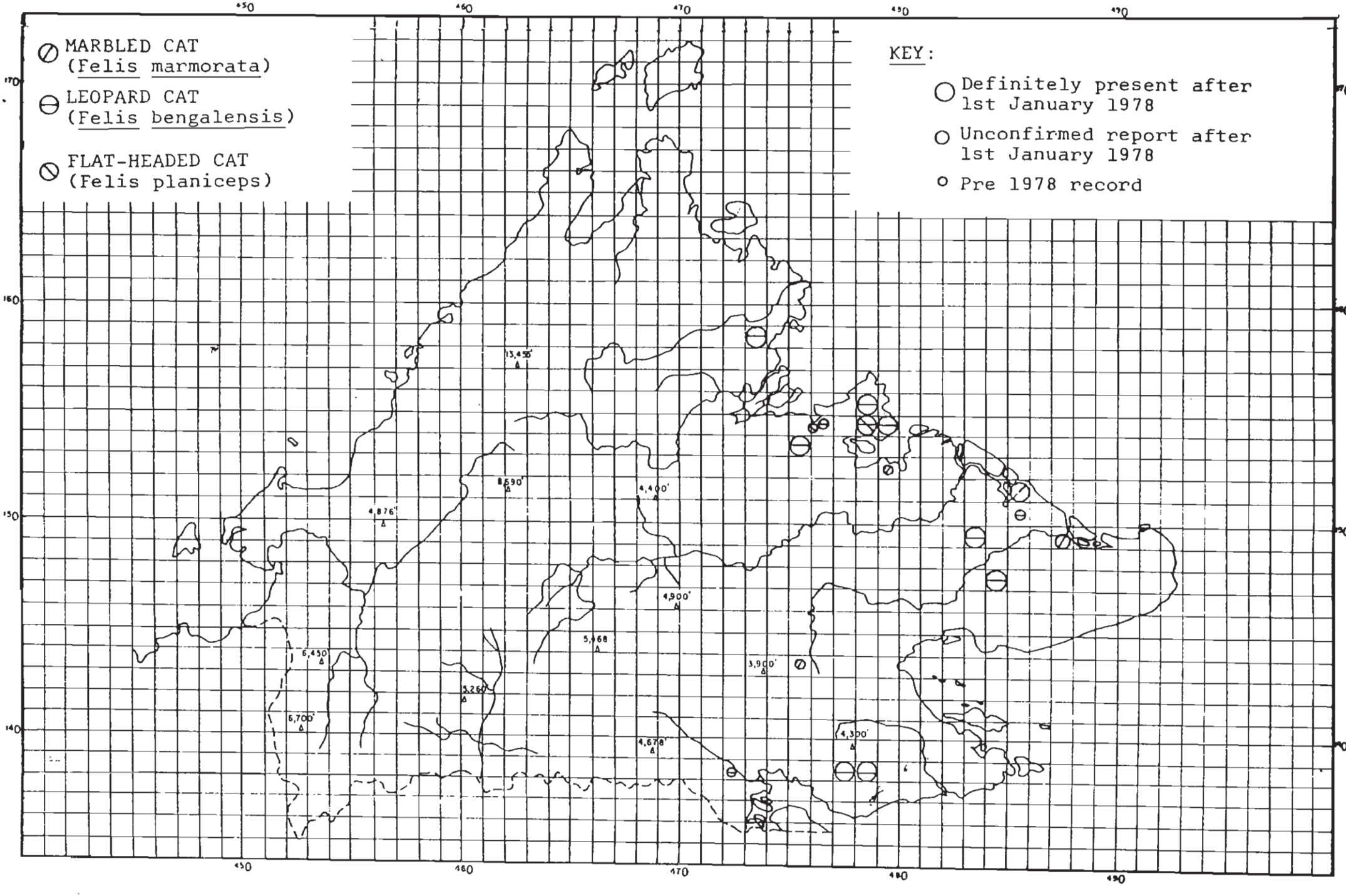
(8) WILD CATS
Family: Felidae
Order: Carnivora

Ecology

There are four species of wild cats in Sabah excluding the clouded leopard. The Marbled Cat (Felis marmorata), Bay Cat (Felis badia) and Flat-headed Cat (Felis planiceps) appear to be forest-dwelling species and almost nothing is known of any of them. The Leopard Cat (Felis bengalensis) was observed in small-holding areas with mixed agriculture near towns, in new and old cocoa plantations, and in logged lowland and upland dipterocarp forest. It also occurs in oil palm plantations, but was never seen in primary forest. It probably preys largely on rats and beetles. All the wild cats are nocturnal.

Distribution and Abundance

There are too few records of the wild cats, except the leopard cat, to comment on their distribution. The only marbled cat seen during the Faunal Survey was on a sandy beach with Casuarina trees and grass, and a man-


MARBLED CAT
(Felis marmorata)
LEOPARD CAT
(Felis bengalensis)
FLAT-HEADED CAT
(Felis planiceps)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,690'
4,876'
4,400'
4,900'
5,468
6,450'
5,700'
5,260'
3,900'
4,678'
4,300'

grove/freshwater swamp hinterland. All other records for Malaysia are from dipterocarp forests. No evidence was obtained of the bay cat, and Murut and Kadazan people in south-western Sabah, the region from which records of this species come, did not mention it. A flat-headed cat accompanied by a young individual was seen once in Sepilok Forest Reserve and a wild cat, fitting the description of this species, was shot by a man in the Tambunan area some years ago. Being small, nocturnal forest-dwelling cats with keen senses, all these cats probably flee from man before they can be seen. They are probably more common than is supposed, but numbers must be decreasing with habitat loss.

The leopard cat is seen relatively often because it hunts in open areas. It is probably the commonest wild cat, nevertheless, and numbers are likely to increase with agricultural development. There are no density estimates for any species.

(9) DUGONG (Dugong dugon)
Family: Dugongidae
Order: Sirenia

Although the faunal Survey was concerned with land mammals, a little information was obtained on one marine species, the Dugong.

Ecology

Dugongs feed on plants (but rarely algae) at the bottom of shallow seas. They live in groups of 3-5 individuals.

Distribution and Abundance

Fishermen at Jambongan Island, Terusan Sugut, Dewhurst Bay and Tungku claimed that dugong occur locally but were very rare. In the former two places, the fishermen said that they were usually seen when caught up in fishing nets during the rainy season (December-January). People in the latter two areas had not seen live dugong for several years, although in both areas men claimed to have seen a dead dugong washed up on the beach "recently". A fisherman at Tungku said that dugongs are more common

around Palawan Island (to the north of Sabah) than at any place on the coast of Sabah.

(10) BEARDED PIG (Sus barbatus)
Family: Suidae
Order: Artiodactyla

It has been suggested that there is more than one species of wild pig in Borneo, since there appears to be considerable variation in colour and body size. There is no evidence, however, of any wild pig species other than Sus barbatus, the bearded pig, in Sabah. Variation in colour is partly explained by young pigs being blackish while older individuals tend to be paler. Yet adult males vary in colour from whitish to dark brown, often with a red or yellow tinge. Some apparent colour differences can be attributed to the colour of the mud in which the pig has been wallowing. Local people recognise only one species, and in the languages of the major pig-hunting communities there is only one word for wild pig. In the absence of evidence to the contrary, it is assumed here that all wild pigs in Sabah are bearded pig.

Ecology

Despite the fact that this species is ubiquitous and known to all people throughout Sabah, little is known of the important features of its ecology. A major feature of the bearded pig is that loose associations of several to many individuals range over large areas. Sometimes these associations group together into hundreds or even thousands of individuals, yet few people have seen such large groups, suggesting that they occur infrequently and irregularly. The largest recent single concentration reported to the Faunal Survey was of an estimated 300-400 in the Kalabakan area in the 1970's.

In all areas visited during the Faunal Survey, bearded pigs were either present in relatively small numbers (a few tens per sq. km. at the most) or absent. In those areas where they were absent, old tracks indicated that they had been present weeks or, at most, months previously. The most interesting observations on the

bearded pigs were obtained from the area between the Kinabatangan River (between Sinua and Karamuak) and the Tawai area. In late 1979, bearded pigs were abundant along the banks of the Kinabatangan River. By May 1980, there were only a few scattered solitary individuals in this area, but there were many groups of pigs (20 or more in some) in the region 15-30 km. to the north. These groups appeared to consist mainly of adult pigs. Further north still, (about 30-40 km. from the Kinabatangan River) there were solitary adults and small groups, including mothers with young. In this latter area were large expanses of forests on ultrabasic-derived alluvium dominated by a climbing bamboo, Dinochloa sp., which had recently flowered and would bear fruit within about two months. Possibly the pigs were heading for this bamboo forest. The same bamboo was flowering again in mid-1981.

Important foods of the bearded pig are:-

(1) Seeds of dipterocarp trees

Mass fruiting usually occurs at some time between the months July-November, the exact timing varying geographically and with weather. Seeds of Shorea, Parashorea, Dipterocarpus and Dryobalanops spp. are eaten. In some cases, seeds are eaten after they have begun to germinate.

(2) Other forest fruits

Bearded pigs appear to move up hill ranges to feed on the mass-produced fruits of the family Fagaceae. Various other fruits are eaten, including figs and durians.

(3) Other forest plant material

Roots are eaten but do not seem to be a major dietary item. In secondary forest, the stems of wild bananas are eaten and shrubs and herbs are browsed.

(4) Cultivated plants

In traditional human community areas, bearded pigs enter gardens to feed on hill rice, tapioca and maize (the last two being introduced species). In oil palm plantations, fallen fruits are eaten and the pigs may

climb trees to obtain growing fruits. They take the fruits from cocoa trees in some areas and eat the fallen seeds from rubber trees in the old plantations in western Sabah.

(5) Animal matter

Many rural people believe that earthworms form an important constituent of the bearded pigs' diet. There is no reason to doubt this, given the great amount of digging they do in primary and secondary forest in places with no obvious plant material. Snails are also eaten.

Bearded pigs visit salt sources, although their movements and numbers do not seem to be as markedly influenced by salt sources as do those of larger mammals. Bearded pigs are most active at night-time but they sometimes travel during the day-time, particularly during or after rain and on cloudy days. They often wallow in mud baths made by themselves or in some cases by rhinos. These wallows may be on flat ground or on ridge sides, gulleys or ridge tops.

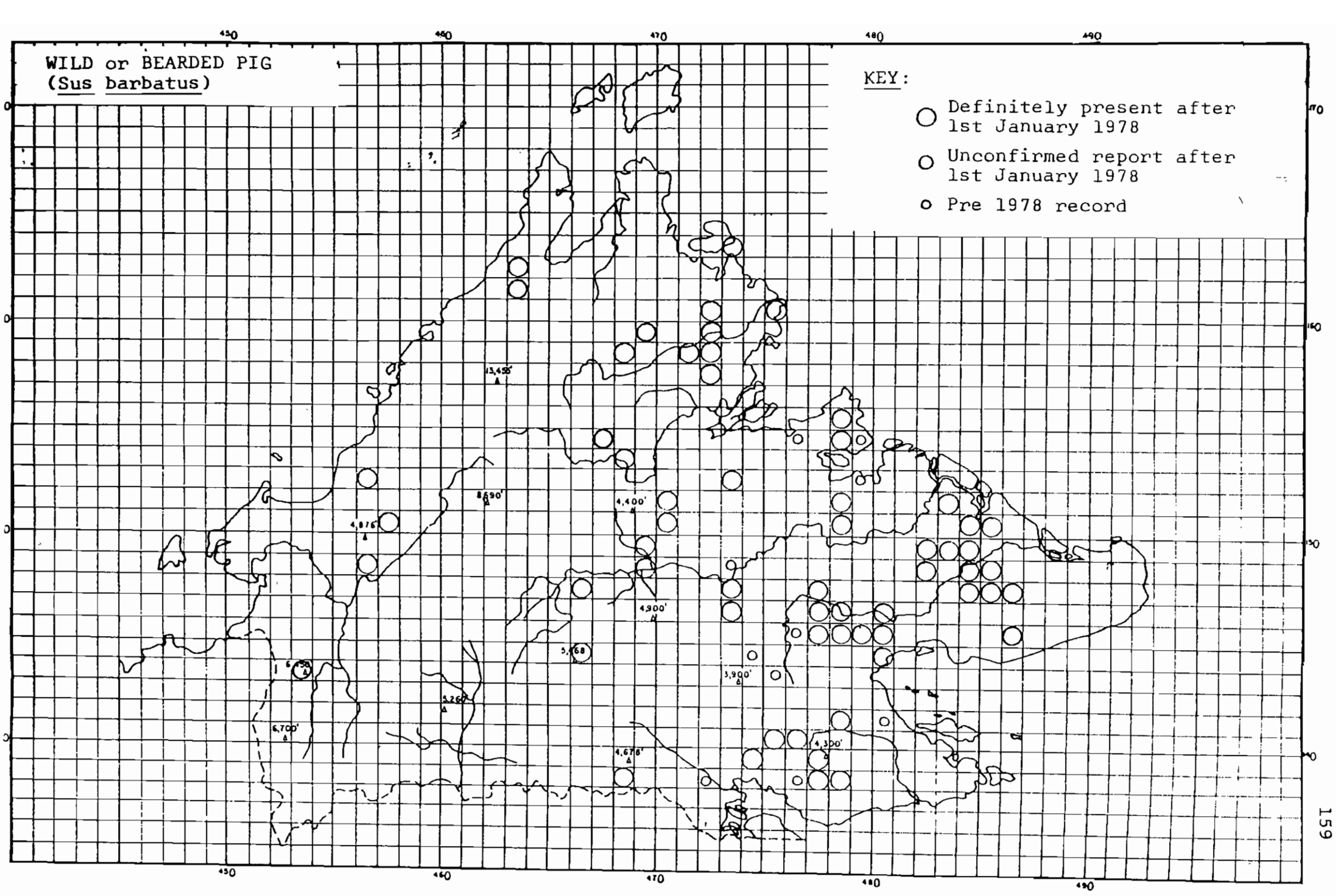
Faunal Survey observations indicate a peak of births around August to September, coinciding with the normal fruiting peak, and in agreement with reliable reports by local people, but there is evidently not an exclusive breeding season. Litter size varies from about 3-10.

Distribution and Abundance

Bearded pigs appear to occur wherever there is some forest cover. They are absent only from the older monoculture plantations and extensive areas which have been settled for a long time.

The impression gained, both by direct observations and by talking to local people, was that bearded pigs are rarer throughout western Sabah than the east. It is not clear whether this is a result mainly of hunting or habitat fragmentation, but is more likely to be the former.

It can be stated that tens of thousands, if not hundreds of thousands of bearded pigs exist in Sabah.


WILD or BEARDED PIG
(Sus barbatus)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
13,455'
8,890'
4,400'
4,875'
4,900'
5,268'
6,700'
4,678'
3,900'
4,300'

(11) MOUSEDEER

Family: Tragulidae

Order: Artiodactyla

Mousedeer are confined to the forested areas of South-east Asia. There are two species in Sabah:-

Lesser Mousedeer (Tragulus javanicus), less than 30 cm. height at the shoulder.

Larger Mousedeer (Tragulus napu), 30-35 cm.

Ecology

Both mousedeer species feed on fallen fruits, leafy material and fungi. They are active at night-time and periodically during the day-time. They usually forage alone or in pairs, but several may congregate at large food sources such as fallen fruits.

Distribution and Abundance

Mousedeer of either species are recorded infrequently above 1,500 feet and this probably accounts for their apparent rarity in western Sabah, where most forest lies above this altitude. Elsewhere, they are widely distributed and often, probably in most cases, syntopic. The larger mousedeer appears to be distributed up to slightly higher altitudes than the lesser and is the commoner species in logged forest. Primary lowland dipterocarp forest seems to support the highest population densities of both species, but more survey work would be necessary to demonstrate this clearly.

(12) DEER

Family: Cervidae

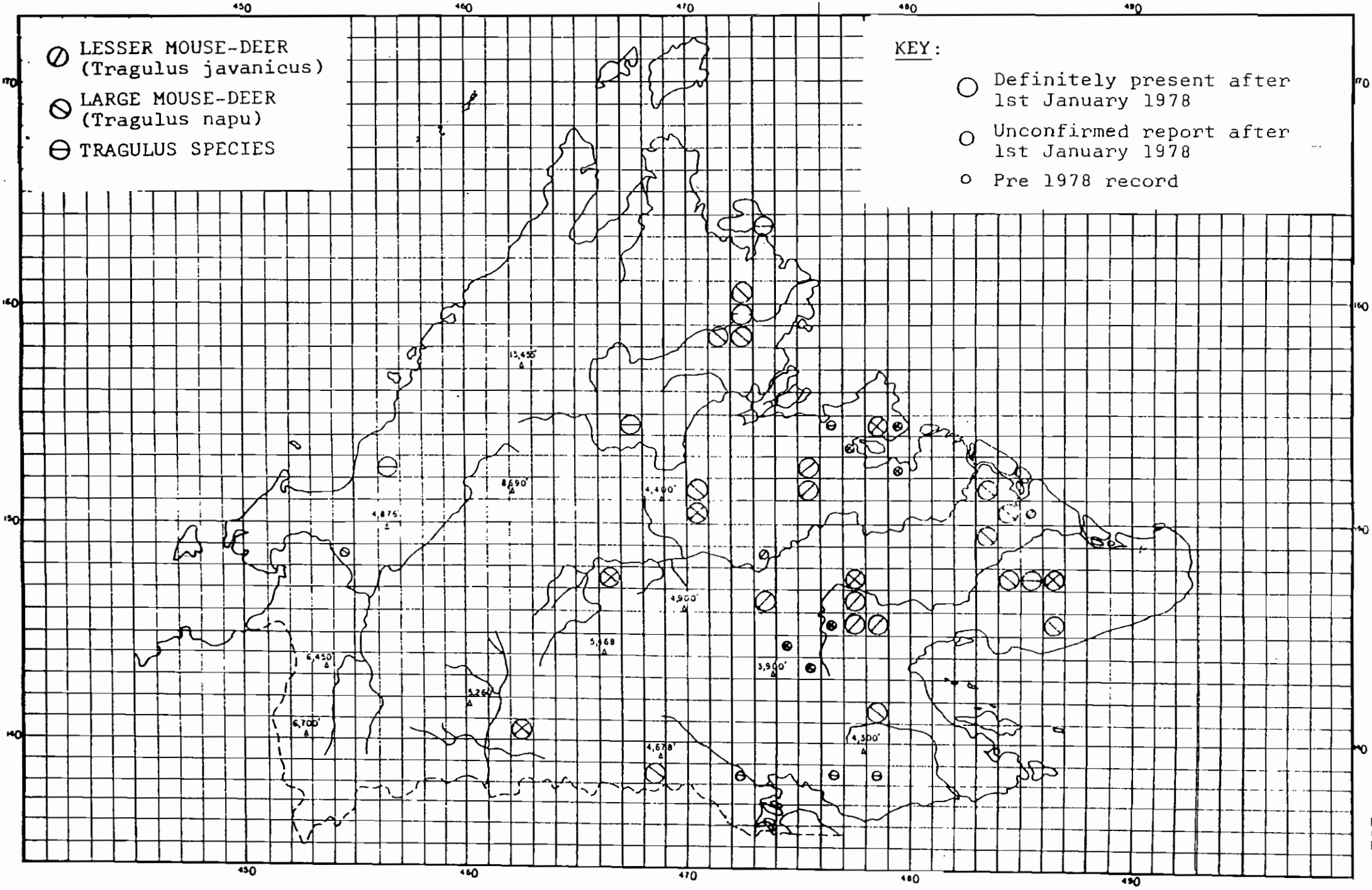
Order: Artiodactyla

There are two species of deer in Sabah:-

Barking Deer or Kijang (Muntiacus muntjak), 50-55 cm. at the shoulder.

Sambhur Deer, Rayau or Rusa (Cervus unicolor), 100-150 cm.

Both have a wide distribution, as far as India and Southern China, in a wide variety of habitats.


LESSER MOUSE-DEER
(Tragulus javanicus)
LARGE MOUSE-DEER
(Tragulus napu)
TRAGULUS SPECIES
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,690'
4,875'
4,400'
4,900'
5,168'
6,450'
3,260'
6,700'
4,678'
3,900'
4,300'

Ecology

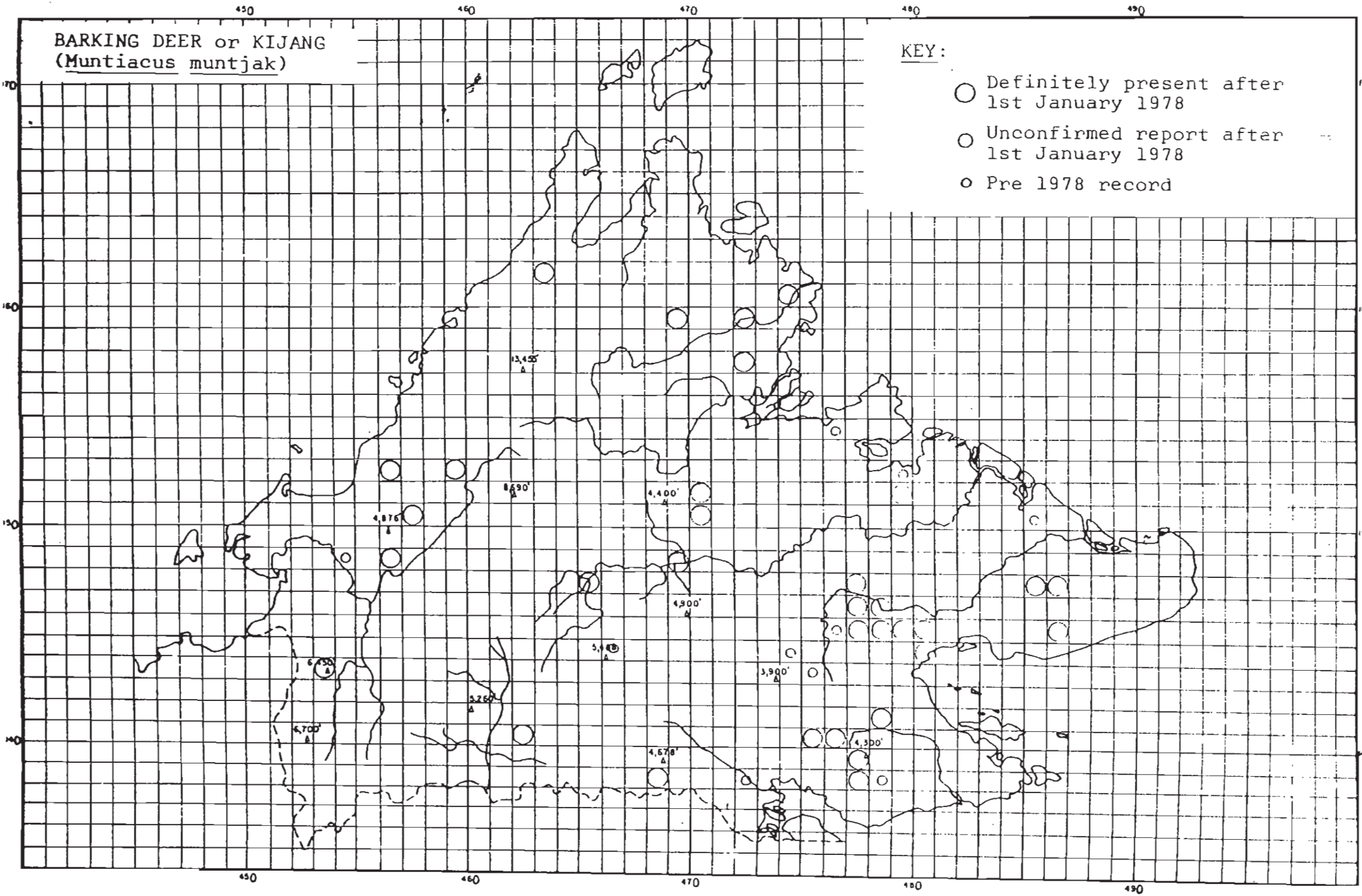
Barking deer, or kijang as they are generally known in Sabah, feed on fallen fruits and on the leaves and shoots of small trees, shrubs, herbs and grasses. Fruits eaten include figs and Diospyros spp., and the seeds of dipterocarps and Fagaceae. In Sabah, kijang are seen either alone or in pairs. There seems to be no seasonal aspect to pairing (32 observations of singletons and 12 of pairs during the Faunal Survey). Singletons were usually seen in primary forest and pairs in logged forest, but this observation may be a product of viewing conditions. They are active periodically at day-time and at night-time.

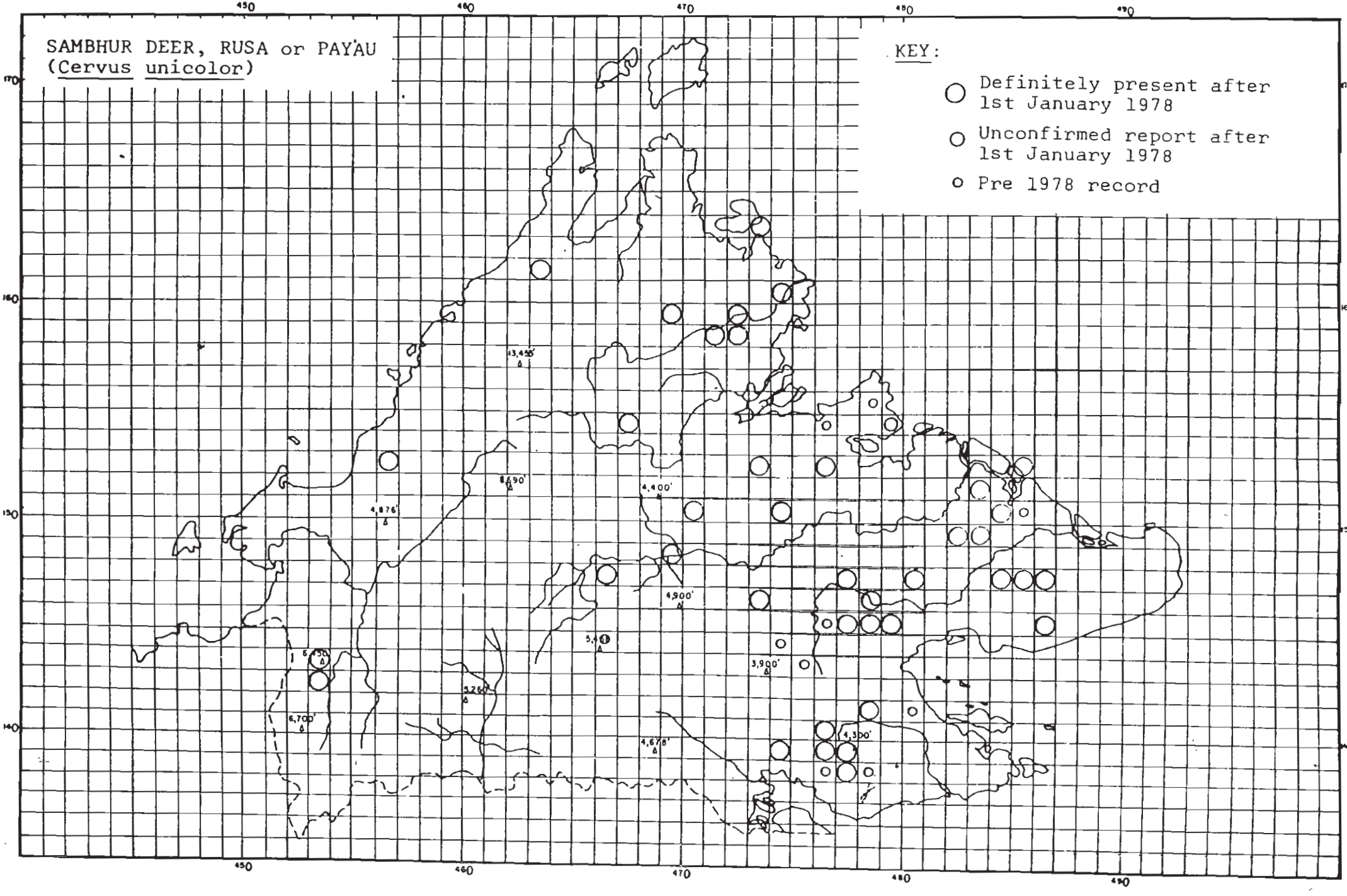
Sambhur deer, or payau as they are known in Sabah, graze on grasses and browse on herbs, shrubs, small trees and climbers. In Sabah, payau are usually seen alone or in small groups but up to six individuals may congregate. Payau are active mainly at night-time and rarely come out into the open to graze other than on poorly-lit nights.

Both kijang and payau visit natural salt sources. There is no evidence of marked breeding seasonality in either species.

Distribution and Abundance

Both kijang and payau were found up to 4,000 feet during the Faunal Survey and they are known to occur even higher. Kijang were more often detected at higher altitudes (average - 700 feet a.s.l.; 69 records) than payau (average - 500 feet a.s.l.; 53 records). There appear to be two reasons for this difference. Firstly, payau are grazers as much as browsers, and lush grass tends to occur most abundantly at lower altitudes, notably in the heavily logged over lowlands of eastern Sabah. Secondly, payau appear to prefer flat or gently sloping areas, whereas kijang live even on very steep slopes, which tend to occur at higher altitudes. The kijang was the only mammal species, in fact, noted to be more abundant on steep terrain than in flatter areas. The kijang is the commonest terrestrial herbivore throughout most of the Crocker Range,


BARKING DEER or KIJANG
(Muntiacus muntjak)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,630'
4,400'
4,876'
4,900'
3,900'
5,260'
6,700'
4,678'
4,300'


SAMBHUR DEER, RUSA or PAYAU
(Cervus unicolor)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,890'
4,400'
4,876'
4,900'
3,900'
6,700'
4,300'
4,678'

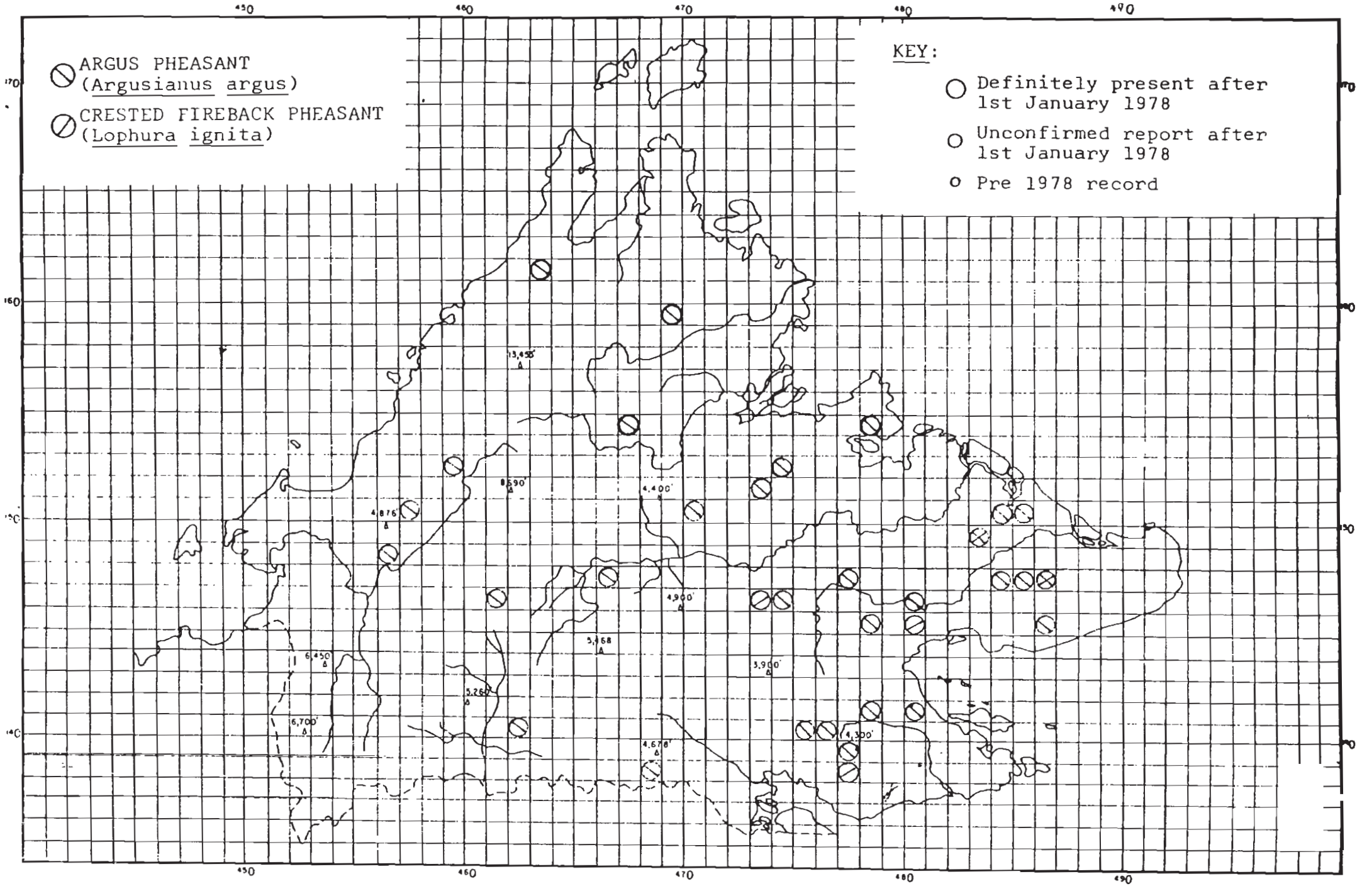
but the payau is locally common on the shallower gradients and old shifting cultivation of the Maligan Range. Kijang are by no means equally abundant throughout the uplands and highlands. The highest abundance recorded was in forest logged 20 years previously (Bakapit; 600-700 feet a.s.l.), yet in similar forest at Malubuk, there was no evidence of kijang. There is no obvious reason why this might be so.

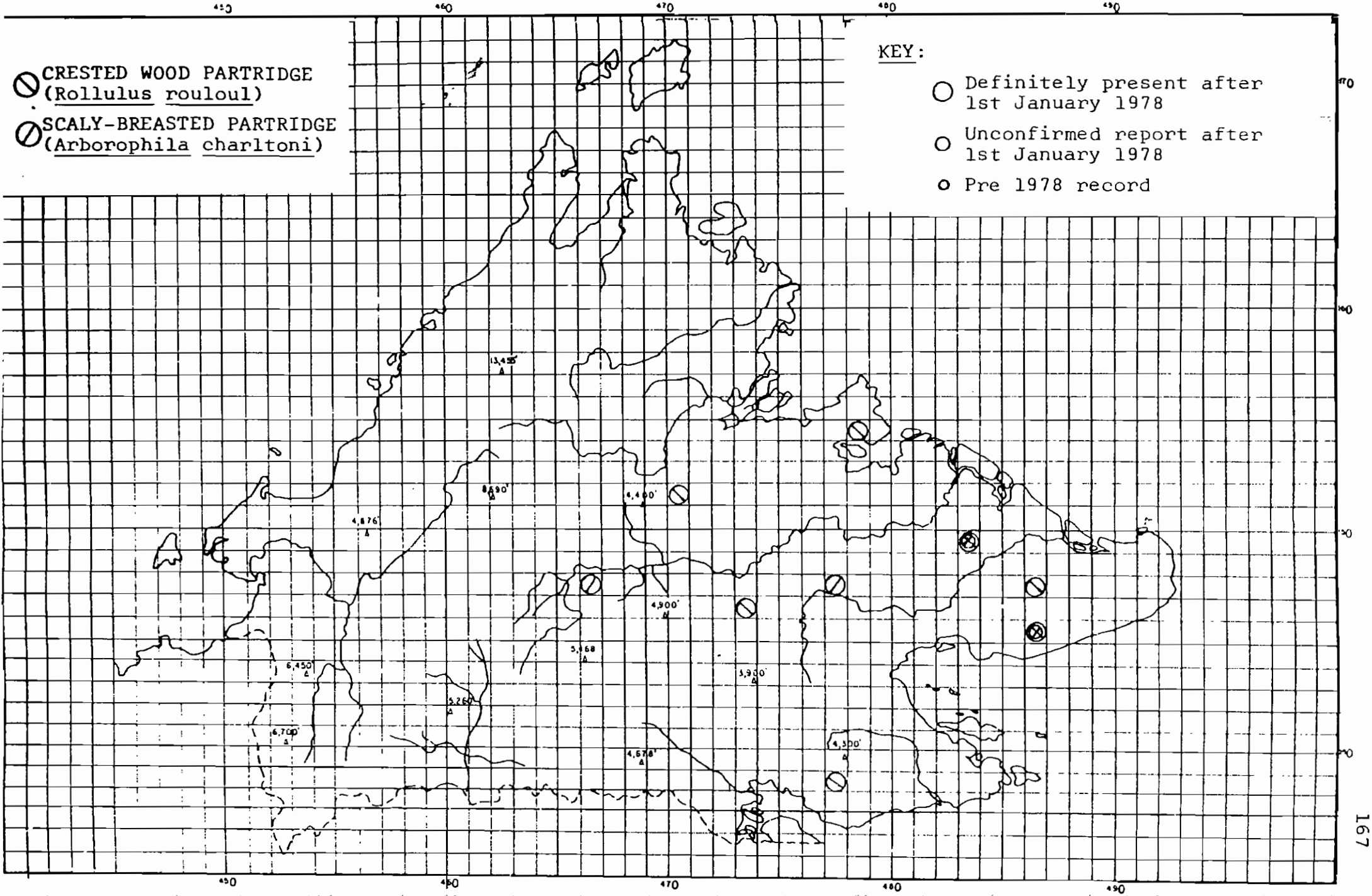
4.2.4. Birds

Information on Sabah's bird fauna is being collected continually by amateur and occasional visiting professional ornithologists, and some new studies started during the Faunal Survey period. Observations collected on birds during the Faunal Survey are part of an on-going process. Records are stored in Sabah on primary data sheets (Section 3.2). For species lists, see Appendices 4-6.

Here, we mention some of the larger birds for which substantial areas of forest habitat will be required to support breeding populations. Some other species are discussed later (Section 4.3.).

Pheasants and partridges are difficult to identify by sight in the conditions of poor visibility normal in Sabah's forests. We consider it encouraging that although the great argus pheasant was never seen by us, the species was identified in many survey sites by its calls. Likewise, the scaly-breasted partridge was seen clearly only three times, but what was believed to be the call of this species was heard in many forested areas throughout Sabah. We believe that many of the other pheasants and partridges whose calls were not recognised are likely to be fairly widespread. Bulwer's pheasant (endemic to Borneo) was never located, but it was definitely present in Tawau Hills in the 1960's (A. Lamb, pers. comm.) and is presumably still there. It is known (by the name of pakiak) to the Murut people of the Maligan Range on the other side of Sabah, since one young hunter described exactly the male Bulwer's pheasant. Other verbal descriptions of what


ARGUS PHEASANT
(Argusianus argus)
CRESTED FIREBACK PHEASANT
(Lophura ignita)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,590'
4,400'
4,876'
4,900'
5,168'
6,450'
3,900'
3,260'
6,700'
4,300'
4,678'


CRESTED WOOD PARTRIDGE
(Rollulus rouloul)
SCALY-BREASTED PARTRIDGE
(Arborophila charltoni)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
13,455'
8,690'
6,400'
4,876'
4,900'
5,168'
6,450'
5,260'
6,700'
3,900'
4,300'
4,678'

might be this pheasant are doubtful, since they could refer to the crested fireback pheasant.

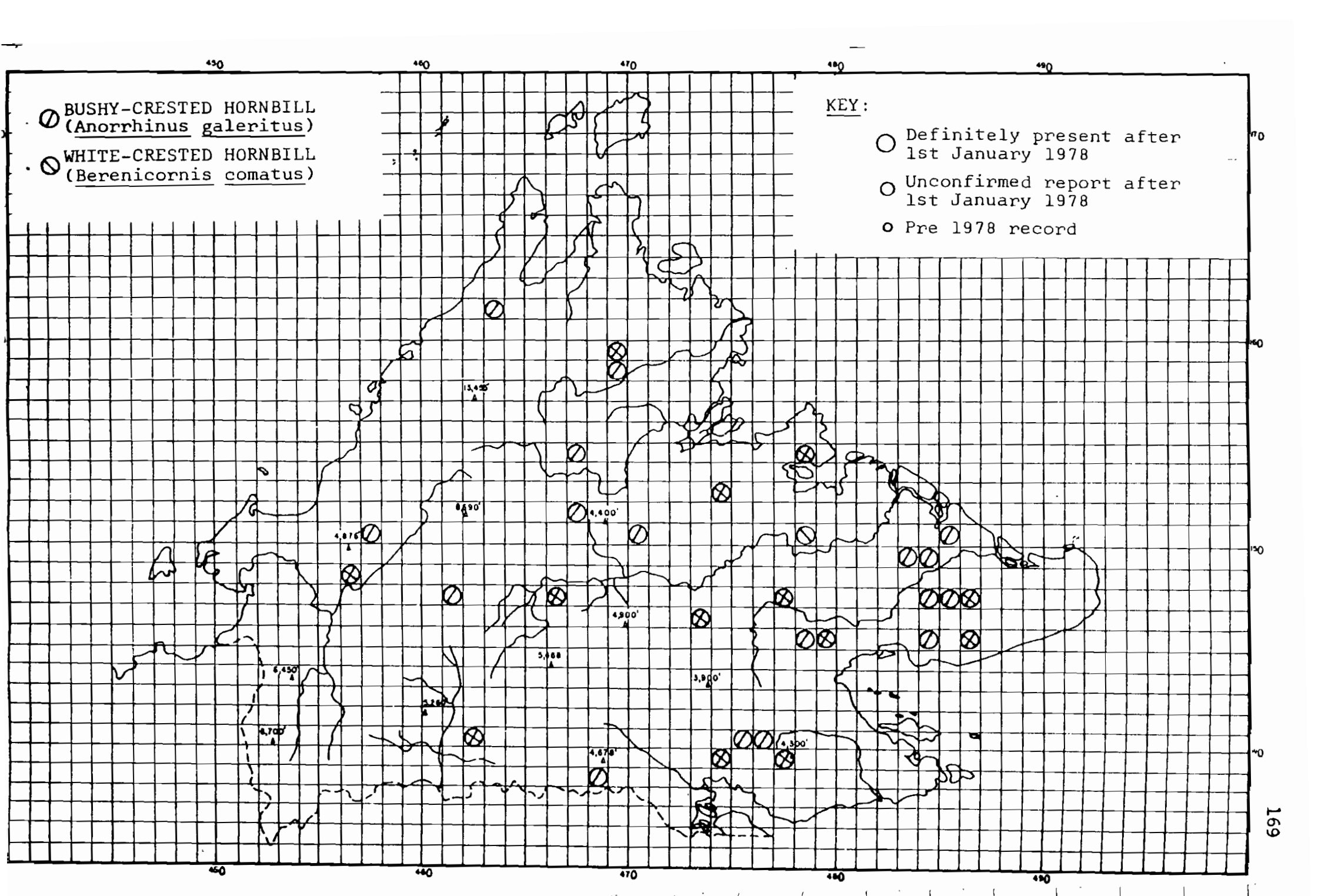
Some of the best-known and most spectacular birds of the dipterocarp forests are the hornbills (Family: Bucerotidae), of which there are eight species in Sabah:-

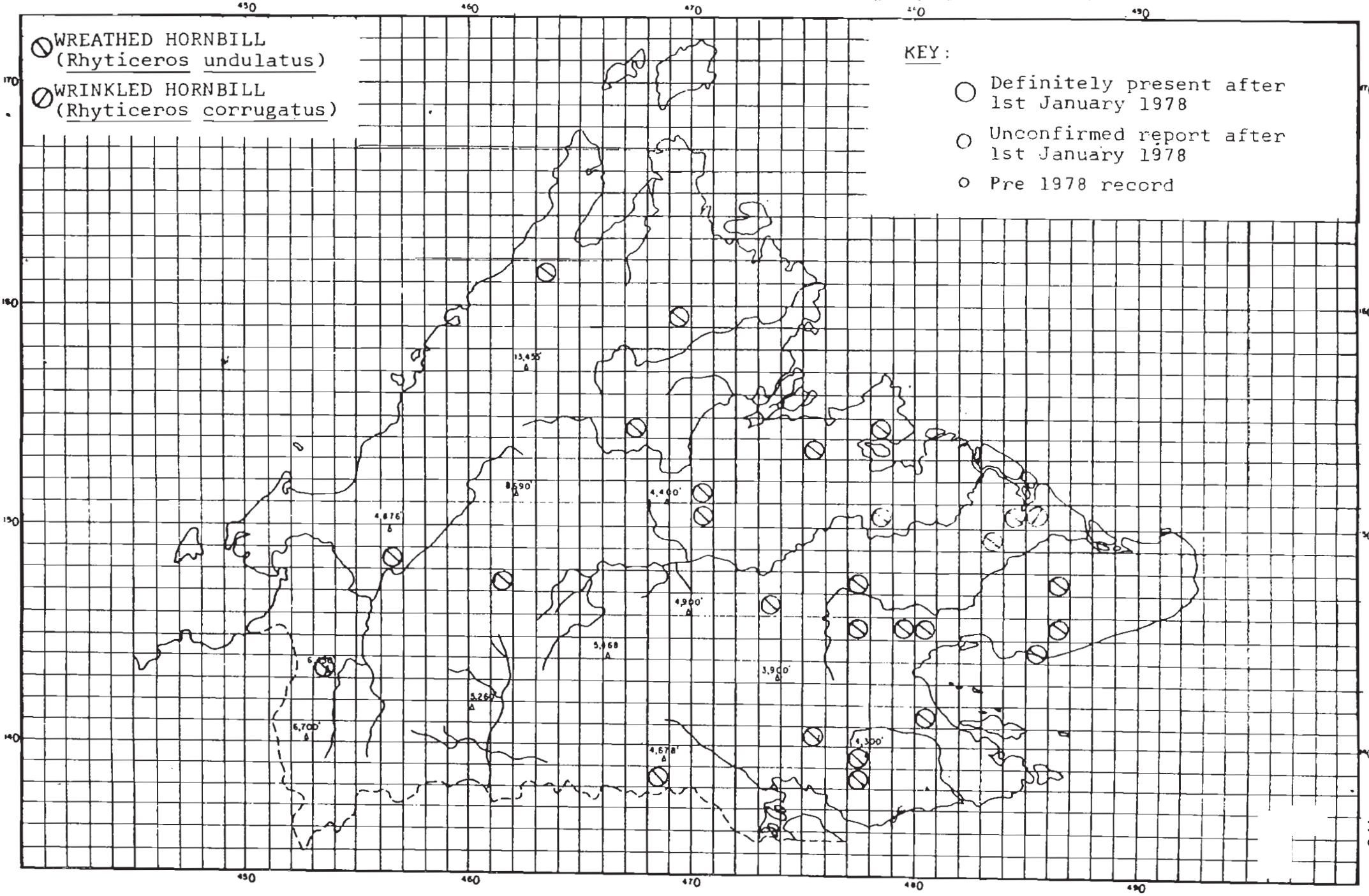
White-crested	(Berenicornis comatus)
Bushy-crested	(Anorrhinus galeritus)
Wrinkled	(Rhyticeros corrugatus)
Wreathed	(Rhyticeros undulatus)
Black	(Anthracoceros malayanus)
Pied	(Anthracoceros coronatus)
Rhinoceros	(Buceros rhinoceros)
Helmeted	(Rhinoplax vigil)

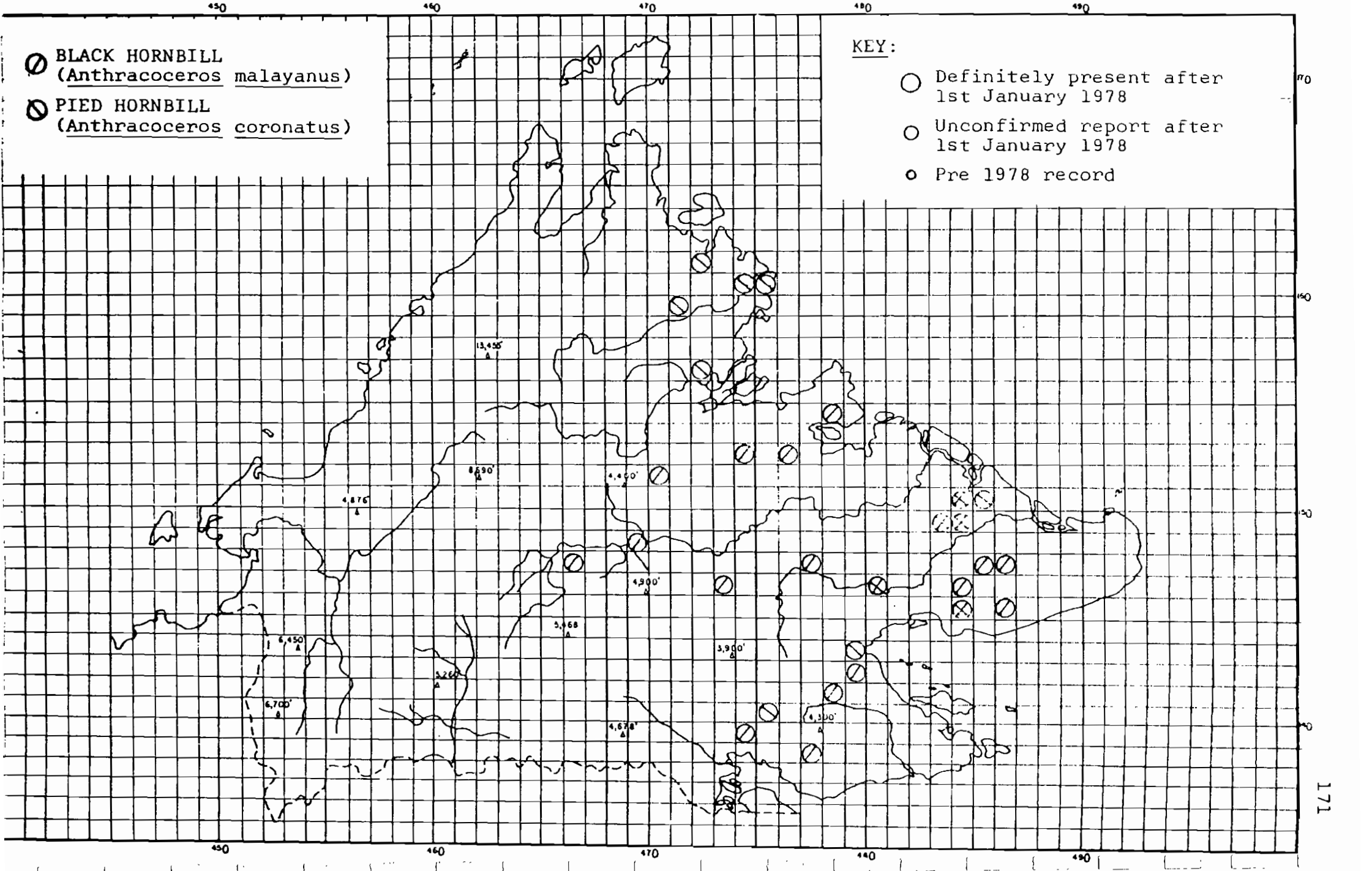
All the species feed mainly or entirely in the trees, and have a mixed diet of fruits and animal matter, including arthropods and small vertebrates.

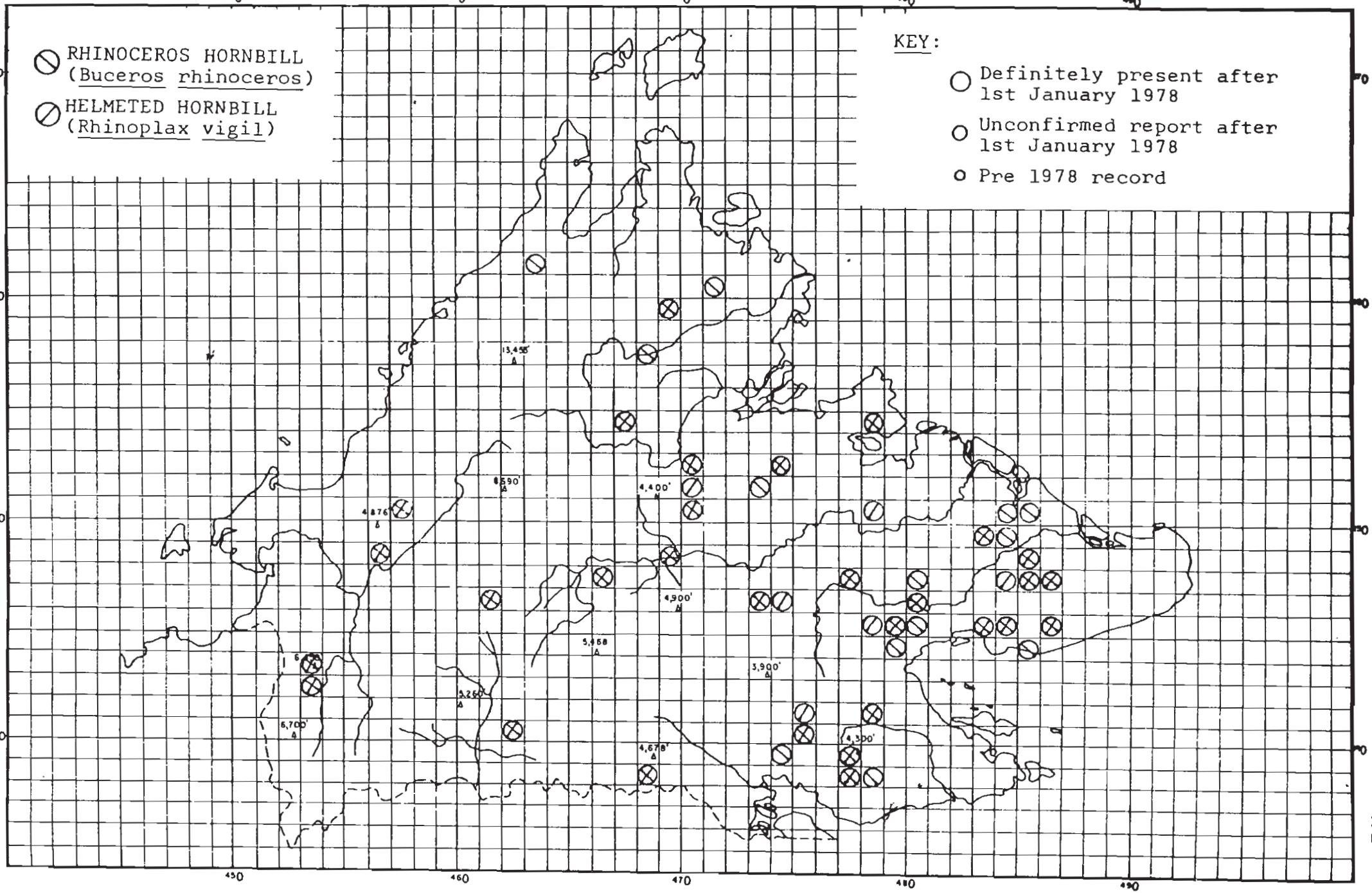
The white-crested, black and pied hornbills live in pairs or small groups. The bushy-crested hornbill lives in territorial groups of 6-12 individuals, the territories being advertised to others by noisy group calls. The wrinkled hornbill, the least known species, lives in groups of 2-4, foraging between tall trees. The similar but larger species, the wreathed hornbill, is usually seen in loosely-associated groups of 3 or more. The rhinoceros and helmeted hornbills, the two largest species, live as adult pairs. Young birds leave the parents and form wide-ranging flocks of up to 30 individuals. Both species live in and above the tree canopy. The rhinoceros hornbill specialises in eating the fruits of the families Myristicaceae, Meliaceae, Lauraceae and Burseraceae, while the helmeted hornbill specialises in figs (Ficus spp.) (31).

The wrinkled appears to be the rarest hornbill species and is possibly restricted in distribution. The pied is a riverine species, while all the remaining hornbill species live inland, widely distributed in most forested areas. White-crested hornbills were found mainly in dense vegetation, not above 2,000 feet a.s.l. and were nowhere abundant. Bushy-crested hornbills occurred in all kinds of dipterocarp forest, irrespective of terrain or amount of disturbance, to more than 3,000 feet. Black


BUSHY-CRESTED HORNBILL
(Anorrhinus galeritus)
WHITE-CRESTED HORNBILL
(Berenicornis comatus)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
430
450
470
490
170
150
130
110
450
470
490
13,455'
8,690'
4,400'
4,876'
4,900'
5,088'
3,900'
6,450'
6,700'
4,678'
4,300'


WREATHED HORNBILL
(Rhyticeros undulatus)
WRINKLED HORNBILL
(Rhyticeros corrugatus)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
13,455'
8,690'
4,400'
4,876'
4,900'
5,468'
3,900'
5,260'
6,700'
4,300'
4,678'
450
460
470
480
490
170
160
150
140


BLACK HORNBILL
(Anthracoceros malayanus)
PIED HORNBILL
(Anthracoceros coronatus)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
13,455
8,890'
4,876
4,400'
4,900'
5,468
6,450
3,900'
3,260
6,700'
4,678'
4,300'


RHINOCEROS HORNBILL
(Buceros rhinoceros)
HELMETED HORNBILL
(Rhinoplax vigil)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,590'
4,400'
4,876'
4,900'
5,458'
3,900'
5,250'
6,700'
4,678'
4,300'

hornbills appeared to prefer dense, tangled forest on flat terrain. This was the only species of hornbill in climbing bamboo forest on ultrabasic alluvium at Rukuruku, and the highest altitudinal record was just over 1,000 feet a.s.l. Wreathed hornbills were found in most areas up to 4,000 feet a.s.l., but highest population densities were consistently in the Silabukan area. Rhinoceros and helmeted hornbills were recorded in all forest areas visited except the forests on ultrabasic soils and podsols at Rukuruku. Both tended to be most abundant in primary lowland and upland dipterocarp forest, but this was not always the case. Highest densities occurred in Silabukan, Ulu Segama and at Bukit Ibul (3,000-4,000 feet a.s.l.). In the latter dipterocarp-lower montane transition zone, there was an extraordinarily high density of strangling figs as well as a preponderance of Lauraceae and Myristicaceae trees.

Approximate population density estimates are available for all the hornbill species in their preferred habitats (wrinkled hornbill, Sarawak - 32; pied hornbill, Krau Game Reserve, Peninsular Malaysia - unpublished data; all other species, Kutai Reserve, East Kalimantan - Mark Leighton, unpublished data). These estimates are used in a later section (5.3).

There was only one definite new species record for Sabah: the white-throated babbler (Malacopteron albogularе), previously known from other parts of Borneo, which was present in two areas between Telupid and the Kinabatangan River. The colouring of these birds was different from those recorded previously elsewhere.

4.3 THE EFFECTS OF HUMAN ACTIVITY ON WILDLIFE

4.3.1. Introduction

The previous section was concerned with the current status of wildlife in pristine habitats. With the rapid

land development now occurring in Sabah it was necessary to assess what effects human activity was having on wildlife.

A major factor which is adversely affecting all mammal and bird populations is that of fragmentation of populations. The logging operations and agricultural development have caused populations to be isolated in areas of pristine habitat which are surrounded by exploited habitats. This applies in particular to the lowland and upland dipterocarp forests, rather than montane forests, and has its greatest impact on the small populations of Sabah's rarest mammals.

The adverse effects take two forms - firstly, isolated areas may be too small to provide food for all members of the population, especially those which travel large distances and range over large areas. Species in this category include elephants, rhinoceros, bearded pigs, certain bat species and some pigeons. Secondly, if species occur at low population densities, they may be unable to find a mate in the small areas of forests which they inhabit.

Ultimately, fragmentation of populations will not only affect individual animals, but have serious effects on the species. The risks of "inbreeding", unintentional introduction of diseases and, in some cases, illegal hunting will lead to extinction of populations. If the species is a rare one, either existing at low population densities under natural circumstances, or having a restricted geographical range, then the risk of species extinction is high.

In the following sections, we examine separately the effects of the three most extensive forms of human activity — logging, agriculture and hunting — on mammals and birds.

4.3.2. Logging

The effects of logging on the vegetation have been considered (section 2.3) and the consequences of these changes on the animal community are considered here.

In Sabah, logging means the selective removal of large trees, mainly dipterocarps. Inevitably, the process of felling and removing trees which average 40-50 m. in height greatly disturbs the habitat and its animal life. While timber is being extracted, and for a few weeks afterwards, logging adversely affects all the mammal species and almost all the birds investigated by the Faunal Survey. But, although logging has long-term adverse effects on most species, it is beneficial to others whose food supply increases at some time after logging has finished.

Direct effects of logging activity on mammals and birds may be summarised as follows:-

(1) Alteration in food supply.

(2) Degradation of the forest structure, making travel more difficult for many species.

(3) Reduction in the number of nesting or sleeping sites.

(4) Increased exposure to the sun, and dessication.

(5) Increased exposure to predators.

(6) Often, forced migration into adjacent primary forest leading to direct conflict with other members of the same species already present there.

While it is true that some animal species ultimately benefit from heavy logging, most do not, and efforts to minimise the destructive impact would, on balance, be advantageous to wildlife. The effects of logging on the species surveyed are examined in the following eight sections:-

(1) Sumatran Rhinoceros

Although the Sumatran rhinoceros does range and feed in logged forest, evidence from Sabah and West Malaysia indicates that this species has a strong preference for primary forest. It is not clear why this preference exists. One possible explanation is that, being a browser on small forest trees and saplings, this species suffers a great reduction in food supply after logging. An alternative, or additional, explanation is that it is prone to

over-heating outside dense forest cover. In Sabah, there are believed to be at least 8 rhinos living either entirely or mainly in logged forest. Given the extent, intensity and speed of current logging, however, it cannot be assumed that the species will survive without protection of some extensive primary forest; small patches in logged regions are insufficient.

(2) Tembadau

Logging in the eastern lowlands of Sabah has provided a greater food supply for tembadau than was the case in the original primary forest, because the old roads and tractor paths, railway lines and log dumping points are recolonised by grasses. Blocked streams may also increase the number of drinking pools available. It is not yet evident whether the tembadau population will increase in the logged uplands and highlands of interior Sabah.

(3) Elephant

Elephants, like tembadau, readily adapt to logged forest conditions because logging results in an increase in the growth of all their major food plants. Curiously, there is no evidence that the elephant population in eastern Sabah has been increasing in size, even in areas 10-20 years after the first logging (although quantitative information is lacking). Possibly, elephant numbers are limited partially by some factor other than the abundance of vegetable foodstuffs.

(4) Honey Bear

Consideration of the honey bear's ecology indicates that its food supply will be considerably less in logged forest than in primary dipterocarp forest. Of a total of 17 post-1978 records of this species from known provenance, only 4 were in logged forest.

(5) Clouded Leopard

Of 8 post-1978 records of the clouded leopard, 2 were in primary forest, 2 on logging roads through primary forest and 4 in secondary forest, varying from 1-19 years after logging. They have been seen with cubs in logged forest. The bias towards seeing tracks and animals in

logged forest means that determination of habitat preference is impossible without detailed study. Since it is likely that the distribution and abundance of clouded leopards depend largely on that of the prey species, more information is required on food preferences.

(6) Primates

The effects of logging are expected to be especially severe on the primates because their arboreal habit makes them dependent on trees. To assess the effects of logging, two surveys were done, in 19-year old logged forest at Bakapit and 15-year old forest at Malubuk. The results obtained in these two logged areas were compared with the results from surveys in adjacent upland and lowland primary forest areas. Two additional surveys were done in small, primary forest Virgin Jungle Reserves surrounded by extensive areas of logged forest (Lung Manis and Gomantong). The results are shown in Table 11 and, although they represent only a small sample, they are indicative of the effects of logging on primates.

Orang-utans are adversely affected by logging, as is shown in these results as well as those of other studies. There is evidence of mortality due to tree falls during timber operations, from reports of deaths and the confiscation of orphaned infants from timber camps. The long-term effects are shown in the depressed population figures in logged forest compared to nearby primary forest. With two exceptions, evidence of orang-utans was seen in logged forest only in the eastern lowlands and Segama uplands. The presence of animals in logged forest, however, should not be taken to imply that this habitat can support a resident population in the long-term. Often, orang-utans may simply be migrating through the areas to patches of pristine forest.

This migration away from disturbances has been reported previously (16), and is clearly demonstrated by the results from the Virgin Jungle Reserves (VJR's). The areas in which the VJR's are located were both surveyed in 1960's and found to have low orang-utan population densities, but the VJR's currently have the highest densities

TABLE 11

Abundance of monkeys and apes in primary and logged forest.

SURVEY SITE	STATUS	ALTITUDE (FEET)	ABUNDANCE (GROUPS/SQUARE KILOMETRE) ORANGUTAN	GIBBON	RED LEAF MONKEY	GREY LEAF MONKEY	PIG-TAILED MACAQUE	TOTAL BIOMASS (KG/KM^2) (EXCEPT MACAQUES)
MALABUK	LOGGED-1965	550	+	1.1	1.1			50
BOLE KECIL	PRISTINE	400	3.0	2.9	4.5	0.7	0.7	280
KAWAG	PRISTINE	1200	1.0	2.5	5.2		1.0	250
BAKAPIT	LOGGED-1962	650		2.3	1.3	1.3	3.8	110
SILABUKAN	PRISTINE	600	+	2.4	0.9	3.6		180
TABIN	PRISTINE	450	+	4.3	+	4.3		200
LUNGMANIS	V.J.R.	200	4.1	0.5	+			120
GOMANTONG	V.J.R.	300	3.9	2.9	+		1.0	140

V.J.R. IS AN ISOLATED PATCH OF PRIMARY FOREST, LESS THAN 500 HA IN AREA

+ SIGNIFIES PRESENCE, BUT OF UNKNOWN ABUNDANCE.

of any survey sites. This can be explained by the immigration of individuals from the surrounding logged areas to the pristine forest. The ability of orang-utans to migrate has important implications for conservation because it suggests that with careful planning of logging and agricultural developments, they could be "directed" to move into pristine forest areas. Currently, there are numerous places where small numbers of orang-utans are being isolated in patches of pristine forest, which are insufficiently large to support them.

The degree to which logging alters the number of food trees, sleeping sites and arboreal pathways of gibbons varies between areas, depending on chance local variations in logging damage intensity. This is reflected in the variability of estimates for gibbon population densities in logged areas. There is a difference of about 50% between the two logged areas and the corresponding unlogged areas, although Bakapit site has a similar population density to nearby unlogged, upland forest. There may be substantially lower gibbon densities in logged areas, therefore, than in unlogged areas even some 20 years after logging. The adverse effects may not be apparent at first because the gibbons' territories are rigidly fixed in the forest and it is not possible for gibbons to emigrate from the territory when the area has been logged.

The leaf monkey population densities were between 3 and 5 times lower in logged forest than in unlogged areas. This implies that logging markedly decreases the resources required by these species. Although their ranging behaviour is more flexible than gibbons, there was little evidence that leaf monkeys in Sabah move away during logging operations and recolonise the area once timber extraction has ceased. Even up to 20 years after the logging population densities are very low.

The population densities for macaques could not be accurately calculated due to a lack of data. Long-tailed macaques can travel on the ground and are known to colonise areas of abandoned shifting cultivation, so there is

reason to expect that logging will have little adverse effect on their populations. In any case, the coastal and riverine habitats in which they are most common are relatively unaffected by logging operations. The pig-tailed macaque seems to adapt readily to logged forest conditions but it is not clear how logging affects population densities of this species.

The final column of Table 11 shows the total biomass density of all species except macaques at each survey site. These estimates are calculated from data in previous tables and no difference is assumed for average primate group size between primary and logged forest. The figures may be biased, therefore, because it is possible that group sizes do change in response to the new conditions prevailing in logged forest. This change appears to be towards smaller groups, particularly of leaf monkeys and gibbons, in logged forest, but insufficient complete group size counts were made to be sure. The results of the computations show that Bakapit (logged) holds only 61% of the biomass estimated for nearby Silabukan (primary) and Malubuk is more severely affected, having only 20% of the primate biomass density estimated for neighbouring Kawag.

The most apparent cause of low primate population densities in logged forest is the change in the forest tree species composition, with the amount and diversity of food sources being lost. In the areas surveyed, a forest of few, relatively unpalatable plant species predominated 20 years after logging. An additional significant problem in some areas is that logging roads allow hunters access to areas which they would not have reached in the past; this is discussed in Section 4.3.4.

(7) Other Mammals

The great majority of the squirrels and other arboreal or partially arboreal mammals experience difficulty in travel and a reduction in food supply after logging. The major exception is the plantain squirrel, well adapted to most exploited habitats, and probably the red giant flying squirrel also, for which travel is presumably easier

in a more open habitat and assuming sufficient nesting holes remain. Another species which is well-adapted to logged forest and belukar is the lesser (and slender ?) treeshrew. Most smaller mammals, which exist at relatively high population densities, are unlikely ever to be depleted by logging to the extent that they become rare on a State-wide level. An exception could be the tufted ground squirrel, which was never recorded in logged forest and exists at low density even under ideal conditions. For a few species, such as the flying lemur and pangolin, the effects of logging are still unknown, even to the extent of whether the animals benefit or otherwise.

There is considerable variation among the small carnivores in their tolerance of logging. Among the mustelids, the yellow-throated marten appears to be sufficiently adaptable that it can live in logged forest (and tree plantations) as well as in primary forest. The teledu was recorded only in exploited habitats, except at Sepilok, where it was near forest edge.

The Malay weasel is hardly known to anyone, but appears to be a primary forest dweller. The small-clawed otter should be safe as long as there are unpolluted streams, but the hairy-nosed otter must have suffered as a result of the siltation of larger rivers due to logging and agriculture.

All the viverrids observed during the Faunal Survey are evidently sufficiently adaptable that they can tolerate logging - but to different extents. Only the common palm civet appeared consistently to increase in abundance after logging. The small-toothed and banded palm civets and the mongooses appear to adapt fairly well, but the remaining species do not.

Bearded pigs live and breed in logged and unlogged forests, but it is not clear how logging affects food supply, ecology or population densities. Primary forest supplies many nutritious fruits and seeds for the pigs, especially during the fruiting seasons, but many of the food trees are lost during timber extraction and there is

no information to show whether this loss is replaced as trees regenerate in logged forest. In two areas - Lingkabau in north-eastern Sabah and in the middle Segama below the Bole River - indigenous people have hunted pigs over a long period and report that their densities do decrease after logging. Conversely, some hunters report increases in pig populations after logging. These reports, however, are based on brief visits to areas and there is often no knowledge of the original abundance. Additional problems of interpreting these reports are pig migrations which could give short-term population increases in any area and the results are probably biased because of the ease of seeing pigs and their tracks in logged forest.

All the mousedeer and deer species occur in logged and otherwise disturbed forest. The lesser mousedeer seems to be affected adversely by logging while the payau is generally more common in disturbed forest than primary forest. The larger mousedeer and kijang appear to be roughly equally abundant, on average, in primary and logged forest, but there are as yet unexplained differences between different areas in Sabah.

(8) Birds

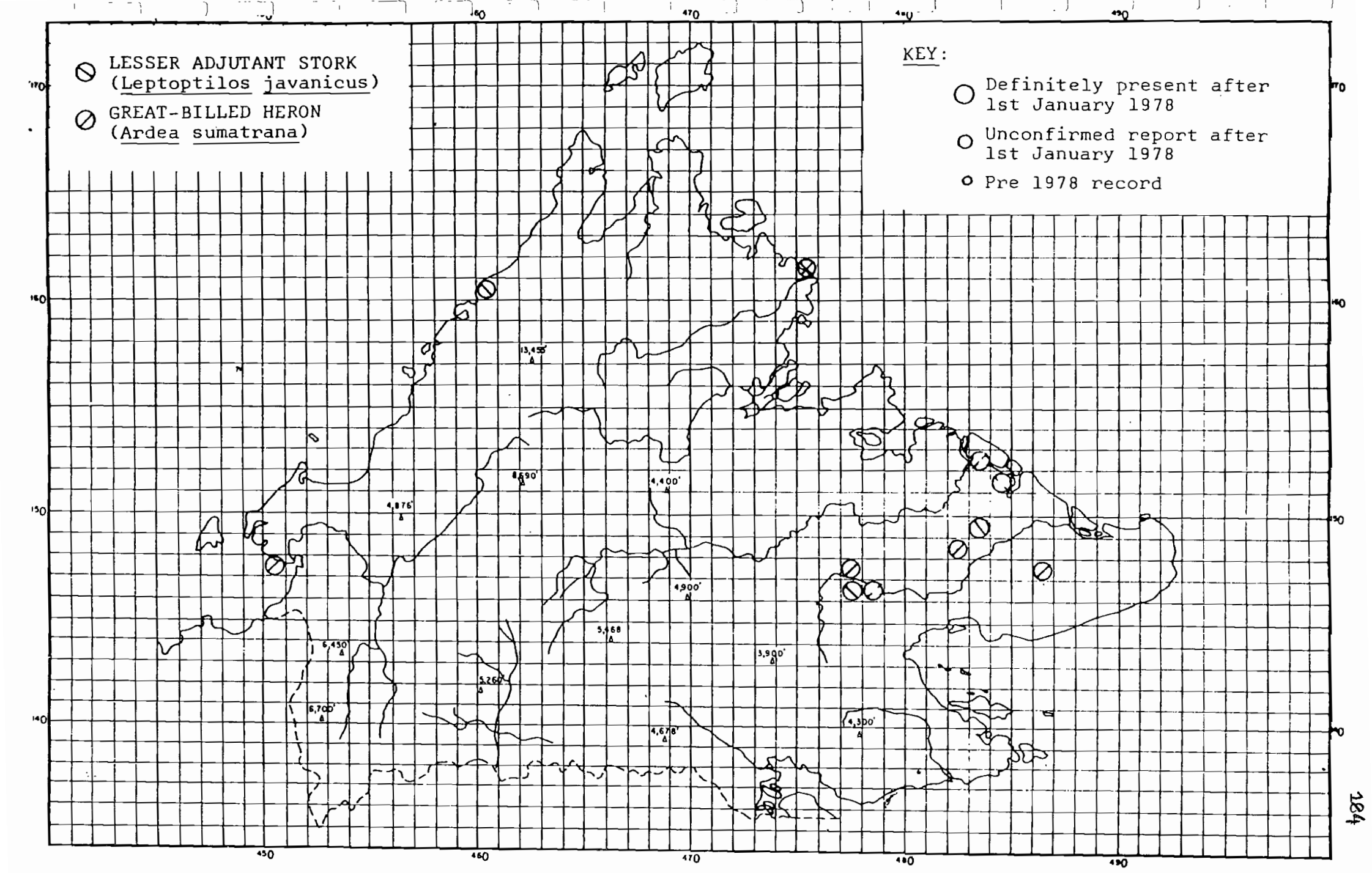
The general nature of the Faunal Survey did not permit detailed investigation of particular bird species. Elucidation of the dynamics of changes in the bird community after logging require further study, and a start has been made by researchers in both Sabah and Peninsular Malaysia. Here, some general trends are outlined and a selection of bird species, with differing ecologies, are commented on.

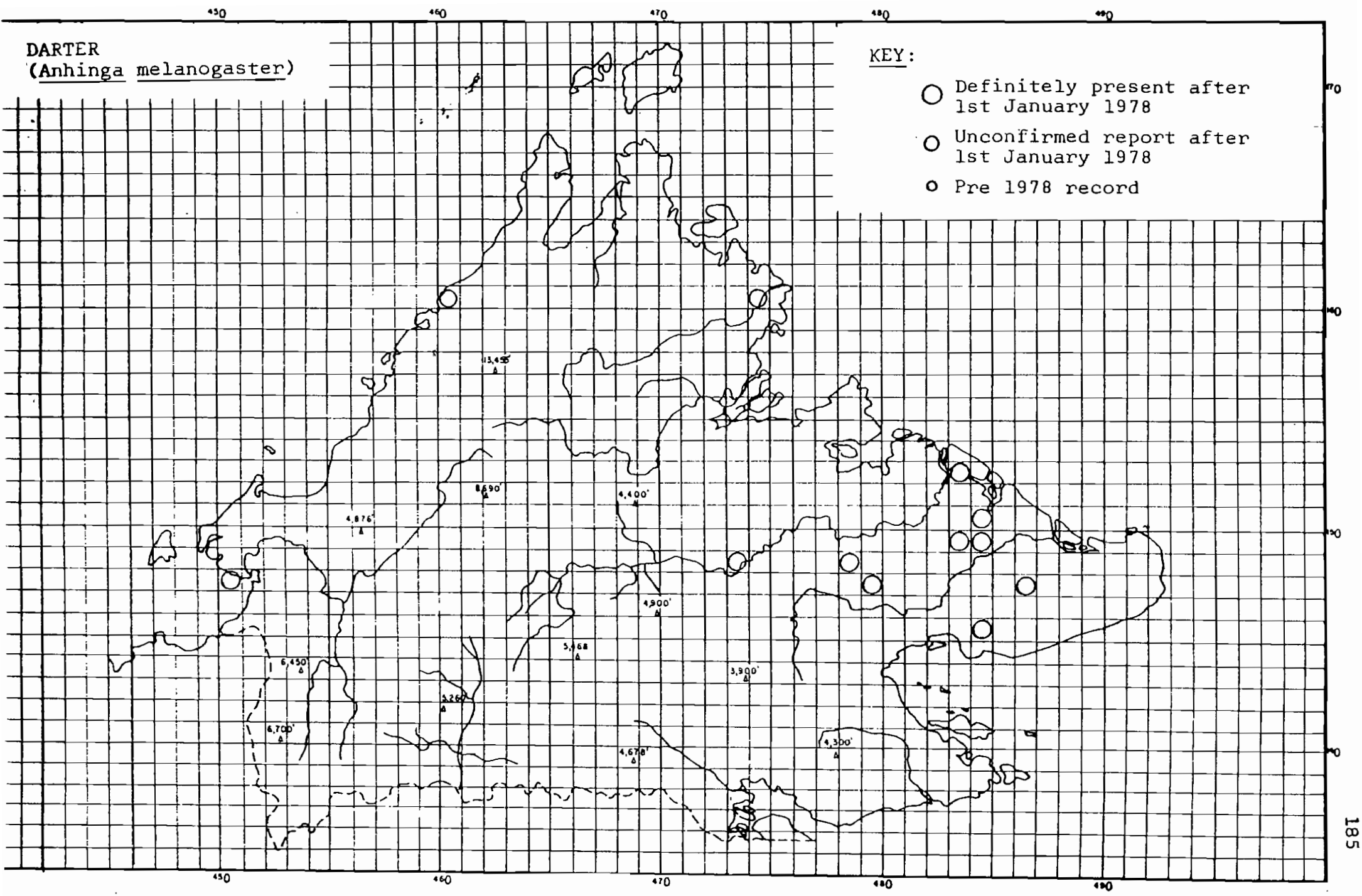
Of all bird species recorded in forest habitats during the Faunal Survey, 9% were only seen in primary lowland forest and a further 9% only in primary upland or highland forests. These observations are partly accounted for by the greater number of surveys in primary forest, but also indicate that some species do not readily adapt to logged forest. The species which are relatively dependent on primary forest include certain trogons, pittas, kingfishers, woodpeckers and wren-babblers.

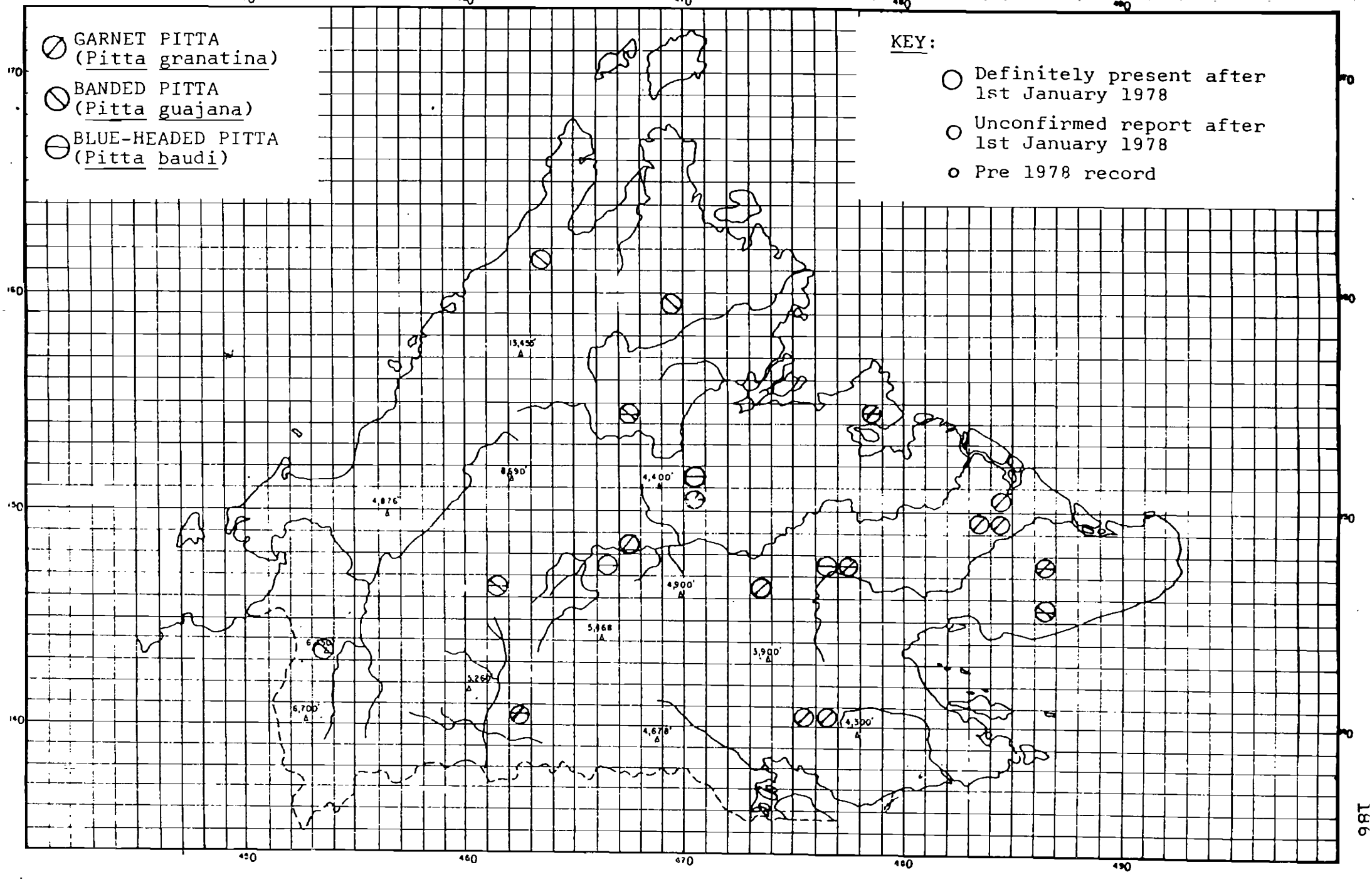
Other species, such as some bulbuls and tailor birds, are more abundant after logging. The precise effects of logging are difficult to assess because of the patchwork of habitats, including some pristine areas, which occur in logged forests and the continual processes of change which occur in the vegetation as the forest regenerates. More species were seen during surveys of logged forest than primary forest, partly because the diversity of habitats might support a greater diversity of bird species and partly because the conditions of visibility are better in logged forest. It is undoubtedly important to maintain areas of pristine habitat in which the less adaptable species may breed and eventually recolonise the regenerating forest.

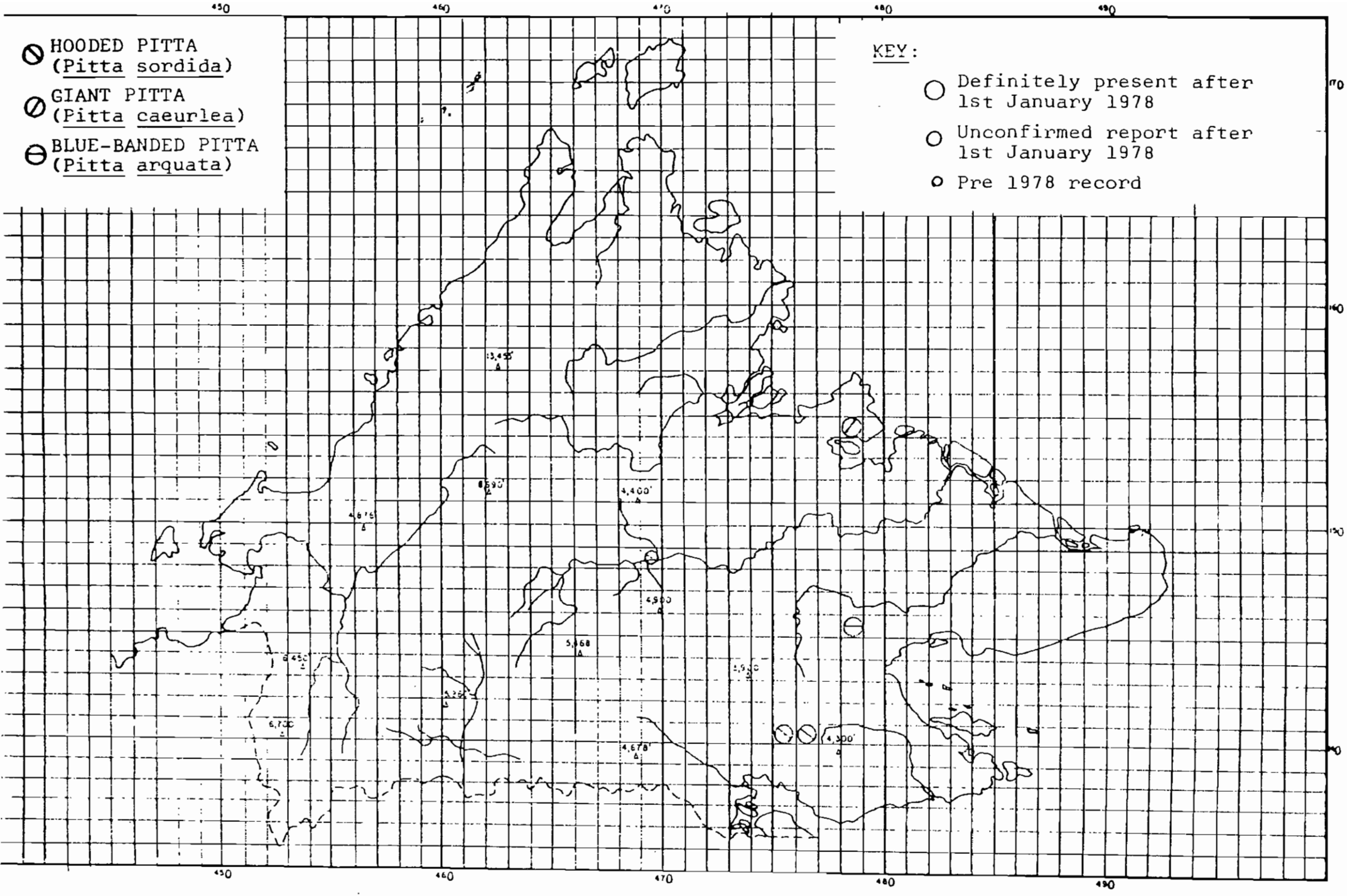
The herons and storks, all being birds of watercourses and other open areas, may have benefitted in parts of their range because of an increase in suitable habitat, but we have no information on the effects of siltation (due to logging) on their food supplies. The dusky-grey heron, lesser adjutant and Storm's stork were all recorded more than 10 km. from major waterways in logged forest on flat, swampy terrain. The darter has adapted well to heavy logging in the eastern lowlands and is now seen perched beside stagnant pools and lakes formed by blocked streams, as well as along the larger rivers.

Among the hornbills, responses vary. The pied hornbill clearly prefers riverine forest, however patchy or open, which is generally little-disturbed by logging anyway. A few years after logging, population densities of white-crested, bushy-crested and black hornbills in Sabah did not appear to be much lower in logged forest than in primary forest, but more detailed long-term data is required. The wrinkled hornbill in Sabah is insufficiently known to make comment, but the other three large hornbills - wreathed, rhinoceros and helmeted - are all affected adversely by logging. Large areas of forest, whether logged or not, are required to support viable breeding populations. Logging causes a great reduction in their food supply, increases the distance between food sources and may destroy some nesting trees. If it is assumed that


LESSER ADJUTANT STORK
(Leptoptilos javanicus)
GREAT-BILLED HERON
(Ardea sumatrana)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
13,455'
8,590'
4,400'
4,876'
4,900'
5,468'
6,430'
3,900'
5,260'
6,700'
4,678'
4,300'
450
460
470
480
490
170
160
150
140


DARTER
(Anhinga melanogaster)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
13,455'
8,690'
4,876'
4,400'
4,900'
5,468'
6,450'
5,260'
6,700'
3,900'
4,300'
4,678'


GARNET PITTA
(Pitta granatina)
BANDED PITTA
(Pitta guajana)
BLUE-HEADED PITTA
(Pitta baudi)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
13,455'
8,890'
4,400'
4,876'
4,900'
5,968'
3,900'
6,700'
4,678'
4,300'
450
460
470
480
490
170
160
150
140


HOODED PITTA
(Pitta sordida)
GIANT PITTA
(Pitta caeurlea)
BLUE-BANDED PITTA
(Pitta arquata)
KEY:
Definitely present after 1st January 1978
Unconfirmed report after 1st January 1978
Pre 1978 record
450
460
470
480
490
170
160
150
140
4,400'
4,900
5,868
4,678'
4,300'
6,730

70-80% of the large trees used for feeding by these hornbills are removed during logging, then each hornbill will need an area four or five times larger than previously, assuming that there are no other changes in requirements after logging. All three species do live in logged forest, but we do not know if the breeding rate is satisfactory or if retention of some primary forest is essential.

Of the pittas - generally regarded as rather strictly forest-dwelling birds - three or possibly four species were recorded in more than one survey area during the Faunal Survey. The garnet pitta was the most commonly heard species and its distinctive melancholy whistle was noted in most logged forest surveyed as well as in shifting cultivation, but always in dense undergrowth. The blue-headed pitta was the most commonly seen species, but excepting one record in 20-year old logged forest, was always in primary forest. The banded pitta was the only species recorded in primary highland forest in western and northern Sabah and was also recorded in the Dent Hills, both in primary and 20-year old logged forest. The hooded pitta was seen only in a tree plantation with one possible record in newly-logged forest. Evidently, most pittas are affected adversely by logging, but could remain if disturbance is light and patchy; and they will return to logged forest provided that sufficient time has elapsed for regeneration of a contiguous tree canopy.

A similar situation appears to obtain for the trogons, another type of bird characteristic of enclosed, shady patches in the forest.

4.3.3. Agriculture

Subsequent to logging, agricultural schemes may be developed on suitable soils. Almost all of Sabah's mammals and birds are adapted to forest habitats of one sort or another and it is to be expected that only a few species will survive in agricultural areas. Of those, some will interfere with crop production, usually by eating the crop, and become pests. For wildlife, there is a

big difference between shifting and permanent cultivation, and there are differences between the different kinds of permanent cultivation.

The result of shifting cultivation is to produce a patchwork of different vegetation, most of which is regenerating into forest. There is always primary forest adjacent, allowing many animals to recolonise the regenerating forest. The amount of shifting cultivation will continue to decrease in Sabah, and its present and future occurrence is unlikely to have much bearing on the conservation of species or habitats in Sabah. There are substantial areas of lalang grass resulting from shifting cultivation in northern and western Sabah, covering several percent of the land area, which appear to have no chance of regenerating to forest. After burning, the new grass shoots are eaten by the payau, but these areas are devoid of any arboreal mammals and have very few birds or terrestrial mammals. It is planned to plant most of them with the tree, Acacia mangium which will improve the habitat for some species.

In areas where cultivation has stopped, and the forest is regenerating, population densities of all diurnal primates is low, with the exception of the macaques; long-tailed macaques were common in forest only 5-8 years after cultivation at Pinangah. The tarsier was also found in young, Macaranga dominated forest. Callosciurus species (tree squirrels) were common, although other species were attracted to the fruit trees on the margins of the cultivated land such as the tufted ground squirrel and Sundasciurus species. Terrestrial mammals attracted to these food sources were larger mousedeer and common porcupine.

In considering the effects of permanent cultivation on wildlife, those species which only enter or feed in plantations should be distinguished from those which live and breed within cultivated areas.

Many species pass through and feed in areas newly opened up for agriculture, and a few may be pests for a short time, but they soon disappear permanently. This

group includes the orang-utan, gibbons, long-tailed porcupine, honey bear, otters, clouded leopard, rhinoceros and tembadau. Agriculture is detrimental to all these species because habitat is eliminated.

A second group includes species which enter plantations from adjacent forest or belukar to feed on material other than the crop plant, such as insects or earthworms. Among these are the moonrat, common treeshrew (which was also observed eating unripe oil palm fruits), banded linsang and some raptorial birds. Agricultural development reduces the amount of habitat for these species but is not considered a threat to their survival.

A third group consists of those species which live inside forest but frequently enter plantations to eat the crop. This includes macaques, Prevost's squirrel, some flying squirrels and fruit bats, the common porcupine, masked palm civet and bearded pig, all of which eat fruits off trees and/or root crops; the two deer species, which browse on some tree crops; and elephants which eat a variety of crops. In mature oil palm plantations, several bulbul species characteristic of forest edge were seen feeding on fallen palm fruits; crested fireback pheasants and crested wood partridges, which had probably entered for the same reason, were also observed below Tawau Hills.

A fourth group is constituted by those mammals and birds which can live and breed within cultivated areas as long as there is some belukar. This applies to the lesser (slender ?) treeshrew, slow loris, common palm civet, leopard cat and at least 33 bird species in mature cocoa plantation; to the pangolin, teledu andvarious birds in permanent mixed agriculture; and to the yellow-throated marten, collared mongoose and at least 55 bird speices in mixed tree plantation. Only one mammal species, the plantain squirrel, was observed breeding entirely within monocultures in the absence of any belukar.

Finally, the use of herbicides and pesticides during agricultural development is potentially detrimental to wildlife but it is not yet evident because the effects are cumulative and long-term. The use of such chemicals,

particularly some of those applied to kill grass in new plantations, may pose an immediate threat to a few grazing species, most notably tembadau. Fortunately, the current most commonly-used grass and weed killers in Sabah are almost certainly non-toxic to tembadau, but the situation should be monitored continually. In theory, tembadau could obtain a substantial amount of food from plantation weeds. If effective measures can be taken to control hunting, it should be possible for tembadau to live in partial co-existence with permanent agriculture, as long as toxic chemicals are controlled.

4.3.4. Hunting

Traditional Hunting

Most of Sabah's indigenous peoples were, and to a large extent, still are hunting people. There is evidence of man taking a variety of wild mammals as food from at least 8,000 years ago at Madai (south-eastern Sabah) to more than 35,000 years ago at Niah in Sarawak.

Large mammals were hunted by one or more men using spears, sometimes aided by dogs. This is still the method used by native people in all interior parts of Sabah to obtain wild meat. There is insufficient fossil evidence to indicate to what extent indigenous man contributed to a decline in large mammals, but it seems very likely that the tapir was exterminated in Borneo largely by hunters with spears, and the Sumatran rhino almost so. The rhinos have been hunted primarily for their valuable horns rather than for meat. One European explorer at the beginning of the present century noted that the skins of "tree tigers" (clouded leopard) were worn by Pensiangan (southern Sabah) Muruts during inter-tribal warfare. The distribution and abundance of those species hunted for their meat - primarily bearded pigs, deer and tembadau - have been reduced by hunting but (possibly excepting the tapir) only the tembadau has been exterminated locally, and possibly recently as a result of the use of guns rather than spears. In a few areas, traps involving a horizontally-set spear

attached to a trip-wire are set on pig paths. These are dangerous to people and now only very rarely used.

Blow-pipes and poisoned darts were used formerly by some interior peoples for obtaining arboreal and small terrestrial animals, but use of this weapon has almost completely died out. Most kinds of indigenous traps involve a noose, the most familiar type being the jerat set for medium-sized terrestrial mammals and birds.

Present Hunting

Present-day hunting (other than pest control in plantations) usually falls into one of four categories (below), the first three for meat, the last one also often for pleasure. There is no hunting specifically for furs and almost none for any other purpose, although in many cases the meat is sold, and so financial gain may be a motive.

(1) Indigenous people using traditional methods

This occurs wherever there is some forest near indigenous communities, and usually bearded pigs and payau, taken with spears and dogs, are the favourite prey. Only a very small proportion of Sabah's population now practise such hunting, which is not considered to be a significant threat to wildlife.

(2) Local people using shotguns

This is done in primary and secondary forest or at the forest edge bordering plantations or gardens, where it may serve a secondary purpose of pest control. Deer and bearded pigs are most often taken but, depending on the individual hunter, anything encountered may be shot. In oil palm and cocoa plantations adjacent to forest, most hunting with shotguns is done at or near the plantation boundary. Some hunters patrol the plantation periphery and enter at suitable places, while others build temporary platforms in trees and wait there for the pigs to come out of the forest. Where indigenous people hunt with shotguns in the forest, all mammals, particularly primates, tend to suffer a decline along with the ungulates. There are almost no cultural restrictions on what may be

eaten. In many localities, especially in western Sabah, this kind of hunting has been a major factor in decimating and some cases exterminating mammals.

(3) Trapping by surveyors and timber camp workers

Surveyors, trail cutters and timber camp workers who spend much of their time in or near forest may set jerats and other types of traps to obtain fresh meat. They most often catch deer, civets, porcupines and ground-dwelling birds, but during the Faunal Survey other mammals including clouded leopard, tembadau, a young rhino and possibly a young elephant were caught in jerats set deliberately for tembadau and rhino. Generally, however, trapping may be intense locally but over a sufficiently short period that it is not considered a major threat to wildlife.

(4) Use of guns in logged forest

The roads that accompany logging allow a large area to be covered easily, either by vehicle or on foot. Deer, bearded pigs and tembadau are most sought, but some hunters will shoot at any mammal. Hunting is done usually at night-time, often from a vehicle (which is illegal) on which a moveable lamp is mounted so that mammals may be detected by the reflection of light from their eyes. Roads on which bridges and culverts have broken are penetrated on foot with the aid of a torch.

It is not clear what are the likely long-term effects of this kind of hunting, which is a recent phenomenon. For this reason, and also to assess the feasability of setting up hunting reserves (see below), a special study is warranted. The rhinoceros is now so rare that this kind of hunting poses a major threat to the species' survival in Sabah and the numbers of tembadau are being severely depleted also.

The Effects of Hunting on Mammals and Birds

(1) Sumatran Rhinoceros

The rhinoceros was formerly distributed widely throughout Sabah but had been exterminated from many areas by hunting even before the wide-scale opening up of forest of the past twenty years. Probably this species has been

hunted for its horns and other parts for at least one thousand years. In the late nineteenth and early twentieth centuries, rhinos were still commonly encountered on the coastal areas of eastern Sabah and contemporary newspapers periodically reported on Europeans shooting rhinos in the Sandakan and Lahad Datu areas. During the early years of this century rhino horns, presumably obtained locally, were usually quoted by the "British North Borneo Herald" as being on sale in Sandakan. After World War 2, an already reduced population was decimated further, especially during 1950's-60's by skilled Iban hunters from Sarawak. Despite being a solitary, forest-dwelling animal, populations of this rhino are decimated by any form of persistent hunting.

Given the small size of the rhino population in Sabah, hunting is now a very serious threat to the species. Over the past five years, an average of at least one rhino has been killed yearly in Sabah. In 1981, a young rhino was killed in a jerat in Silabukan and an adult was shot dead in the Segaliud-Lokan area.

Prevention of rhino hunting is the very highest immediate priority in mammal conservation in Sabah.

(2) Tembadau

Tembadau have always had a two-sided relationship with man. Contemporary reports from the late nineteenth and early twentieth centuries indicate that tembadau were present and perhaps common wherever indigenous man practised shifting cultivation. Hunting was done traditionally with spears, a method which was used until 1950's in some areas (for example, in Dewhurst Bay, by Tidung people, and in the Tongud area, where they were exterminated), and until 1970's in the Maligan Range. It is claimed that in former times, hunters on the Lower Sugut River dressed in grass camouflage and crept up on tembadau to hamstring them with parangs. In north-western Sabah, tembadau were hunted on the beach by Bajau men on horseback. Generally, it seems that tembadau populations benefitted from shifting cultivation which increased food supply, and withstood the relatively low level of hunting by traditional methods.

Reports from old residents of the Tenom, Keningau, Tambunan and Upper Sugut areas indicate that tembadau were exterminated locally somewhere around or soon after World War 2, a time when firearms were used by more people than had been the case before the War. It seems that hunting with guns (nowadays shotgun with ball-shot or rifle) has been the primary factor leading to the decline in the distribution and abundance of tembadau, together with a decrease in the extent of shifting cultivation and, more recently, loss and fragmentation of habitat. Whereas logging, like shifting cultivation leads to a considerable increase in food supply for tembadau, the logging roads provide easy access and hunters with guns into areas they were previously unable to enter. Since 1960's, herds have been decimated in this way.

We estimate that at least 10 tembadau were shot annually during the period of the Faunal Survey and the actual number could be much higher.

(3) Elephant

The possibility that the present restricted distribution of elephants may be attributable, at least partially, to former hunting pressure has been mentioned already. Only from Tongud, however, is there a report of indigenous man killing elephants with spears within living memory. In the late nineteenth and early twentieth centuries, shooting of elephants by planters and other expatriates for crop protection or sport was uncontrolled. At least tens and possibly hundreds were killed during the decade prior to about 1930, when hunting became more controlled, for the purpose of crop protection rather than sport. Elephants were killed for their meat by the Japanese during World War 2. Shooting of elephants for crop protection has continued over the past thirty years, such that they have been almost eliminated from the Sandakan Peninsula and Semporna Lowlands. Illegal hunting of elephants for ivory or sport happens very rarely; the available evidence suggests about once per year. Over the past one hundred years, elephant hunting for whatever purpose has had little impact on the total population size, and the decrease in distribution is inevitable with permanent agricultural development.

(4) Honey Bear

People do not go out deliberately hunting bears in Sabah, but hunters with a gun tend to shoot at them, either because they are considered to be dangerous or because the gall bladder is sought as medicine. There is a belief, particularly among the Chinese, that the gall bladder is effective against severe injuries. Timber camp workers and village people often take bear cubs if they are found by chance 'parked' in the forest while the mother is searching for food. Over the past few years, one or two such bears annually have been confiscated by FD(WS) or handed in by the owners when the bear becomes too large to handle.

Given the species' normal low population density, these forms of "hunting" may constitute a significant drain on the population. Loss and fragmentation of habitat, however, constitute a bigger threat.

(5) Clouded Leopard

Hunters do not go out specifically to hunt clouded leopards, but as with bears, most will shoot them if encountered, either because they are considered dangerous, or for the fur or as sport. At least two were shot in 1981 and one was caught in a trap in 1980. The chance of seeing a clouded leopard is very small, and they are not deliberately trapped, so hunting is not considered to be a significant threat. Where there have been hunting communities for a long time, scarcity of the clouded leopards prey animals must limit this species' population density.

(6) Primates

Both long-tailed and pig-tailed macaques are regarded as pests by people growing fruit, rice or maize, since all these crops are eaten by both species. For this reason, and in some cases to obtain food also, macaques are shot or trapped wherever they enter cultivated crops. In no area visited during the Faunal Survey, however, had macaques been exterminated from suitable habitat, even after intensive shooting for several years (cocoa and oil palm plantations in Tawau), or hunting by long-standing communities (Maligan Range).

For species which are more dependent on primary forest - leaf monkeys, gibbons and orang-utans - hunting was investigated at several sites in western Sabah. In the upland forest at Sapulut, in an area often visited by hunters who were primarily interested in ungulate prey, the population densities were relatively high, except for orang-utans which are rare throughout the region. Further west, in the Crocker Range, the number of hunters is greater and they appear to be equally interested in primates and ungulates for prey. Since these forests are on steeper and higher land, however, it is difficult to distinguish the degree to which altitude or hunting are responsible for the low population densities in these areas; both are significant.

Evidence from the Crocker Range shows clearly that orang-utans and gibbons are frequently shot, and the shy behaviour of leaf monkeys implies that they too are hunted. The distinct distributions of primates, such as the absence of orang-utans from the Maligan Range but their presence in northern parts of the Crocker Range at similar altitudes, suggests that hunting has eliminated some local populations of primates.

Proboscis monkeys appear to have suffered significantly from hunting throughout the mangroves of Sabah's west coast, since in several localities reports indicate that they are now rare or absent in places in which they were once found commonly. The decrease has occurred markedly within the past 10 to 35 years, coinciding with the period when guns and outboard motors became available to local people.

(7) Other Mammals

The larger mammals tend to suffer the most from hunting. The smallest mammal to suffer heavy, albeit seasonal, hunting by shooting is the flying fox (Pteropus vampyrus), a species not investigated during the Faunal Survey. Vast numbers are shot from flocks when they go to raid orchards of ripe fruits, mainly in the months August to October. Many people eat these huge bats, but the main motive for shooting is crop protection. It

seems very unlikely at present that shooting is having much effect on the species' survival, since roosts are largely undisturbed and there is no hunting throughout most of the year.

The pangolin is valued among the Chinese as having medicinal properties, but much less so than rhinos or bears. It is taken only at chance encounters and hunting poses no threat to the species in Sabah.

Squirrels are considered too small to be worth hunting for food, but occasionally giant squirrels and giant flying squirrels are shot by hunters seeking larger prey. Only the plantain squirrel, and in some places, Prevost's squirrel are trapped or shot regularly, purely where they are agricultural pests. On a local scale, porcupines are trapped by surveyors, or poisoned as agricultural pests.

None of the mustelids, viverrids or small wild cats are specifically sought for any reason (except the common civets, as pests on fruit), and hunting poses no threat to any species.

The dugong may have suffered seriously from hunting in the past; survey work is required before current threats can be assessed.

Bearded pigs are hunted for food more than any other animal in Sabah. In rural areas, they are killed with spears or shotguns. Despite heavy hunting pressure in some parts of western Sabah, probably for thousands of years, there seem to be no forested areas where bearded pigs have been exterminated completely. It is unlikely that hunting alone will pose a threat to the survival of the species.

The rate and intensity of hunting of deer and mouse-deer probably cannot be assessed, and such information would be of little value without knowledge of carrying capacity and reproductive rates in different habitats. To give some idea of hunting intensity, the most reliable report is quoted here. In one area of logged lowland and upland dipterocarp forest, about 500 sq. km. in extent

with about 100 km. of suitable road and a single access point, a resident worker estimated that about 10 payau and 12 kijang are killed monthly. The intensity would be much higher locally in parts of the heavily logged east coast lowlands. None of the deer or mousedeer species are ever likely to become endangered, but in view of the fact that they are among the most sought-after game animals in Sabah (particularly the payau) it is important that some attention be paid to formulating a rational management policy.

(8) Managed Hunting Reserves

With the undeniable fact that deer and pig hunting is very popular among Sabahans, it would seem to be worthwhile to conduct research with a view to formulating a hunting management policy. Although FD(WS)'s manpower is currently insufficient, it is worth considering that, ultimately, managed reserves may be an appropriate way of permitting people from towns and rural settlements to hunt for pleasure and for meat. Areas of logged forest would be retained at reasonable distances from settlements, either between agriculture and Forest Reserve, or within agricultural areas. With appropriate management, tembadau could be added to the list for hunting.

A great deal of basic research into the biology of these species is needed, but some could be done fairly easily. For example, the relative abundance of deer under different hunting intensities could be assessed in current forested areas which are designated for agricultural development. The information would be crude, but may give some indication of the rate of hunting which would allow a sustained yield from a deer population. More difficult would be an assessment of the minimum area needed to support viable populations.

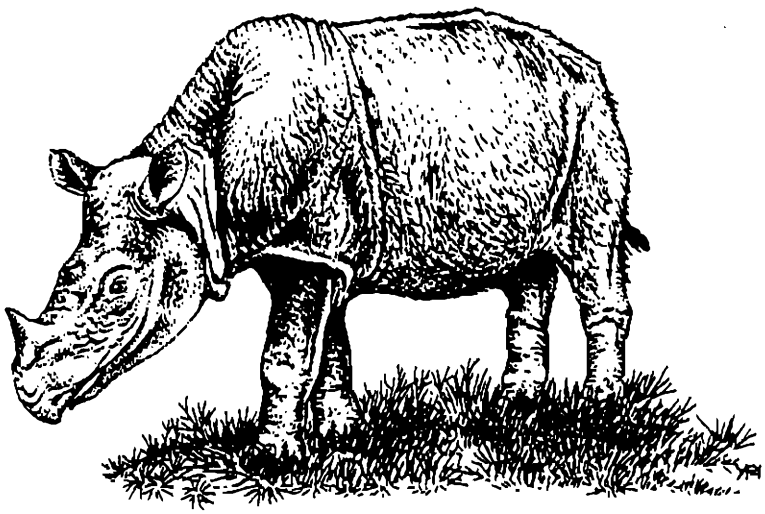
(9) Birds

Hunting is not considered to be a serious threat to any bird species in Sabah, except possibly waders in some coastal localities not visited during Faunal Survey. With a few exceptions (described below) birds are not specifically sought in Sabah for food or decorative purposes. A

substantial proportion of opportunistic hunting with guns is done at night-time and the use of blowpipes has almost died out.

The birds which are caught or hunted are: pheasants and partridges (collectively referred to as ayam hutan) and pigeons, all for meat; shamas and hill mynahs, kept for their song and talking ability respectively; and Malay lorikeets, kept for their attractiveness as cage birds. Spectacular birds, such as raptors, herons and hornbills, are occasionally encountered kept as pets, but these are obtained only rarely. Pheasants and partridges are most often trapped in cage traps or jerats, although other methods are used, while pigeons are usually taken with a shotgun. Shamas and lorikeets are obtained by laying down a sticky sap (usually from Artocarpus trees) on suitable perches, and attracting birds by placing nearby a caged individual of the desired species. Mynahs are obtained as chicks from nest holes.

5. WILDLIFE CONSERVATION



Sumatran Rhinoceros

5.1 INTRODUCTION

Sabah is undergoing rapid and widespread development. What is true now will not be so in 1990. For example, the large mammals and birds are adapting now to the logged forests of the eastern lowlands, but most of this will be permanently cultivated in the future. Whereas until the mid-1970's almost all of the State's export timber came from eastern Sabah, now the south-west is being opened up. In 1980, about 135 sq. km. of primary upland and highland dipterocarp forest were logged in the area between Keningau and Sapulut, the timber being taken out by road over the Crocker Range. In 1982, there will be for the first time a direct road link between Tawau in the south-east, and Sapulut in the south-west. This will allow access to the most interior part of Sabah.

Ultimately, the survival of most of Sabah's wildlife will depend on effective conservation of samples of all pristine habitats with proper management of forest exploited for timber and other natural resources. The greatest need, therefore, is for the establishment of a network of conservation areas, to include both pristine and logged forest, which must be chosen for their importance in plant and animal conservation, and not because they are useless for logging or agriculture.

In the sections below, we firstly describe the present kinds of "conservation areas" which exist or are permitted according to State legislation.

The main features of four important existing conservation areas on mainland Sabah are summarised. We then show that there are some major omissions in the present system of conservation areas and discuss briefly two important topics: minimum areas of habitat required for effective conservation and the value of logged forest. Four species which require special and immediate attention - rhinoceros, tembadau, elephant and orang-utan - are discussed and guidelines are suggested for a conservation plan for each species.

We strongly recommend the establishment of five

specific new conservation areas. The reasons for our suggestions are outlined and a basic procedure to be followed in establishing each of them is suggested. Finally, research priorities for wildlife management and conservation in Sabah are listed.

5.2 PRESENT CONSERVATION AREAS

5.2.1. Categories of conservation area

The following kinds of conservation area exist in Sabah (see Table 12):-

A. FOREST RESERVES (Map 11)

i. Protection Forest Reserve

"For safe-guarding water supplies, soil fertility and environmental quality; and the minimisation of damage by floods and erosion to rivers and agricultural land". Protection Forest Reserves are on steeply-sloping land, generally functioning as water catchment areas serving communities and agriculture downstream. In the past, classification of Forest Reserve as Protection or Commercial (see below) has been somewhat arbitary. From June 1978 to October 1980, the amount of Protection Forest Reserve was reduced from 505,987 ha. to 188,582 ha. (1,8). An extra 35,976 ha. is expected to be added, bringing the total area to 3% of Sabah. More than half this area is accounted for by the Crocker Range.

ii. Commercial Forest Reserve

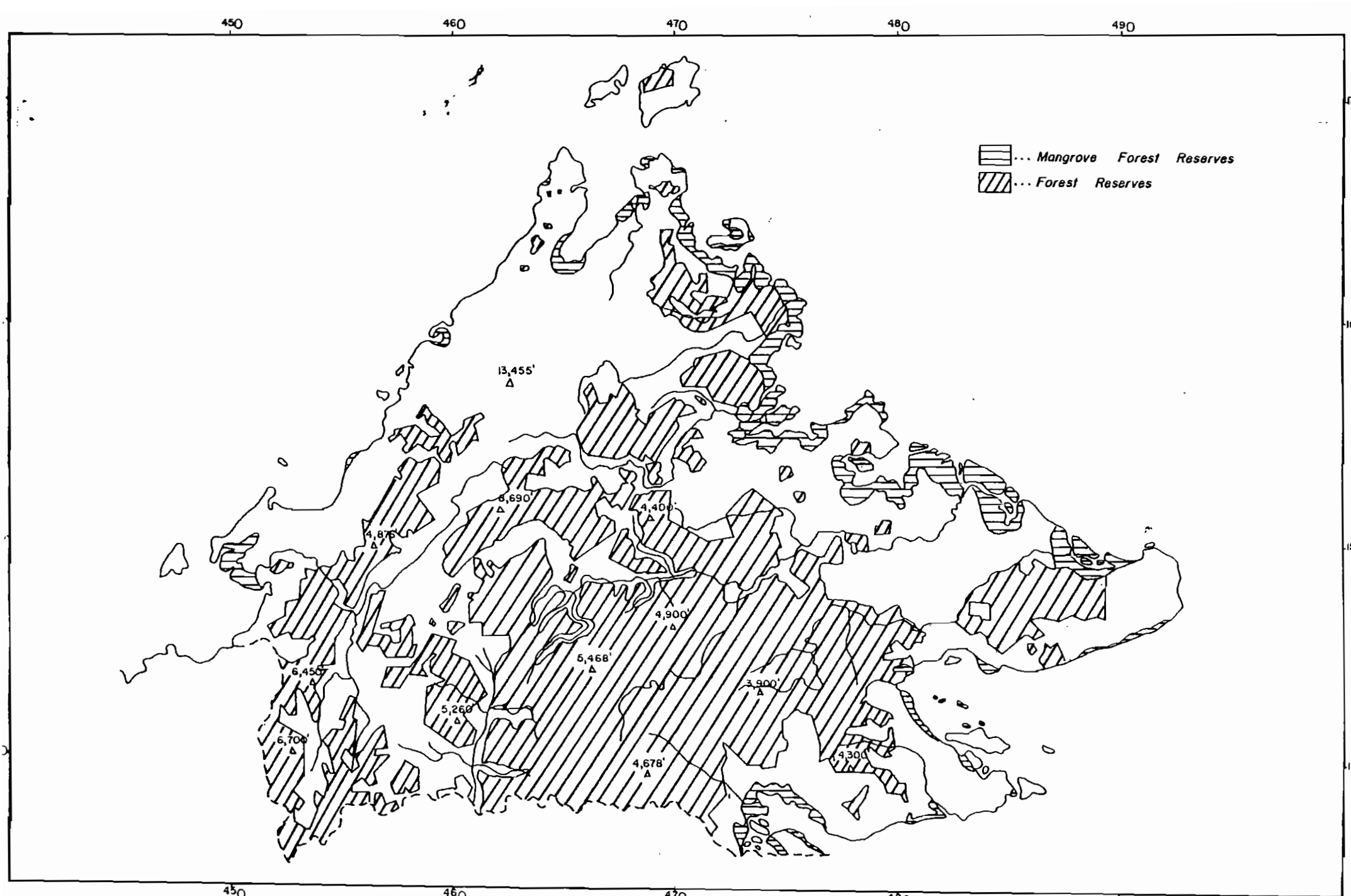
"For the supply in perpetuity, at reasonable rates, wood and other forest products, for agricultural, domestic and industrial purposes, and for export". In 1980, there were 3,343,510 ha. of land either gazetted, preliminary notified or proposed as commercial Forest Reserve (44% of Sabah), of which 2,767,120 ha. (83%) was still primary forest. It

TABLE 12

SIZE OF PRESENT CONSERVATION AREAS IN SABAH

+ F.R. = Forest Reserve

Status	Area (ha.)	Percentage of Sabah
Protection F.R.+	188,582	2.5
Commercial F.R.+	3,343,510	43.9
Domestic F.R.+	9,160	0.1
Amenity F.R.+	15,008	0.2
Mangrove F.R.+	73,845	1.0
Virgin Jungle Reserve	36,186	0.5
Water Catchment Areas	2,591	0.03
Bird Sanctuary	7,000	0.1
Game Sanctuary	0	0
National Park	106,598	1.4
Total	3,776,480	49.6
Area afforded total protection	2,591	0.03



MAP ... CURRENT AND PROBABLE FUTURE FOREST RESERVES

was estimated, however, that only about 1,813,000 ha. (54%) of that primary forest bears extractable timber (1). Commercial Forest Reserve is a mixture of habitats, therefore, ranging from heavily logged (more accessible, flatter areas) to primary (remote, steep areas).

iii. Domestic and Amenity Forest Reserve

The functions of these two classes are: "for the supply of forest products for domestic use" and "for amenity and arboretum use" respectively. The Forest Policy for Peninsular Malaysia, 1978, amalgamates Domestic with Commercial Forest and defines Amenity Forest as for the "Conservation of adequate forest areas for recreation, education, research and protection of the country's unique flora and fauna". These two categories of Forest Reserve occupy only 0.3% of Sabah.

iv. Mangrove Forest Reserve

Mangrove Forest Reserve includes nipah and mangrove trees. Cutting for domestic use or export is permissable in all mangrove except 1,090 ha. of Virgin Jungle Reserve.

v. Virgin Jungle Reserve (V.J.R.)

The VJR's were introduced to preserve samples of natural vegetation as a gene pool, seed orchard and refuge for wildlife. In the absence of more definite guidelines, some accessible VJR's have been logged and unloggable parts of Commercial Forest Reserves have been classified as VJR's. Most are between about 100 to 1,000 ha. in extent, and occupy a total of 0.5% of Sabah.

B. WATER CATCHMENT AREAS

The purposes of preserving water catchment areas are obvious. As yet, there is no definite policy regarding such areas and some have been disturbed; in the future they will inevitably assume more importance, particularly near urban development.

C. BIRD AND GAME SANCTUARIES

There are five Bird Sanctuaries (Table 13 and Map 12) but only the Kota Belud Bird Sanctuary on Tempasuk Plain was visited during the Faunal Survey.

There are no Game Sanctuaries. "A proposal was made in 1933 to reserve under the Land Ordinance a considerable area of the Upper Segama and Tingkayu drainages in order to protect the rhinoceros, but this proposal had to be abandoned due to opposition by timber interests" (33). Other areas were suggested subsequently, including a part of the Segaliud-Lokan Forest Reserve, but nothing came of these suggestions. In 1963, the Fauna Conservation Ordinance was passed, providing for the declaration of Game Sanctuaries. Some ten years later, two proposals for Game Sanctuaries were made: Sungai Lokan (6,700 ha.) for orang-utan conservation and another (131,300 ha.) in Ulu Tungud (34). These proposals came to nothing.

The Land Capability Classification (3) recommended only one area as a Game Sanctuary - Danum Valley in the Ulu Segama Forest Reserve.

The concept of a Game Sanctuary, as a place where "game" animals are preserved to ensure the survival of species hunted for trophies or meat, is out-of-date and a more important function of species preservation needs to be served.

D. NATIONAL PARKS AND RESERVES

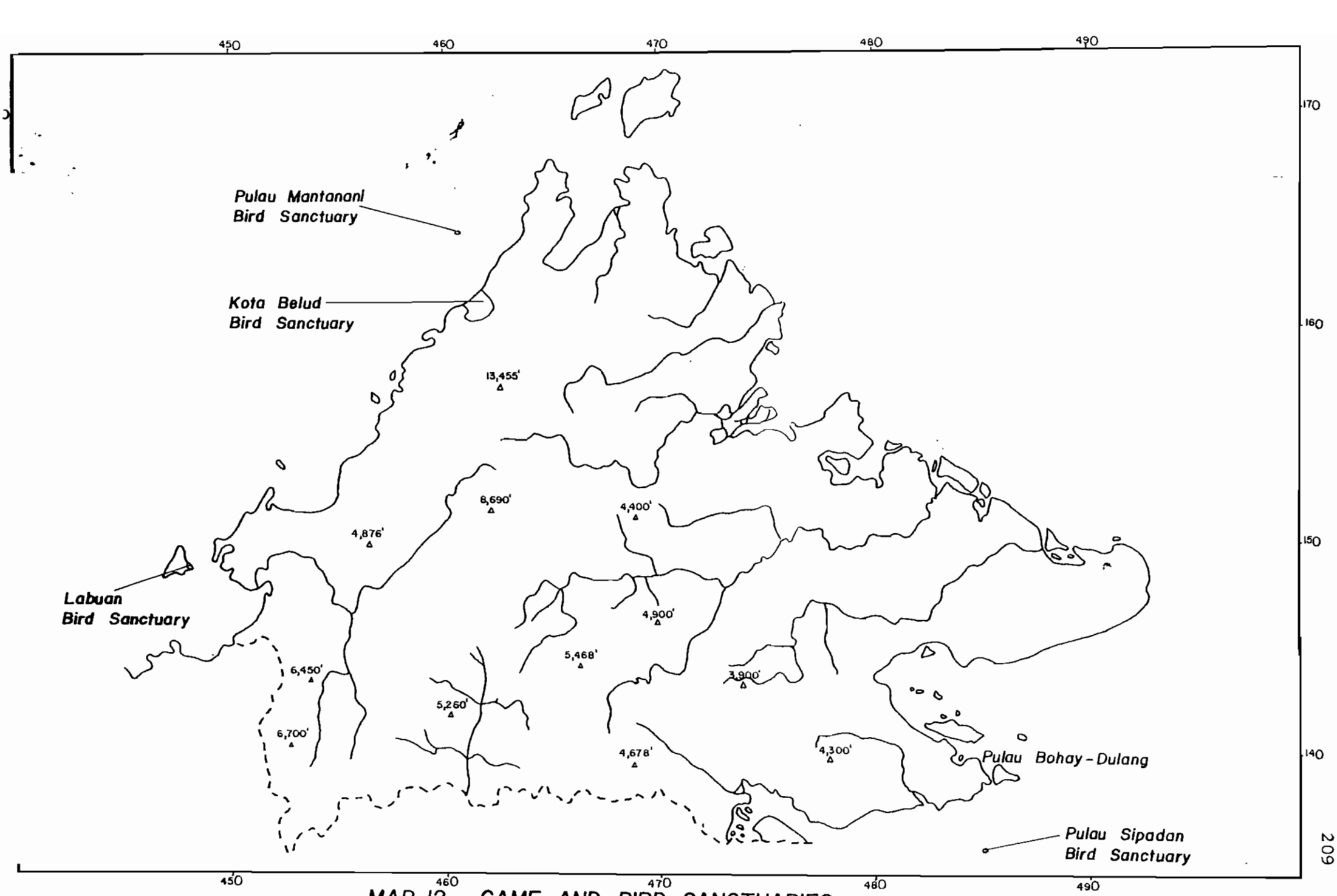
The first National Park, Kinabalu, was gazetted in 1964, following the National Parks Ordinance (1962). There are now five National Parks and no National Reserves (Table 14 and Map 13). Three of them are offshore islands, and a fourth island National Park has been proposed. Klias National Park (which reverted to its former Forest Reserve status in 1981) was gazetted to provide protection for mangrove flora and fauna. Tawau Hills, noted in the Land Capability Classification as of scenic and amenity value, is also an important water catchment area supplying the Tawau district.

Under present legislation, National Parks may be

TABLE 13

BIRD SANCTUARIES IN SABAH

Name	Year gazetted	Remarks
Pulau Bohay-dulang	1937	Cultured pearl industry established on the island. Proposed as part of a new National Park.
Pulau Sipadan	1937	Originally for protection of 4 rare pigeon species. No recent information, but hunting occurs.
Kota Belud (Tempasuk Plain)	1960	Inhabited by man, but appears to be very important for migratory birds.
Labuan	-	Inhabited. No recent information.
Pulau Mantanani (and Pulau Lunsungari)	1962	To protect island birds. No recent information.

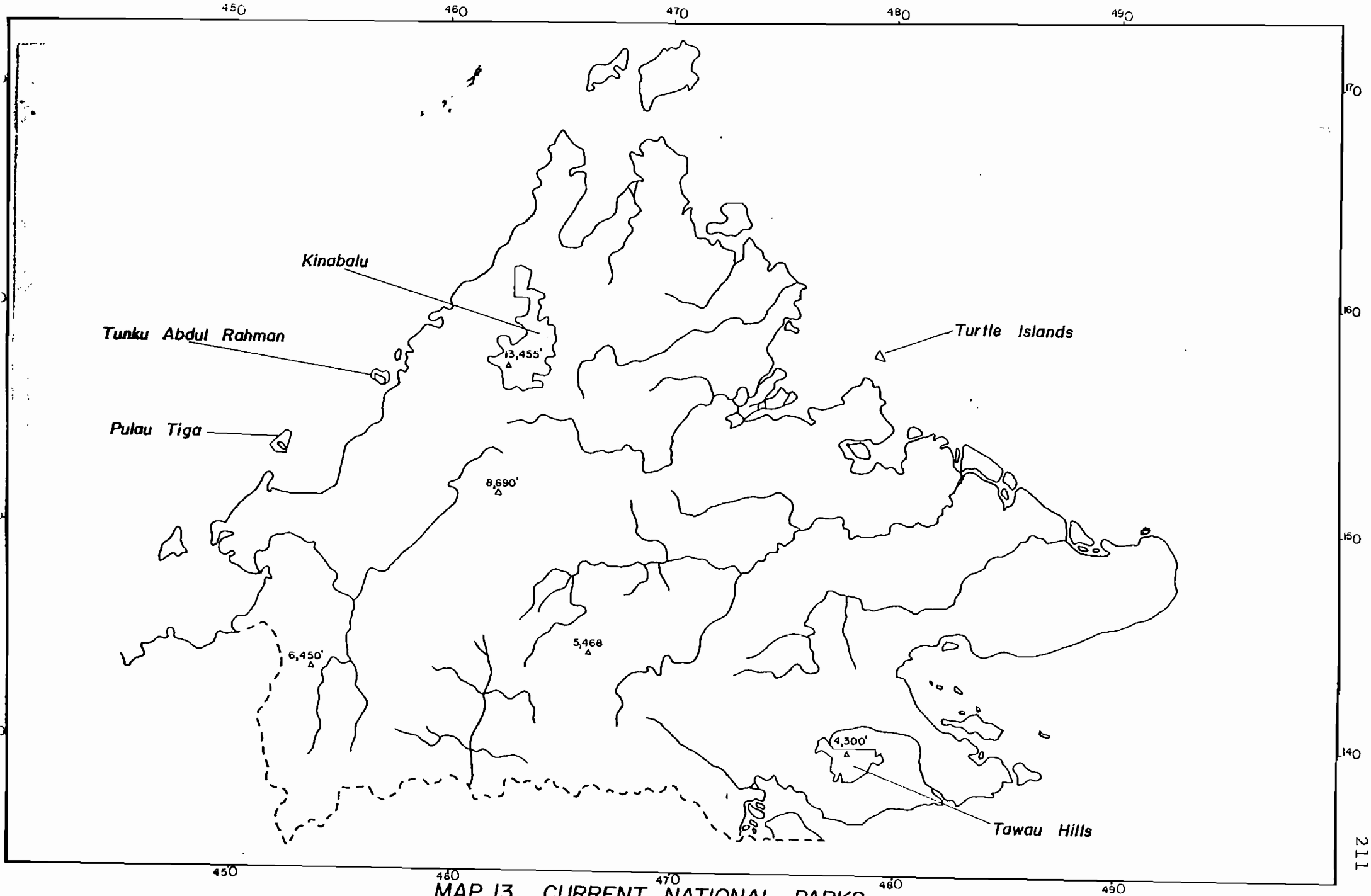


MAP 12. GAME AND BIRD SANCTUARIES

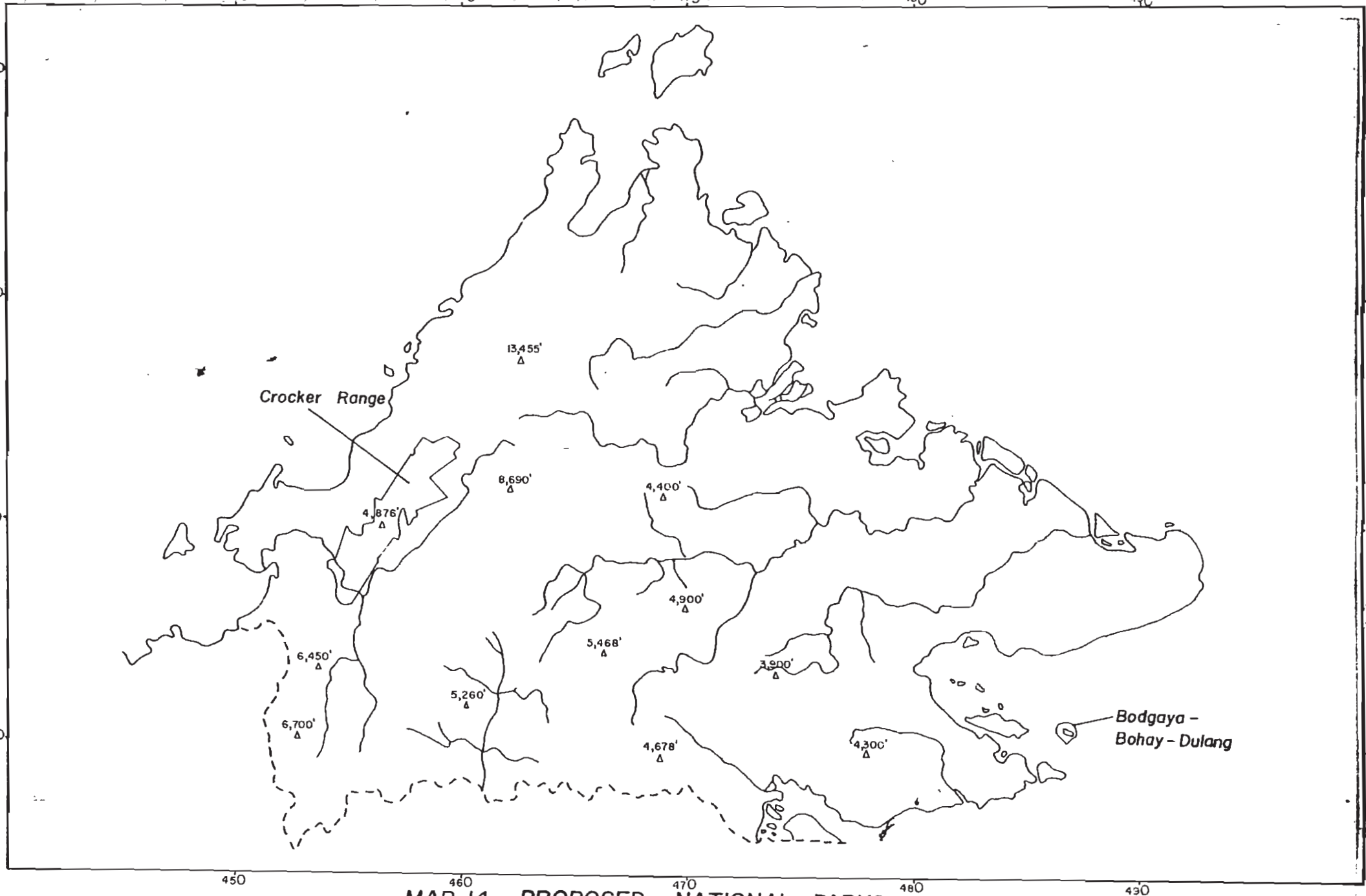
TABLE 14

NATIONAL PARKS IN SABAH

Name	Land Area (ha)	Main Features
Kinabalu	76,800	Of outstanding biological importance and scenically unique.
Tunku Abdul Rahman	1,736	4 islands off Kota Kinabalu. A recreation area.
Pualu Tiga	60	4 islands. Recreational potential.
Turtle Islands	18	3 islands, important for turtle conservation.
Tawau Hills	27,984	Isolated hills of volcanic rock, surrounded by logged forest (40% of Park area).
TOTAL	106,598 ha.	



MAP 13. CURRENT NATIONAL PARKS



MAP 14. PROPOSED NATIONAL PARKS

degazetted without enquiry. Two new National Parks have been suggested by the authorities in Sabah (Map 14).

5.2.2. Important Existing Mainland Conservation Areas

There are four important areas on Sabah's mainland which enjoy fairly secure protection (Table 15).

(1) Mount Kinabalu (76,800 ha.) is Sabah's and probably Borneo's greatest natural feature, fully worthy of total protection for the preservation of its unique natural resources and beauty. Many species have been studied in the Park, and a very high level of endemism has been noted for the plant and animal species present, despite the fact that only a very small proportion has been explored. The Park is Sabah's main tourist attraction at the present time, and an important outdoor recreation area for Sabah's people.

(2) Sepilok Virgin Jungle Reserve (formerly Sepilok-Kabili Forest Reserve) is the site of most of the Forest Department's oldest research plots and silvicultural experiments, as well as the internationally known Orang-utan Rehabilitation Centre. The value of this 4,000 ha. reserve to forest research, tree conservation, orang-utan conservation and, most recently, as a conservation education centre is in no doubt.

(3) The Crocker Range Forest Reserve (129,815 ha.) affords protection to much of the steepest land on the west coast, where any exploitation would be damaging to the water supply of both the Pegalan Valley and coastal communities. It forms a fine supplement to Kinabalu National Park in protecting the array of montane animal species which are found only in north-western Borneo. It also contains the only outlet to the sea for rivers flowing west from the interior: the spectacular Padas Gorge.

There is an immediate need to protect this area from further illegal incursions of shifting cultivators. Since the main purpose of protecting the Range is to safeguard

TABLE 15 MAJOR EXISTING CONSERVATION AREAS ON MAINLAND SABAH

NAME OF AREA	MAJOR NAMED PHYSICAL FEATURES	APPROX. AREA (ha.)	HABITATS - MAJOR TYPES & % OF TOTAL AREA	HUMAN DISTURBANCE
Kinabalu National Park	Mount Kinabalu (13,455 feet). Mount Tambuyukon (8,462 feet). Mount Templer (3,773 feet).	76,800	70% montane forests. 30% upland and highland dipterocarp forests.	Little at periphery, mainly hunting.
Sepilok Virgin Jungle Reserve	Sepilok and Kabili Rivers	4,000	Mostly primary lowland dipterocarp forest. Some kerangas and old logged dipterocarp forest.	Forest Dept. research activities.
Crocker Range Forest Reserve	Membakut, Kimanis and other rivers. Padas Gorge - highest peak 5,000 feet.	129,815	58% upland and highland dipterocarp forest. 42% montane forests.	10% + shifting cultivation. Hunting in some places.
Tawau Hills National Park	Mount Magdalena (4,300 feet). Maria Peak (3,500 feet).	27,985	84% upland and highland dipterocarp forests. 14% montane forest.	94% of forest at less than 1,000 feet and 23% at 1,000-3,000 ft. logged. Some hunting.

water supplies to rural communities, the responsibility lies within the Forest Department's policy aims. There is no need, therefore, to change the status of this area to National Park.

(4) Tawau Hills National Park (27,985 ha.) has lost some of its former scenic and conservation value, since an estimated 40% of the Park area was logged prior to its gazettement in 1979. But it is still sufficiently large, and connected with Forest Reserves, to be a valuable conservation area. It is close to Tawau, and so has the potential to provide a local out-door amenity area.

5.3 SOME CONSIDERATIONSFOR CONSERVATION PLANNING

5.3.1. Omissions in the present system of conservation areas

The first and major omission from current protected areas is primary lowland and upland dipterocarp forest, particularly the former. Sepilok Virgin Jungle Reserve is probably adequate for the conservation of many tree species (including belian and a number of dipterocarps) and for many smaller mammals and birds. But a substantial proportion of the 4,000 ha. Reserve consists of steep sandstone ridges or areas of sandy soils which are not representative of the surrounding lowlands. Furthermore, Sepilok will soon be totally isolated from other dipterocarp forest and will not be large enough to support populations of the larger mammals and birds in the long-term. It will certainly not be sufficient for rhinos, tembadau and elephants. Population density estimates from elsewhere in Sabah suggest that the maximum number of orang-utans that can be supported without supplying extra food is about forty. All other VJR's in lowland and upland dipterocarp forest are much smaller than Sepilok and some are, or soon will be, as isolated.

In our opinion, the greatest priority is for the

conservation of at least one tract of primary lowland and upland dipterocarp forest, to be part of a much larger logged area. The primary forest areas would be designed in particular to incorporate conservation of rhinos, orang-utans and plant species of the different lowland regions.

Secondly, no coastal areas (Mangrove/Nipah, Freshwater Swamp and Beach habitats) are sufficiently protected for the long-term conservation of coastal fisheries or preservation of proboscis monkeys, silvered leaf monkeys, estuarine crocodiles and other fauna.

Thirdly, there is no clear policy by which VJR's are selected to conserve representative portions of the original vegetation. The trend in recent years has been to select unrepresentative portions. A rationally-chosen system of VJR's would not only help to preserve a diverse array of Sabah's flora, but would temporarily support mammals and birds displaced while logging occurs in the surrounding forest.

To overcome these ommissions, and develop an effective conservation policy, it is necessary to identify the areas most valuable for wildlife preservation. There are then three aspects of long-term conservation that must be considered:-

(a) selecting areas that are large enough to support viable populations of animals and plants,

(b) ensuring that there is adequate legislation to give effective protection and

(c) having sufficient manpower to ensure that the law is upheld.

5.3.2. Minimum areas required

There is a continuous decrease in the area of forest that can be set aside for conservation. It is necessary to estimate the minimum area of land that must be set aside to support viable populations that will maintain each species in the long-term. It is assumed

that if sufficient areas are set aside for the rarer mammals then those species which are more abundant will be preserved also.

It is generally considered by biologists that a continuous population of at least several tens of individuals is needed to ensure that a species does not die out as a result of in-breeding, disease or disturbance such as hunting. Some estimates for a minimum total population size, however, are much higher, running into hundreds or even thousands. The figure will vary according to differences in the genetic composition and breeding system of each species. For practical purposes, a viable species population will be considered as any which has more than 200 adult individuals.

A study conducted in Sarawak, on dipterocarp forests similar in species diversity to those in Sabah, revealed that for two different areas with different tree species composition, 2,000 ha. of primary forest would be required to preserve 200 individuals of every tree species exceeding 30 cm. girth. For both areas, however, only 60% of species would be represented by 200 individuals in an area of 1,000 ha. (35). We assume that 2,000 ha. should be considered as a minimum size for conservation areas of primary forest in Sabah. In another study, in Kelantan, Peninsular Malaysia (36), it was found that for tree species which grow larger before they are reproductively mature, larger areas would be required. For example, the ipoh tree (Antiaris toxicaria) existed at a density of about one tree (exceeding 120 cm. girth) in 40 ha. on sedimentary rock and was absent on granite. Thus, 8,000 ha. of primary forest on sedimentary rock would be required to preserve 200 such trees.

Estimated minimum areas of preferred habitat necessary to preserve 200 individuals of some mammal and bird species are shown in Table 16. Since the largest species - which require the largest areas - are shown, it will be apparent that for all species except rhinoceros and elephant, 80,000 ha. is estimated to be adequate.

It should be noted that these estimates are based

TABLE 16

ESTIMATED MINIMUM CONTINUOUS AREAS FOR CONSERVATION OF 200 ADULT INDIVIDUALS OF SOME MAMMAL AND BIRD SPECIES

SPECIES	PREFERRED HABITATS	MINIMUM AREA (SQ.KM.)
Sumatran Rhinoceros	LD, UD	6,000
Elephant	L	6,000
Orang-utan	LD	150
	UD	200
Honey Bear	LD, UD, (HD?)	800
Clouded Leopard	LD, UD (HD?)	800
White-crested Hornbill	LD, UD	150
Bushy-crested Hornbill	LD, UD, HD	150
Wrinkled Hornbill	(LD, F?)	320
Wreathed Hornbill	LD, UD, HD	300
Black Hornbill	LD	150
Pied Hornbill	R	50
Rhinoceros Hornbill	LD, UD, HD	250
Helmeted Hornbill	LD, UD, HD	400

F : Freshwater Swamp Forest

HD : Primary Highland Dipterocarp Forest

L : Logged Lowland Dipterocarp Forest

LD : Primary Lowland Dipterocarp Forest

R : Riparian (Riverine) Forest

UD : Primary Upland Dipterocarp Forest

on a figure of 200 adult individuals in the population. It is probable that many species could still survive if smaller populations were preserved, but they would be more dependent on careful management. It is still worth saving even small areas, therefore, if they contain rare or endangered species.

5.3.3. The value of logged forest for conservation

It was shown in Section 2.3 that some tree species may disappear completely after logging. An additional point not considered there is that after logging, trees are further separated from others of the same species and that those species pollinated by insects may suffer reduced or no fruit production. effects of increased dessication and light intensity o r remaining have not been investigated. In the absenc f sufficient information, it is assumed that the survival of some tree species (common ones and those without special pollinators) will be better assured in a large area of logged forest, while for others (rare or with special pollinators), relatively small areas of primary forest are better.

With regard to mammals and birds, this Survey has indicated that logging in itself is unlikely to lead to the total extinction of species, provided that some patches of forest remain undisturbed within the logged area, to act as refuges for the more sensitive species. There is good evidence for the primates that logging leads to a long-term decrease in population densities, and indications that this is the case for many other mammals. It should be added that the effects on mammals and birds more than twenty years after logging are unknown and cannot be predicted. Furthermore, presence of a species after logging should not be taken to mean that it is safe from extinction. Populations may be slowly declining, but we may not be aware for many years.

The two most important factors to be remembered are that, for the majority of plant and animal species, (1) the lighter the intensity of logging, the better, and (2)

most mammal populations decrease with logging, so a larger area of logged forest than primary forest is required to support 200 individuals. If large, continuous tracts of primary dipterocarp forest cannot be set aside for conservation of plants and animals, then an alternative approach is to reserve large areas of logged forest (larger than 80,000 ha.) containing patches of primary forest (none of which are smaller than 2,000 ha.) for the conservation of plants and animals particularly sensitive to logging.

5.3.4. Species requiring special attention

The distribution of wildlife species is not uniform throughout the State so it is necessary to select conservation areas in places where species are present and abundant. The rarest mammals are in need of most immediate protection so their distribution and requirements have the highest priority in determining the selection of areas for conservation.

SUMATRAN RHINOCEROS

Problems

(1) Numbers are critically low (current estimate: 15-30 individuals in Sabah) and there may be as few as 7-12 in Silabukan, Borneo's last known breeding population.

(2) The Silabukan population is in Commercial Forest Reserve, currently being logged, with about 50% of the land in this region being suitable for agriculture.

(3) Throughout Sabah, rhinos are sought for their horns. Although there is legislation against killing rhinos, FD(WS) has insufficient manpower to provide adequate protection and many hunters are willing to take the risk.

(4) Even a very small population of rhinos needs tens of thousands of hectares of forest.

(5) This species is highly sensitive to logging.

Guidelines for a conservation plan

The remaining rhinos in Sabah either belong to the Silabukan population, or live in the extensive area of Forest Reserve in central and southern Sabah, or are isolated in the areas surrounded by or due to be opened up for agriculture. Several approaches could be adopted to make the best of this situation.

Firstly, those individuals becoming isolated by agricultural development cannot contribute to the species' survival if they are left where they are now. Consideration should be given to catching these animals, partly to allow them to come together for breeding and partly to gain experience should it become necessary in the future to risk translocation of the Silabukan population. It would be necessary to decide whether any rhinos caught should be kept in captivity to form a breeding unit or whether they should be released into a sufficiently protected forested area in Sabah. Given the dangers of illegal hunting, the possibility of a captive breeding unit should be considered fully as a preferable alternative. A major decision would be whether to form the unit in Sabah (which could be a major tourist attraction) or in an internationally-recognised zoo with proven rhino breeding expertise.

Secondly, the rhino situation in the interior primary forests of Sabah is inadequately known. Most of this area lies within Sabah Foundation's 100-year logging concession. In particular, three areas not investigated during the Faunal Survey should be surveyed for rhinos - the headwaters of the Segama/Danum, Kuamut/Maliau and Imbak River systems. This interior region may prove to be suitable for maintaining a breeding population of rhinos.

Thirdly, a firm decision should be made soon on how to deal with the Silabukan rhino population. It has been suggested that these rhinos should be translocated to the interior of Sabah. This is not recommended for the following reasons:-

i. If the translocation attempt is not entirely success-

ful, then the breeding population may be irreversibly fragmented, thus hastening extinction rather than preventing it.

ii. No part of Sabah has assured long-term safety; rhinos may not stay in the area to which they are translocated; and translocation would attract hunters.

iii. The difficulty and expense involved in catching and translocating rhinos would be great. The cost of catching and translocating one rhino for one year's effort may be of the order of M$300,000.

Given these considerations, the Silabukan area should be the main rhino conservation area. There are currently over 140,000 ha. of lowland and upland dipterocarp forest (mostly logged) in the Silabukan and adjacent Lumerau Forest Reserves, including a central core area of about 25,000 ha. of primary forest. Excisions for agricultural development could reduce the largest continuous tract of forest to 100,000 ha. and logging licence commitments already made would reduce the primary forest core to about 10,000 ha.

Key points in maintaining this area as a conservation area for rhinos would be:-

(1) Keep the maximum continuous forest area as Commercial Forest Reserve; future logging would be managed carefully.

(2) Recognise this area as the most important conservation priority and maximise the guard force against poachers.

(3) Conduct a detailed survey to assess the distribution, size and structure of the current rhino population.

(4) Investigate the use of natural salt sources by rhinos in the Silabukan area and the potential of artificial salt licks in management.

(5) Identify important parts of the Silabukan area and gazette them as Game Sanctuaries or, if appropriate, VJR's.

Plate 9. Mud wallow of a Sumatran rhinoceros (Dicerorhinus sumatrensis) in Silabukan Forest Reserve.

Plate 10. Elephants (Elephas maximus) in the Kretam area of Saban, now being opened up for agricultural development. Shown here are an adult female and young.

TEMBADAU

Problems

1. The best areas for tembadau are being or are expected to be opened up for permanent agriculture. This is eliminating suitable habitat and fragmenting tembadau populations.

2. Tembadau are highly prized for their meat and poaching is a serious threat. They are particularly vulnerable in being attracted to light at night-time. FD(WS) has insufficient manpower to conduct effective anti-poaching patrols.

3. The situation regarding tembadau in areas unsuitable for agriculture is little-known (particularly those in the upper reaches of the major east-coast rivers). It is uncertain if these animals will be sufficient to maintain long-term populations.

4. The potential threat of poisoning from herbicides and insecticides has not been assessed.

Guidelines for a conservation plan

Individual seladang (Bos gaurus), closely related to the tembadau, in West Malaysia live in ranges of thousands of hectares (37), but only a small fraction of this area is used for feeding. Domestic cattle in Sabah can survive on ½ ha. of grassland, so a population of 200 tembadau should be able to exist in a few hundreds of ha. with maintenance of sufficient pasture, permanent water supply, artificial salt licks and shade.

Ideally, managed reserves would be retained in some of the areas where tembadau are still common. Small, managed reserves could be better protected than large areas. Lack of manpower would be a problem if FD(WS) were entirely responsible, but perhaps surmountable if other sections were involved (for example, if the Reserve were part of an agro-forestry project). Constant liaison with organisations developing adjacent land would be beneficial in minimising

poaching and poisoning risks.

The area between the Segama and Kretam Rivers would be a first choice for a Tembadau Reserve, because it supports the greatest numbers of tembadau recorded during the Faunal Survey and is now being opened up rapidly for agriculture. Two other areas worth investigating for their tembadau conservation potential are Kumbaun and the land between the Paitan and Sungai Rivers and Pantai Boring. These areas are unlikely to be developed in the near future due to lack of road access and to soil which limits the number of suitable crops.

ELEPHANT

Problems

1. Over the period 1971-80, an average of 10 elephants were killed annually (range: 4-21) as a result of their destruction of plantations or gardens. In 1981, the rate of agricultural development in suitable elephant habitat (that is, the rate of clearance of logged lowland forest) was more than 120 sq. km. per year. If elephant population density in logged lowland forest is taken to be 0.1 per sq. km, then the equivalent of at least 12 elephants are loosing their homes annually. The best agricultural areas coincide with the highest elephant population densities and it is in these areas that development is proceeding most rapidly. Development is somewhat patchy in distribution, and the population will be fragmented and later forced into isolated pockets of forest, as has happened in Peninsular Malaysia. The major threat to elephants in Sabah is loss of habitat to agriculture.

(2) Whatever the actual population size of elephants in Sabah, it can be stated that at least 50% of the population exists in areas designated for agricultural development. It must be accepted that elephants will have to be removed or eliminated from agricultural areas and, unless there is a major change in

development policy, a massive reduction in elephant population size is likely.

Guidelines for a conservation plan

There have been a number of suggestions on how to cope with the elephant problem in Sabah, mostly involving driving or translocating elephants out of agricultural areas to other places. We do not recommend attempting anything of this sort until the locations of long-term conservation areas have been clarified and there is a good chance that the elephants will stay where they are put.

If land development proceeds according to current plans, there will eventually be two separate areas with potential for elephant conservation: (1) the Silabukan/Lumerau Forest Reserves in the middle of the Dent Peninsula and (2) the main block of Forest Reserve in central Sabah, to the west of the major planned agricultural development. All areas likely to remain forested between these two areas will almost certainly be too small to contemplate long-term conservation.

For elephants to stay in areas where they are now rare or absent, and which are unsuitable for agriculture, it will be necessary to improve the suitability of the habitat for a resident breeding population. If the distribution and abundance of elephants in Sabah is limited, at least partially, by the availability of one or more minerals, then there are considerable implications for conservation and management. Research into this matter is of the highest priority. In the past, the distribution of elephants has undoubtedly been limited also by steep terrain (avoided wherever possible by elephants) and a very sparse, patchy distribution of suitable food plants in the upland and highland dipterocarp forests. Nothing can be done about terrain, but the amount of food plants increases considerably after logging in upland/highland forests. Individual elephants are unlikely to move voluntarily into new habitats immediately after they become available, so driving or translocation will be necessary in some cases.

There are no quick solutions to the elephant problem. Conservation and management activities will have to operate partially on a trial-and-error basis, and over a period of many years. Until the pattern of land use in Sabah has become more or less stable, there will always be some damage to agriculture and the problem of what to do with elephants isolated within agricultural areas will remain.

Key points in a management plan for elephants would be:

1. Adhere to a policy of retaining current Forest Reserves and not permitting agriculture inside, especially in the Silabukan-Lumerau block.
2. Avoid patterns of land development which isolate elephants from the two major long-term conservation areas. Rivers are not a problem, since elephants can swim across even the largest in Sabah.
3. Investigate thoroughly the role of minerals, starting with sodium, in influencing elephant ranging. Initiate and maintain trial artificial salt licks in Forest Reserves.
4. Investigate the feeding ecology of elephants in logged upland-highland dipterocarp forest, their effects on forest regeneration, and how food supply could be improved.

ORANG-UTANS

Problems

1. Orang-utans, although distributed through most areas of the State, have high population densities only in the eastern lowlands and Segama uplands.
2. They are prone to hunting pressures - severe in the western parts of Sabah, much less in eastern areas - which is contributing to the decline in their populations.
3. Logging activities cause considerable decline in

population densities over large areas. Some individuals live in logged forest but others appear to emigrate, presumably eventually dying through lack of food or exclusion by resident orang-utans. Permanent agriculture does not support orang-utans.

4. Both logging and agricultural developments are concentrated in the areas where the greater part of the orang-utan population is found.

Guidelines for a conservation plan

To maintain a viable population of orang-utans, an area of primary forest must be preserved, since this species is intolerant of exploited habitats. An area of high orang-utan density in primary forest is preferred, and the area should also be unsuitable for agriculture to avoid future conflicts of interest. The Danum Valley area, which has been previously recommended as a Game Sanctuary (3) or National Park (38) fits these criteria of selection, although more thorough surveys are needed to estimate the population density in the area. The Danum area may be the last stronghold of the species because adjacent forests have been logged or cultivated.

Mortalities during timber extraction are inevitable, but orang-utan losses could be minimised if animals were given the opportunity to migrate from logging operations. This would be possible if logging activities were directed along a broad front in the same geographical direction to avoid the isolation of patches of forest. An additional possibility is to leave corridors of pristine habitat through which animals can escape to sanctuaries.

In the case of individuals which have already become isolated in patches of forest it may be possible for them to survive on the food resources present if there is no hunting pressure. It is generally considered inadvisable to translocate animals from such isolated areas to other forested areas because of the possibility of introducing diseases or disrupting the ecology of the resident population through overcrowding. Possible exceptions are Sepilok VJR and Tawau Hills National Park. At Sepilok, there is a

small, isolated resident population which contributes relatively little to the species' survival in Sabah but serves as an attraction to the educational centre. Orang-utans have already been introduced into the area, they are provided with extra food and are known to breed with wild individuals. In some cases, it may be preferable to translocate animals to Sepilok rather than let them die. This can only be done, however, if there are manpower resources made available and techniques are perfected for translocation. There is no evidence, to date, of orang-utans in Tawau Hills, indicating that they are probably very rare there. Given the protected status of the area, translocation of orang-utans to Tawau Hills National Park should be considered.

5.4 SUGGESTIONS FOR NEW CONSERVATION AREAS

New conservation areas are proposed here to complement the current National Parks and Forest Reserves, with the aim of providing a complete system for the conservation of the mammals and birds investigated during the Faunal Survey. All would be preserved undisturbed or managed expressly for wildlife conservation. They are the minimum recommended areas, having been chosen so as to avoid conflict with current development plans. We regard protection of the proposed areas as urgent, since development policy decisions made in the early 1980's will affect permanently the survival chances of Sabah's large mammals.

The total extent of the areas suggested for wildlife conservation does not seem unreasonable. Peninsular Malaysia has a human population density of about seven times greater than Sabah's and consequently less land to spare for wildlife. Despite this, it has done better than Sabah in wildlife conservation (Table 17). Whereas Sabah has about 1.4% of its land area currently protected, Peninsular Malaysia has 6%. In this section, we suggest additional areas to be conserved primarily for wildlife,

TABLE 17 A comparison of existing and proposed wildlife conservation areas in Sabah and Peninsular Malaysia

Country	Type of Conservation Area	Total Area (ha.)	% of Land Area
Sabah	Game Sanctuaries	0	0
	National Parks	106,598	1.4
	Proposed Reserves	108,265	1.4
	Total	214,863	2.8
Peninsular Malaysia	Wildlife Reserves and Sanctuaries	874,474	2.6
	National Parks	1,140,000	3.4
	Proposed Reserves and Parks	1,313,036	4.0
	Total	3,327,510	10.0

which would bring the total percentage of Sabah's land area conserved primarily for wildlife to 2.8%. In Peninsular Malaysia, a further 4% of the land has been proposed for wildlife conservation, bringing the total to 10%.

The following conservation areas are proposed (Table 18 and Map 15).

5.4.1. SILABUKAN

Reasons for proposal

(1) Contains the last substantial area of primary lowland and upland dipterocarp forest in eastern Sabah and provides the last chance to conserve a representative portion of these habitats.

(2) Contains the only known breeding population of rhinos in Borneo.

(3) The only area suitable for the long-term conservation of elephants in eastern Sabah.

(4) Contains at least six natural salt sources, believed to be important in maintaining populations of all the large herbivorous mammals.

(5) May be important in maintaining an equable rainfall/water supply to the agricultural areas of the Dent Peninsular.

Suggested Procedure

In the interests of rhino conservation, the largest possible area of remaining primary forest would be set aside. For example, a rhinoceros expert has recommended that an area of about 25,000 ha. should be considered (39). It is recognised, however, that logging commitments have been made already for all but about 10,000 ha., and the following suggestions are made on this basis.

(1) Maintain patrols and increase efforts to prevent rhino poaching.

(2) Retain the present Silabukan and Lumerau Forest

TABLE 18 PROPOSED CONSERVATION AREAS

NAME OF AREA	MAJOR NAMED PHYSICAL FEATURES	APPROX. AREA (HA.)	HABITATS - MAJOR TYPES & % OF TOTAL AREA	HUMAN DISTURBANCE	PRESENT STATUS	PROPOSED STATUS	CONSERVATION VALUE TO THREATENED SPECIES (+)	HABITAT CONSERVATION PRIORITY (+)
SILABUKAN	Tabin and Lumpongan Rivers Mount Hatton (1,873 feet)	10,000 primary forest core in 100,000 logged forest.	50% Lowland 45% Upland 5% Highland throughout	Logging in progress; illegal hunting in some parts.	C, V.J.R.	G.S. and V.J.R., C	10	10
DANUM VALLEY	Ulu Segama, Danum & Beatrice Rivers. Highest peak, Mount Danum (3,385')	42,755	96% primary upland and highland dipterocarp forest incl. some on ultrabasic soils	Logging and hunting around western periphery	C	To be decided	7	10
TANJUNG LINSANG	Kalamba and Kapis Rivers	5,000	100% fresh-water swamp forest, mangrove/ nipah and beach vegetation	Small-scale wood cutting by local poeple	S	G.S.	5	7
KUMAMBU	Kumambu River nearby	510	100% logged lowland dipterocarp forest	Road access permits hunting	V.J.R.	G.S.	4	6
GUNUNG LOTUNG	Maliau River Mount Lotung (5,270')	50,000	67% montane forests; 33% highland dipterocarp forest	None	C	To be decided	0	9

KEY

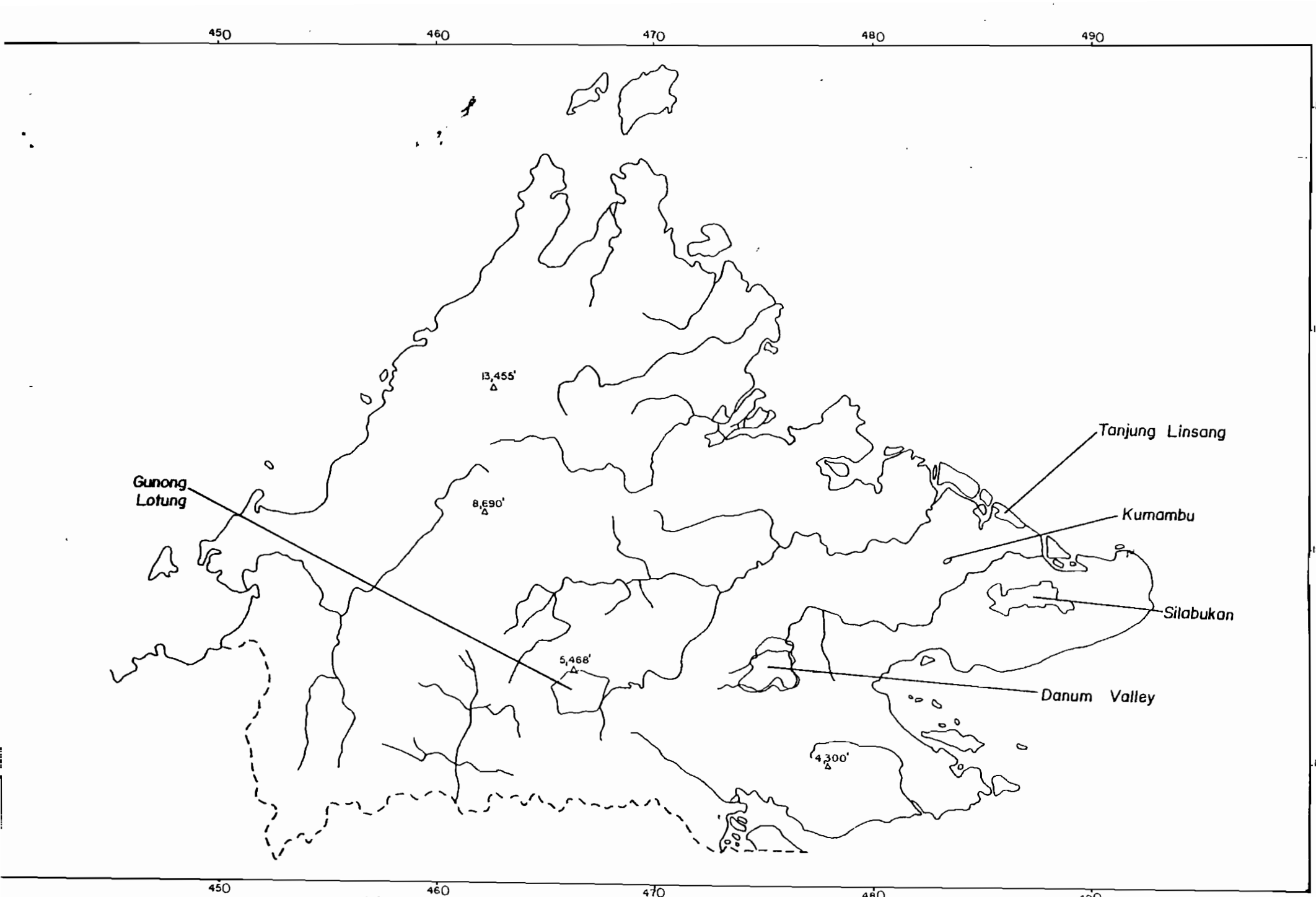
C - Commercial Forest Reserve

G.S. - Game Sanctuary

S - State-land

V.J.R. - Virgin Jungle Reserve

(+) - See Appendix 7 for explanation



MAP 15. PROPOSED CONSERVATION AREAS

Reserves as Commercial Forest Reserve. It is envisaged that a continuous forested area of about 100,000 ha. will remain after planned and likely excisions have been made. This area would be managed on a sustained yield basis for timber production, taking into account the requirements for rhino and elephant conservation.

(3) One or possibly more central core area(s) totalling about 10,000 ha. would be retained under primary forest cover. The primary forest would have the dual purposes of conservation of the lowland dipterocarp forest flora and providing a refuge for rhinos during logging. The exact location of the core area(s) would be decided after botanical surveys and an assessment of the rhino's use of this part of the Silabukan area. The primary forest area(s) would be gazetted as a Game Sanctuary and/or Virgin Jungle Reserve.

(4) There are at least two natural salt sources a few km. to the east of the proposed conservation area on land designated for agricultural development. It is recommended strongly that these salt sources, surrounded by forest, should be added to the conservation area in the interests of both wildlife and agriculture.

(5) Priority field investigations are:-

i) All aspects of the rhino population (Sections 5.3.4. and 5.5.).

ii) Botanical inventories in the area currently under primary forest.

iii) Current and potential use of the entire Silabukan/Lumerau area by elephants.

(6) Draw up a preliminary management plan for the Silabukan area, taking into account the whole forested area and surrounding agriculture. (Main relevant authorities: Forest Department, Sabah Foundation, Agriculture Department).

5.4.2. DANUM VALLEY

Reasons for proposal

(1) The area has been recommended as a Game Sanctuary (3) or National Park (38). More recently, Sabah Forest Department, Sabah National Parks and Sabah Foundation have expressed opinions that Danum Valley should be given some form of protective status.

(2) The unlogged part (42,755 ha.) of the original proposed conservation area (59,685 ha.) contains a diverse flora, including a fine, undisturbed upland valley and an ultrabasic massif.

(3) There is a correspondingly diverse fauna.

(4) The primary forest area can absorb temporarily some of the wildlife (including orang-utans and possibly rhinos) displaced from surrounding logged forest.

(5) The proposed Danum Valley conservation area constitutes a substantial proportion of the Ulu Segama water catchment area; logging will have deleterious effects on the agricultural areas along the Lower Segama.

Suggested Procedures

(1) The 42,755 ha. of unallocated primary forest would form the core of a much larger conservation area - the eastern part of Sabah Foundation's logging concession area. The core would remain undisturbed for the purposes of water, soil, flora and fauna conservation. The entire core area would be surrounded by a "buffer zone" of logged forest within which no hunting or agriculture would be permitted. The minimum width of the buffer zone would be decided after field investigation.

(2) The status of the core area should be decided to the agreement of all relevant parties, but some legislation should ensure against logging the area.

(3) The core area boundary should be marked on the

ground and patrolled to prevent hunting and illegal logging.

(4) Parts of the Ulu Segama area have potential for mineral exploitation; developments in mineral prospecting in the Danum Valley area should be monitored.

(5) The potential of the Danum Valley conservation area as a long-term centre for research into the dipterocarp forest ecosystem should be investigated fully.

(6) Priority field investigations are:-

i) Estimate size of orang-utan population.

ii) Use of the area by rhinos.

iii) Botanical inventories in areas not already covered.

(7) Draw up a preliminary management plan (main relevant authorities: Forest Department, Sabah Foundation).

5.4.3. TANJUNG LINSANG

Reasons for proposal

(1) The area includes mangrove/nipah, beach and freshwater swamp habitat, none of which (excepting 1,090 ha. of mangrove) are given total protection in the current system of conservation areas.

(2) The proposed area is not suitable for conventional agriculture.

(3) It is stated by local hunters that estuarine crocodiles breed within the proposed conservation area. The potential for crocodile farming in Sabah would be served by preserving such breeding areas.

(4) The area contains proboscis monkeys and silvered leaf monkeys. There are also tembadau, payau and marbled cat in the area.

(5) The area has potential for recreation and tourists.

Suggested Procedures

(1) Surveys to: — map habitat types; locate crocodile breeding areas; assess numbers and ranging behaviour of tembadau; assess distribution and numbers of proboscis and silvered leaf monkeys; inventory of other wildlife; assess use of the area by local people.

(2) In consultation with local inhabitants, whose livelihood depends largely on fishing and hunting, draw up the boundary for a suitable conservation area.

(3) Draw up a preliminary management plan for the area (main relevant authorities: Forest Department, Fisheries Department, local community leaders).

5.4.4. KUMAMBU

Reasons for proposal

(1) Conservation of tembadau.

(2) To form a small wildlife reserve in a biologically rich area otherwise designated for agriculture.

Suggested Procedures

(1) Maintain patrols to prevent tembadau poaching. Liaise with organisations developing adjacent areas.

(2) Possible management schemes to be discussed (Forest Department and Department of Veterinary Medicine and Animal Husbandry).

(3) Assess numbers and ranging behaviour of the tembadau population in the Kretam area.

5.4.5. GUNUNG LOTUNG

Reasons for proposal

(1) A huge arc-shaped sandstone ridge, one of Sabah's most spectacular natural features, named Gunung Lotung (the Loris Mountain).

(2) Contains a diverse flora.

(3) The mountain is a major source of water flowing into the Kinabatangan River; disturbance to the forest cover could aggravate greatly the flooding problem experienced in the lower Kinabatangan.

Suggested Procedures

(1) Major expedition to be mounted for inventory of all natural resources in the Gunung Lotung area.

(2) Draw up boundary for area to be totally protected.

5.5. RESEARCH PRIORITIES

Basic knowledge necessary for management of wildlife and conservation areas is lacking. Subjects on which research is most urgently needed include the following:-

Wildlife Management

(1) Ecology of Sumatran rhinoceros in logged forest.

(2) Ecology of elephants in logged forest, especially uplands, and their effects on regeneration.

(3) Ranging behaviour and diet of tembadau in proposed conservation areas.

(4) Use of natural salt sources by large mammals and the potential of artificial salt licks in management.

(5) Translocation methods, especially for rhinoceros and orang-utan.

(6) Ranging behaviour and diet of bearded pigs, and their importance as a food source for rural people.

(7) The biology of deer in regenerating forest and the potential for managed hunting.

(8) Factors limiting cave swiftlet populations.

(9) Factors influencing the rate and quality of dipterocarp forest regeneration after logging.

(10) Means of increasing the carrying capacity of logged forest for rare species.

Conservation Areas

(1) Influence of altitudinal and topographical factors on population densities of mammals.

(2) Inventory of plant and animal species in different habitats and regions.

(3) Thorough survey of the current system of Virgin Jungle Reserves, and identification of omissions in habitats and species.

(4) Investigation of the value of small forest reserves in tree plantations to species conservation and pest control.

APPENDIX I - THE SURVEY SITES

NO:	NAME OF SURVEY AREA	PHYSIO-GRAPHIC REGION	MAP REFERENCE LATITUDE (north)	MAP REFERENCE LONGITUDE (east)	STATUS OF LAND	ALTITUDE (feet)	TOPOGRAPHY (predominant)	HABITAT(s)	TYPE OF SURVEY	NO: OF DAYS	DATES	TRAIL LENGTH (metres)	WEATHER	FRUIT ABUNDANCE
1	Sepilok Virgin Jungle Reserve	SP	5° 50'	117° 57'	V	100 - 300	F - G	LD	E/I	many/ 8	July 1979 - Nov. 1981	2,300	L-3	1
2	Kunkun (Tangkulap (F.R.)	LP	5° 28'	117° 13'	C	200 - 300	G	LD	I	10	28.4.80 - 9.5.80	1,850	F-6 L-5 H-1	2
3	Bole Kecil (Ulu Segama F.R.)	SH	5° 10'	117° 51'	C	300 - 500	G	LD	I	10	29.3.80 - 7.4.80	1,680	F-3 L-3 H-4	1
4	Ulu Tabin (Lumerau F.R.)	DH	5° 11'	118° 43'	C	400 - 500	G	LD	I	7	9.9.81 - 17.9.81	1,680	F-1 L-2 H-3	3
5	Tabin Salt Spring (Silabukan F.R.)	DH	5° 12'	118° 40'	V	400 - 800	G	LD/ UD	I	5	9.3.80 - 13.3.80	2,785	F-4 H-1	2
6	Ulu Telidusan (Sugut F.R.)	KAP	6° 16'	117° 09'	S	500 - 900	S	UD	I	6	6.6.81 - 11.6.81	2,125	F-5 L-1	1
7	Kawag (Ulu Segama F.R.)	SH	5° 01'	117° 56'	C	1,200	G	UD	I E	6 5	27.3.80 - 7.4.80	2,000	F-4 L-2 H-2	1
8	Ulu Sapulut	KH	4° 37'	116° 36'	C	1,400	G	UD	I	9	29.4.81 - 7.5.81	1,500	F-3 L-6 H-1	2
9	Ulu Kiberibi (Ulu Tungud F.R.)	LH	5° 51'	116° 58'	C	1,500	S	UD	I	8	2.6.81 - 10.6.81	1,500	F-2 L-1 H-2	3
10	Samantolang (Ulu Serudong)	KH	4° 23'	117° 02'	C	1,600	S	UD	I	8	10.7.80 - 19.7.80	1,800	F-3 L-2 H-4	2
11	Ulu Losan, Melalap (Crocker Range F.R.)	CRS	5° 17'	115° 58'	P	1,650 - 2,800	S	HD	I	7	28.9.80 - 4.10.80	1,500	F-1 L-3 H-3	2

NO:	NAME OF SURVEY AREA	PHYSIO-GRAPHIC REGION	MAP REFERENCE LATITUDE (north)	MAP REFERENCE LONGITUDE (east)	STATUS OF LAND	ALTITUDE (feet)	TOPOGRAPHY (Predominant)	HABITAT(s)	TYPE OF SURVEY	NO: OF DAYS	D A T E S	TRAIL LENGTH (metres)	WEATHER	FRUIT ABUNDANCE
12	Langui Langui (Templer Extn., Kinabalu N.P.)	CRN	6° 21'	116° 36'	NP	2,500	S	HD	I	6	20.11.79 - 27.11.79	1,450	F-1 L-7 H-2	1
13	Gunung Madalon (Templer Extn., Kinabalu N.P.)	CRN	6° 29'	116° 36'	NP	2,200 - 2,950	S	HD	I	6	20.11.79 - 27.11.79	1,515	L-2 H-4	3
14	Ulu Kimanis (Crocker Range F.R.)	CRS	5° 29'	116° 01'	P	3,500	S	LM	I	8	26. 9.81 - 6.10.81	1,850	F-2 L-1 H-4	1
15	Bukit Ibul (Maligan)	MR	4° 50'	115° 42'	C	3,500 - 4,000	G	LM	I	6	2.5.81 - 7.5.81	1,530	F-1 L-1 H-4	2
16	Ulu Rukuruku (Tawai)	LP	5° 36'	117° 14'	S	250	F - G	K,UB	I	5	5.5.80 - 9.5.80	2,770	F-3 L-2	2
17	Lungmanis Virgin Jungle Reserve	LP	5° 44'	117° 40'	V	100 - 300	F - G	LD	I	6	5.10.79 - 10.10.79	1,500	F-2 L-2	1
18	Gomantong Virgin Jungle Reserve	KLP	5° 31'	118° 04'	V	300	F	LD	I	6	27.10.79 - 2.11.79	2,100	F-3 L-1	1
19	Sungai Langut (Pinangah)	MV	5° 12'	116° 51½'	S	200 - 400	F - G	SC LD	I	5	31.5.80 - 4.6.80	1,570	L-1 H-4	1
20	Malubuk (Kuamut F.R.)	SH	5° 08½'	117° 33'	C	500 - 650	G	LU	I	6	28.7.81 - 6.8.81	1,850	F-4 L-2	3
21	Bakapit (Silabukan)	DH	4° 59½'	118° 41'	C	600 - 700	G	LU	I	7	9.9.81 - 17.9.81	1,675	F-4 L-2 H-3	3
22	Sabah Softwoods (Brumas)	TH	4° 37'	117° 45'	A	750	G	T	I	10	26.6.81 - 6.7.81	1,000	F L-2 H-1	
23	Bal Estates (Merotai)	TH	4° 25'	117° 50'	A	400 (200-) (1,300)	G	C,O	I (E)	7	11-16 & 20.7.80	1,500	F-7	-

NO:	NAME OF SURVEY AREA	PHYSIO-GRAPHIC REGION	MAP REFERENCE LATITUDE (north)	MAP REFERENCE LONGITUDE (east)	STATUS OF LAND	ALTI-TUDE (feet)	TOPOGRAPHY (Predomi-nant)	HABI-TAT(s)	TYPE OF SURVEY	NO: OF DAYS	D A T E S	TRAIL LENGTH (metres)	WEATHER	FRUIT ABUNDANCE
24	Klias Peninsula	KLP	5° 26'	115° 25'	M	0	F	M/N	E	4	17.8.79 - 20.8.79	-	F-2	-
25	Tanjung Linsang (Dewhurst Bay)	ED	5° 38'	119° 38'	S	0	F	B, M/N	E	3	29 & 31.8, 8.9.80	-	F-3	-
26	Tempasuk Plain	CP	6° 24'	116° 23'	BS	0	F	CG	E	1	12.1.81	-	F-1 L-1	-
27	Lower Sugut	SD	6° 12' 6° 40'	117° 18' 117° 43'	S/ C	0 - 100	F	M/N,R LL,F, SC,B	E	9	14.10.81 - 22.10.81	-	F-2 L-5 H-1	-
28	Kretam	ED/ SV	5° 18' 5° 37'	118° 26' 118° 35'	A V	0 - 300	F - G	LL	E	20	27.8-7.9.80; 15-17.11.80; 7-11.3.81	-	-	-
29	Segaliud-Lokan	LP	5° 30' 5° 43'	117° 33' 117° 49'	S	100 - 400	F - G	LL	E	14	12-14.12.79; 28-29.12.79; 24-27. 2.80; 15-29.4.80	-	-	1
30	Mananam Plain and Milian Valley	MP MV	5° 16' 5° 33'	116° 49' 117° 14'	S	100 - 500	G	LL, SC	E	6	29.4.80 - 1.5.80; 22-24.11.80	-	F-3 H-3	-
31	Tabin-Tagas (Silabukan F.R.)	SV/ DH	5° 02' 5° 17'	118° 29 118° 42'	C V	100 - 1,000	F - S	LL,LU LD,HD	E	27	1-8.3.80; 17-20.11.80; 12.12.80; 11-14.4.81; 8-13.4.81	-	-	-
32	Ulu Danum	SH	4° 54'	117° 34'	C	1,500	G	LD	E	2	5-8.8.79	-	-	-
33	Tiulon (Ulu Milian F.R.)	WR	5° 12'	116° 28'	C	1,500 - 2,000	G	UD	E	3	9.10.81	-	F-3 L-3 H-3	2
34	Tawau Hills National Park	TH	4° 22' 4° 31'	117° 47' 118° 04'	NP	300 - 4,300	S	LU,HD LH,UD LL,LM	E	12	26.6.80 - 7.7.80	-	F-4 L-5 H-3	-
35	Crocker Range (Tambunan Area)	CRS	5° 38' 5° 41'	116° 14' 116° 17'	P S	2,000 - 4,500	S	HD,LM SC	E	6	16.10.80 - 21.10.80	-	F-3 L-1 H-2	-

ABBREVIATIONS USED FOR PHYSIOGRAPHIC REGION

CP	Crocker Plains
CRN	Crocker Range (north of Kinabalu)
CRS	Crocker Range (south of Kinabalu)
DH	Dent Hills
ED	Eastern Deltas
KAP	Kaindangan Peneplain
KIL	Kinabatangan Lowlands
KLP	Klias Plain
LH	Labuk Highlands
LP	Lokan Peneplain
MP	MANANAM Plain
MR	Maligan Range
MV	Milian Valley
SD	Sugut Delta
SH	Segama Highlands
SL	Semporna Lowlands
SP	Sandakan Peninsula
SV	Segama Valley
TH	Tawau Highlands
WR	Witti Range

STATUS OF LAND

A	Alienated land
BS	Bird Sanctuary
C	Commercial Forest Reserve
F.R.	Forest Reserve
M	Mangrove Forest Reserve
N.P.	National Park
P	Protection Forest Reserve
S	State Land
V	Virgin Jungle Reserve

TOPOGRAPHY

F	Flat
G	Gentle slopes
S	Steep slopes

HABITATS

B Beach vegetation

C Cocoa plantation

F Freshwater Swamp Forest

HD Highland Dipterocarp Forest

K Kerangas Forest

L Vegetation on limestone

LD Lowland Dipterocarp Forest

LH Logged Highland Dipterocarp Forest

LL Logged Lowland Dipterocarp Forest

LM Lower Montane Forest

LU Logged Upland Dipterocarp Forest

M/N Mangrove/Nipah

O Oil Palm

R Riverine Forest

SC Shifting Cultivation

T Tree plantation

UB Forest on soils derived from ultrabasic rock

UD Upland Dipterocarp Forest

CG Coastal grasses

TYPE OF SURVEY

E Extensive

I Intensive

WEATHER

F Fine (no rain)

L Light rain

H Heavy rain

Numbers refer to number of days

NUMBER OF DAYS

For extensive surveys, refers to total number of days on survey.

For intensive surveys, refers only to numbers of days the intensive survey trail was followed.

TRAIL LENGTH

Length of intensive survey trail.

APPENDIX 2

HABITAT PREFERENCE, LEGAL STATUS AND CONSERVATION STATUS OF SABAH MAMMALS

		PRISTINE HABITATS							EXPLOITED HABITATS						STATUS	
		M/N	R	LD	UD	HD	LM	Other	L	SC	T	C	O	MA	Legal Status	Conservation status
INSECTIVORA																
Erinaceidae																
Moonrat	(Echinosorex gymnurus)			P	-	M			2			1		1		C
Short-tailed Moonrat	(Hylomys suillus)						P	UM								M
Tupaiidae																
Pentail Treeshrew	(Ptiloceros lowii)															I^+
Common Treeshrew	(Tupaia glis)			-	-	-	-		2		2		1			C^+
Mountain Treeshrew	(T. montana)					M	P	UM								M
(Lesser Treeshrew	(T. minor))															S
(	)		-	P	-	-	-		2	2	2	2	1			
(Slender Treeshrew	(T. gracilis))															I^+
Large Treeshrew	(T. tana)			P	-	-	-		2	-	2					C
Smooth-tailed Treeshrew	(Dendrogale melanura)															M
DERMOPTERA																
Cynocephalidae																
Flying Lemur	(Cynocephalus variegatus)			-	-	-			-						P	U
CHIROPTERA																
Pteropodidae																
Large Flying Fox	(Pteropus vampyrus)	-														C^+(H)
PRIMATES																
Lorisidae																
Slow Loris	(Nycticebus coucang)			-	-	-	-		2			2		2	P	U^+

		PRISTINE HABITATS							MAN-MADE HABITATS						STATUS	
		M/N	R	LD	UD	HD	LM	Other	L	SC	T	C	O	MA	Legal Status	Conservation Status
Tarsiidae																
Tarsier	(Tarsius bancanus)			-	-	-			2	2					P	U+
Cercopithecidae																
Grey Leaf Monkey	(Presbytis hosei hosei)			P	P	P	-			-					P	C
Grey Leaf Monkey	(P. h. sabana)			P	P	P			2	-	1				P	C
Red Leaf Monkey	(P. rubicunda rubicunda)			P	P	P	-	UB,K	2			1	1		P	C
Red Leaf Monkey	(P. r. chrysea)			P	P			UB	2		2				P	C
Silvered Leaf Monkey	(P. cristata)	P	P	M	-	-		B	-						P	R
Proboscis Monkey	(Nasalis larvatus)	P	P	M											P	VR
Long-tailed Macaque	(Macaca fascicularis)	P	P	M	M			B	2	2		1	1	1	P	C+
Pig-tailed Macaque	(Macaca nemestrina)			P	P	P	M	UB,K	2	2	1	1	1	1	P	C+
Ponqidae																
Bornean Gibbon	(Hylobates muelleri)			P	P	P	M		2		1				P	C
Orang-utan	(Ponqo pyqmaeus)	M	-	P	P	M	M	UB,K	2		1		1		P	VR
PHOLIDOTA																
Manidae																
Scaly Ant-eater	(Manis javanica)			-	-	-	-					1		2	P	U+
RODENTIA																
Sciuridae																
Giant Squirrel	(Ratufa affinis)			P	P	P	M	UB	2	1						C
Prevost's or Black Squirrel	(Callosciurus prevostii pluto)			P	P	P	M	UB	2	2		1	1	1		C+
Plantain Squirrel	(C. notatus)		P					UB	2	2		2	2	2		S
Black-banded Squirrel	(C. nigrovittatus)			-			-									U

		PRISTINE HABITATS							MAN-MADE HABITATS						STATUS	
		M/N	R	LD	UD	HD	LM	Other	L	SC	T	C	O	MA	Legal Status	Conservation Status
Ear-spot Squirrel	(Callosciurus adamsi)			P	-	-			1							U
Kinabalu Squirrel	(C. baluensis)															M
Horse-tailed Squirrel	(Sundasciurus hippurus)			-	-	-			2	1		1				C
Low's Squirrel	(S. lowii)			P	P	-			2	1						C
Slender Squirrel	(S. tenuis)			?	?	?										I+
(Jentink's Squirrel	(S. jentinki))						P	UM								M
(Brooke's Squirrel	(S. brookei))						P									M
Red-bellied Sculptor Squirrel	(Glyphotes simus)															M
Four-striped Ground Squirrel	(Lariscus hosei)			-	-	-	-									U
Bornean Mountain Ground Squirrel	(Dremomys everetti)															M
Shrew-faced Ground Squirrel	(Rhinosciurus laticaudatus)															I+
Plain Pigmy Squirrel	(Exilisciurus exilis)			P	P			UB	1	1						C
Whitehead's Pigmy Squirrel	(E. whiteheadi)					P	P									M
Tufted Ground Squirrel	(Rheithrosciurus macrotis)			-	-	-				1					P	R
Thomas's Flying Squirrel	(Aeromys thomasi)			-	-	-	-		-							I+
Red Giant Flying Squirrel	(Petaurista petaurista)				-	-			2							C+
Muridae																
Muller's Rat	(R. muelleri)			-	-	-	-									I+
Brown Spiny Rat	(R. rajah)			-												I+
Red Spiny Rat	(R. surifer)			-	-	-	-									I+
Long-tailed Giant Rat	(R. sabanus)			-	-	-	-	UM								I+
Grey Treerat	(Lenothrix canus)			-												I+

		PRISTINE HABITATS							MAN-MADE HABITATS						STATUS	
		M/N	R	LD	UD	HD	LM	Other	L	SC	T	C	O	MA	Legal Status	Conser-vation Status
Histricidae																
Long-tailed Porcupine	(Trichys lipura)			-	-	-										U
Common Porcupine	(Hystrix brachyura)			-	-	-			2	1			1	1		U+
Thick-spined Porcupine	(Thecurus crassispinis)			-	-	-			2							U
CARNIVORA																
Ursidae																
Malaysian Bear	(Helarctos malayanus)			-	-	-	-		2				-		G	R
Mustelidae																
Malaysian Weasel	(Mustela nudipes)			-	-	-										U
Yellow-throated Marten	(Martes flaviqula)			-	-	-			2	-	1					U+
Ferret-Badger	(Melogale orientalis)															M
Teludu	(Mydaus javanensis)			-					2	2	2	1		2		S
Hairy-nosed Otter	(Lutra sumatrana)		-												P	R
Smooth Otter	(L. perspicillata)	-	-	-												I
Small-clawed Otter	(Amblonyx cinerea)			-	-	M		K	2						P	U
Viverridae																
Tangalung or Malay Civet	(Viverra tangalunga)			-	-	-			2							U+
Banded Linsang	(Prionodon linsang)			-	-	-	-		-			-		1	P	U+
Common Palm Civet	(Paradoxurus hermaphroditus)			-					2		1	2		1		S
Masked Palm Civet	(Paguma larvata)			-	-	-	-		2			1				U+
Binturong	(Arctictis binturong)			-	-	-	-		2		1				P	U
Small-toothed Palm Civet	(Arctogalidia trivirgata)			-	-	-	-		2							U
Banded Palm Civet	(Hemigalus derbyanus)			-	-	-			2							U+
Hose's Civet	(H. hosei)						-	UM							P	I
Otter Civet	(Cynogale bennettii)			-											P	I

		PRISTINE HABITATS							MAN-MADE HABITATS						STATUS	
		M/N	R	LD	UD	HD	LM	Other	L	SC	T	C	O	MA	Legal Status	Conservation Status
Herpestidae																
Short-tailed Mongoose	(Herpestes brachyurus)			-	-	-	-		2							U^+
Collared Mongoose	(H. semitorquatus)			-	-				2		2					U^+
Felidae																
Clouded Leopard	(Neofelis nebulosa)	M		-	-	-	-		2		1				P	R
Marbled Cat	(Pelis marmorata)			-	-			B							P	I^+
Flat-headed Cat	(F. planiceps)			-											P	I^+
Leopard Cat	(F. bengalensis)			-					2		2	2	2	2	P	S
Bay Cat	(F. badia)			-											P	I
SIRENIA																
Dugongidae																
Dugong	(Dugong dugon)														P	I
PROBOSCIDEA																
Elephantidae																
Elephant	(Elephas maximus)		M	P	M				2			1	1	1	G	VR
PERISSODACTYLA																
Rhinocerotidae																
Sumatran or two-horned Rhinoceros	(Dicerorhinus sumatrensis)			-	-	-	-		2						P	E
ARTIODACTYLA																
Suidae																
Wild Pig (Bearded Pig)	(Sus barbatus)	M	-	P	P	P	P	K,UB	2	1	1	1	1	1		C(H)

		PRISTINE HABITATS							MAN-MADE HABITATS						STATUS	
		M/N	R	LD	UD	HD	LM	Other	L	SC	T	C	O	MA	Legal Status	Conservation Status
Tragulidae																
Lesser Mouse-deer	(Tragulus javanicus)			-	-	-			2						G	C
Larger Mouse-deer	(T. napu)			-	-	-			2	1					G	C
Barking Deer or Kijang	(Muntiacus muntjak)			-	P	P	-	K,UB	2		1				G	U^+
Sambhur Deer, Payau or Rusa	(Cervus unicolor)			-	-	-	-		2	2	1	1			G	U^+(E)
Bovidae																
Banteng or Tembadau	(Bos javanicus)			-	-	-			2	2					P	V

EXPLANATION OF SYMBOLS

Pristine Habitats

M/N : mangrove/nipah
R : riparian forest
LD : lowland dipterocarp forest
UD : upland dipterocarp forest
HD : highland dipterocarp forest
LM : lower montane forest
B : beach vegetation
K : kerangas forest
UB : forest on soils derived from ultrabasic rock

P : Preferred Habitats, where the species is always found unless absent as a result of hunting or some factor limiting distribution geographically.

M : Marginal Habitats, where the species is found occasionally, either resident at low density or not resident. Such habitats are probably insufficient to ensure the species' survival.

\- : present, but few records, and status in these habitats uncertain.

Exploited Habitats

L : logged dipterocarp forest
SC : shifting cultivation
T : tree plantations
C : cocoa plantations
O : oil palm plantations
MA : mixed permanent agriculture

2 : resident in these habitats and, at least in some cases, breeding.

1 : sometimes enters these habitats to feed, or pass through, but not resident.

- : present, but few records, and status in these habitats uncertain.

Legal Status

P : totally protected by law.
G : game species; may be hunted under licence.

All other species are not afforded any special status.

EXPLANATION OF SYMBOLS USED FOR CONSERVATION STATUS

(Categories E, V, R and I follow I.U.C.N. Survival Service Commission definitions)

E : ENDANGERED

Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating.

V : VULNERABLE

Taxa believed likely to move into the endangered category in the near future if the causal factors continue operating.

R : RARE

Taxa with small world and Sabah populations (either localised or thinly scattered), that are not at present endangered or vulnerable, but are at risk.

VR : VERY RARE

As above, but likely to move into the vulnerable category unless conservation areas are set aside.

I : INDETERMINATE

Insufficient information is available currently, but such taxa are suspected of belonging to one of the first three categories above.

I^+ : INDETERMINATE$^+$

Insufficient information is available currently, but such taxa are not believed to be endangered, vulnerable or rare.

U : UNCOMMON

Widespread within Sabah, but generally occurring at low population densities. Adversely affected by man-made changes in habitat.

U^+ : UNCOMMON$^+$

As above, but adapts to some man-made changes in habitat.

C : COMMON

Widespread within Sabah and locally abundant. Population densities may reach 5 individuals/hectare or more. Adversely affected by man-made changes in habitat, but sufficiently widespread and/or common to maintain viable populations throughout most of the present species range.

C^+ : COMMON$^+$

As above, but adapts to some man-made changes in habitat, although at lower population densities than in primary forest.

S : SECURE

Common, and adapting well to most man-made changes in habitat. Occurring at even higher densities in man-made habitats than in primary forest.

M : MONTANE

Restricted to, or occurring mainly in, montane habitats of northern Borneo, where locally common.

H : HUNTED

Currently common or secure, but hunting pressure is sufficiently intense that continuous monitoring is recommended.

APPENDIX 3 OCCURRENCE OF MAMMALS AT THE INTENSIVE SURVEY SITES

SURVEY AREA	MOONRAT	COMMON TREESHREW	LESSER/SLENDER TREESHREW	LARGE TREESHREW	SLOW LORIS	TARSIER	GREY LEAF MONKEY	RED LEAF MONKEY	LONG-TAILED MACAQUE	PIG-TAILED MACAQUE	GIBBON	ORANG-UTAN	GIANT SQUIRREL	PREVOST'S SQUIRREL	PLANTAIN SQUIRREL	HORSE-TAILED SQUIRREL	LOW'S SQUIRREL	PLAIN PIGMY SQUIRREL	WHITEHEAD'S PIGMY SQ.	TUFTED GROUND SQUIRREL	LONG-TAILED PORCUPINE	COMMON PORCUPINE	THICK-SPINED PORCUPINE	HONEY BEAR	MUSTELIDS	VIVERRIDS	FELIDS	BEARDED PIG	LESSER MOUSEDEER	LARGER MOUSEDEER	KIJANG	PAYAU
SEPILOK V.J.R.	2	0	0	0		0	1	2	1	0	2	2	2	2		0	0	0		1	2			0	M,T,S		F	2	2	2	0	0
KUNKUN	1	0		0			1	2			2	1		2		0	1	2						0	S			2	1	2	1	
BOLE KECIL	2	0	0	0			1	2	1	0	2	2	2	2		0	2	2								C,T,B	C	0		0	2	1
JLU TABIN	0	2	0	0			2	1	1		2	1	0	0	2			0						0	M,W,	A,B,C,Sh		2		0	2	1
TABIN SALT SPRING	2		0				2	1			2			2												V		2	0	0	0	0
JLU TELIDUSAN	0							2		0	2		2	2		0	0	0						0	?S	V		1			2	1
KAWAG			0	0			2	2		0	2	2	1				1	1						0	S			2			2	1
JLU SAPULUT	0		0	0			2		2		2	0	2	1			1	2		1			0		W			1	0	0	2	1
JLU KIBERIBI		0		0				2		0	2		1	1			1	2										1		0	1	1
SAMANTULANG							2	1		0	2		2	1			1	2								V,Sh		0		0	2	
LANGUI LANGUI		0					1			0	1	0	1	1		0			2	1						B		1			1	
JLU LOSAN		0					1				1		2	1					2		0		0		?M	H		1			1	
JLU KIMANIS	0						1				2	0	2	1					2					0				1				
GUNUNG MADALON										0	2		2	2			1		1	1			0			V	C		0		2	
BUKIT IBUL							2	2			2		2						1					0		Sh		1			2	1
LONGMANIS V.J.R.			0	0				1			1	2	1	1	1			2						0				2	1		2	2
SOMANTONG V.J.R.		0	0	0		0	1	1		0	2	2	1	2	1			2								A		0			2	
JLU RUKURUKU	2	0		0				2		0	2	1	1	2	2			2							S			2		0	1	

KEY

0 - present

1 - rare

2 - common

MUSTELIDS

M - Yellow-throated Marten

W - Malay Weasel

T - Teledu

S - Small-clawed Otter

VIVERRIDS

V - Tangalung

C - Common Palm Civet

T - Three-striped Palm Civet

A - Binturong

B - Banded Palm Civet

Sh - Short-tailed Mongoose

Co - Collared Mongoose

H - (?) Hose's Mongoose

SURVEY AREA	MOONRAT	COMMON TREESHREW	LESSER/SLENDER TREESHREW	LARGE TREESHREW	SLOW LORIS	TARSIER	GREY LEAF MONKEY	RED LEAF MONKEY	LONG-TAILED MACAQUE	PIG-TAILED MACAQUE	GIBBON	ORANG-UTAN	GIANT SQUIRREL	PREVOST'S SQUIRREL	PLANTAIN SQUIRREL	HORSE-TAILED SQUIRREL	LOW'S SQUIRREL	PLAIN PIGMY SQUIRREL	WHITEHEAD'S PIGMY SQ.	TUFTED GROUND SQUIRREL	LONG-TAILED PORCUPINE	COMMON PORCUPINE	THICK-SPINED PORCUPINE	HONEY BEAR	MUSTELIDS	VIVERRIDS	FELIDS	BEARDED PIG	LESSER MOUSEDEER	LARGER MOUSEDEER	KIJANG	PAYAU
SUNGAI LANGUT - OLD GARDENS			0			0			2					1	2	0	0	1				0						1		0		
- PRIMARY FOREST							2		0	0	2		2	2		0	0	2		1			0					1	0	0		
MALUBUK	2		2					1			1	1			2	0	0						0	0				2	1	1		1
BAKAPIT	0	0	0	0			1	1		0	2		2	2	0		2	1						0	T,S	B	C	2		0	2	1
SABAH SOFTWOODS		0	0	0			1	1		0	1														M,T	C,Co	L	2			2	1
BAL ESTATES (COCOA)	0		0		2				1	1					2											C	L	1				1

FELIDS

C - Clouded Leopa:

F - Flat-headed C:

L - Leopard Cat

(for explanation of present, rare and common, see Section 3.3.3).

APPENDIX 4 RESIDENT BREEDING BIRDS OF FOREST HABITATS OBSERVED DURING THE FAUNAL SURVEY

SPECIES		HABITATS IN WHICH THE BIRDS WERE OBSERVED DURING THE FAUNAL SURVEY											Legal Status
		PRISTINE							EXPLOITED				
		M	R	LD	UD	HD	LM	Other	L	SC	T	C	
Oriental Darter	(Anhinga melanogaster)	1	1						1				P
Dusky-grey Heron	(Ardea sumatrana)	1	1						1				P
Purple Heron	(Ardea purpurea)	1											P
Storm's Stork	(Ciconia stormi)								1				P
Lesser Adjutant Stork	(Leptoptilos javanicus)	1							1				P
Bat Hawk	(Machaerhamphus alcinus)			1					1				P
Jerdon's Baza	(Aviceda jerdoni)			1					1				P
Brahminy Kite	(Haliastur indus)			1					1				P
Crested Goshawk	(Accipiter trivirgatus)			1									P
Hawk Eagle	(Spizaetus sp.)								1				P
Black Eagle	(Ictinaetus malayensis)								1				P
Grey-headed Fishing Eagle	(Icthyophaga ichthyaetus)	1											P
Crested Serpent Eagle	(Spilornis cheela)			1	1	1	1		1		1		P
White-fronted Falconet	(Microhierax latifrons)								1				P
Scaly-breasted Partridge	(Arborophila charltoni)			1					1	1			P
Crested Woodpartridge	(Rollulus rouloul)			1	1				1				P
Crested Fireback Pheasant	(Lophura ignita)			1	1				1				P
Great Argus Pheasant	(Argusianus argus)			1	1	1	1		1				P
Large Green Pigeon	(Treron capelli)				1				1				
Thick-billed Pigeon	(Treron curvirostra)			1									
Pink-necked Pigeon	(Treron vernans)			1									
Jambu Fruit Dove	(Ptilinopus jambu)								1				
Green Imperial Pigeon	(Ducula aenea)		1	1					1				P

SPECIES		PRISTINE						EXPLOITED				
		M	R	LD	UD	HD	LM	Other	L	SC	T	C	Legal Status
Mountain Imperial Pigeon	(Ducula badia)			1		1	1	K					P
Emerald Dove	(Chalcophaps indica)			1	1	1			1	1		1	P
Long-tailed Parakeet	(Psittacula longicauda)	1	1	1					1				P
Blue-rumped Parrot	(Psittinus cyanurus)			1									
Malayan Lorikeet	(Loriculus galgulus)				1	1		UB		1			P
Hawk Cuckoos	(Cuculus Spp.)			1					1				
Indian Cuckoo	(Cuculus micropterus)			1	1								
Banded Bay Cuckoo	(Cacomantis sonneratii)			1									
Plaintive Cuckoo	(Cacomantis merulinus)			1	1	1		UB	1		1		
Violet Cuckoo	(Chrysococcyx xanthorhynchus)								1				
Drongo Cuckoo	(Surniculus lugubris)			1	1				1		1		
Raffles' Malcoha	(Phaenicophaeus chlorophaeus)			1	1				1	1	1	1	
Black-bellied Malcoha	(Phaenicophaeus diardi)				1								
Red-billed Malcoha	(Phaenicophaeus javanicus)			1					1		1		
Chestnut-breasted Malcoha	(Phaenicophaeus curvirostris)			1	1	1			1	1	1	1	
Common Coucal	(Centropus sinensis)							UB	1			1	
Short-toed Coucal	(Centropus rectunquis)			1	1				1		1		
Bay Owl	(Phodilus badius)			1									P
? Mountain Scops Owl	(Otus spilocephalus)						1						P
Collared Scops Owl	(Otus bakkamoena)									1		1	P
Brown Hawk-owl	(Ninox scutulata)									1			P
Malaysian Eared Nighjar	(Eurostopodus temminckii)				1	1	1			1			
Whiskered Tree-swift	(Hemiprocne comata)			1					1				
Crested Tree-swift	(Hemiprocne longipennis)	1							1				
Diard's Trogon	(Harpactes diardii)			1	1	1			1				
Red-naped Trogon	(Harpactes kasumba)			1	1	1	1			1		1	

SPECIES		PRISTINE						EXPLOITED				
		M	R	LD	UD	HD	LM	Other	L	SC	T	C	Legal Status
Scarlet-rumped Trogon	(Harpactes duvaucelii)			1	1	1					1		
Cinnamon-rumped Trogon	(Harpactes orrophaeus)			1	1		1		1				
Orange-breasted Trogon	(Harpactes oreskios)						1						
Banded Kingfisher	(Lacedo pulchella)			1	1								
Chestnut-collared Kingfisher	(Halcyon concreta)			1	1								
Stork-billed Kingfisher	(Pelargopsis capensis)	1	1										
Blue-banded Kingfisher	(Alcedo euryzona)			1	1	1			1	1			
Rufous-backed Kingfisher	(Ceyx rufidorsus)			1					1	1			
Red-bearded Bee-eater	(Nyctyornis amictus)			1	1	1			1	1			
Dollar Bird	(Eurystomus orientalis)								1				
White-crested Hornbill	(Berenicornis comatus)			1	1	1			1	1			P
Bushy-crested Hornbill	(Anorrhinus galeritus)			1	1	1	1		1	1	1		P
Wrinkled Hornbill	(Rhyticeros corrugatus)			1					1				P
Wreathed Hornbill	(Rhyticeros undulatus)			1	1	1	1		1				P
Black Hornbill	(Anthracoceros malayanus)			1	1			UB	1	1			P
Pied Hornbill	(Anthracoceros coronatus)	1	1										P
Rhinoceros Hornbill	(Buceros rhinoceros)			1	1	1	1		1		1		P
Helmeted Hornbill	(Rhinoplax vigil)			1	1	1	1		1				P
Brown Barbet	(Calorhamphus fuliginosus)			1									
Gold-whikered Barbet	(Megalaima chrysopogon)			1		1			1	1			
Many-coloured Barbet	(Megalaima rafflesii)			1					1				
Gandy Barbet	(Megalaima mystacophanos)			1	1					1			
Yellow-crowned Barbet	(Megalaima henricii)			1	1	1	1			1			
Golden-naped Barbet	(Megalaima pulcherrima)				1		1						
Mountain Barbet	(Megalaima monticola)						1						
Black-throated Barbet	(Megalaima eximia)						1						

SPECIES		PRISTINE						EXPLOITED				Legal Status
		M	R	LD	UD	HD	LM	Other	L	SC	T	C	
Little Barbet	(Megalaima australis)			1	1	1	1		1	1			
Rufous Piculet	(Sasia abnormis)			1	1				1		1	1	
Speckled Piculet	(Picumnus innominatus)			1									
Crimson-winged Woodpecker	(Picus puniceus)			1	1	1	1		1		1		
Chequer-throated Woodpecker	(Picus mentalis)			1	1	1	1						
Banded Woodpecker	(Picus miniaceus)			1									
Rufous Woodpecker	(Micropternus brachyurus)				1				1				
Grey-capped Woodpecker	(Picoides canicapillus)								1				
Buff-necked Woodpecker	(Meiglyptes tukki)			1	1	1			1		1		
Grey-and-Buff Woodpecker	(Hemicercus concretus)				1								
Olive-backed Woodpecker	(Dinopium rafflesi)			1					1	1			
Great Black Woodpecker	(Dryocopus javensis)			1	1				1	1			
Great Slaty Woodpecker	(Muelleripicus pulverulentus)			1		1		K,UB	1	1			
Maroon Woodpecker	(Blythipicus rubiginosus)			1	1			K			1		
Crimson-backed Woodpecker	(Chrysocolaptes lucidus)			1									
Orange-backed Woodpecker	(Chrysocolaptes validus)			1									
Green Broadbill	(Calyptomena viridis)			1	1	1	1		1	1			
Long-tailed Broadbill	(Psarisomus dalhousiae)						1						
Black-and-red Broadbill	(Cymbirhynchus macrorhynchus)			1			1		1	1		1	
Black-and-yellow Broadbill	(Eurylaimus ochromalus)			1		1	1		1	1	1	1	
Banded Broadbill	(Eurylaimus javanicus)			1	1						1		
Dusky Broadbill	(Corydon sumatranus)			1							1		
Giant Pitta	(Pitta caerulata)			1									
Blue-banded Pitta	(Pitta arquata)				1	1							
Garnet Pitta	(Pitta granatina)			1	1				1	1	1		P
Blue-headed Pitta	(Pitta baudi)			1	1				1				P

SPECIES		PRISTINE						EXPLOITED				Legal Status
		M	R	LD	UD	HD	LM	Other	L	SC	T	C	
Banded Pitta	(Pitta guajana)			1	1	1	1		1				P
Hooded Pitta	(Pitta sordida)										1		P
Bar-bellied Cuckoo-shrike	(Coracina striata)			1	1								
Lesser Cuckoo-shrike	(Coracina fimbriata)			1	1	1			1	1			
Pied Triller	(Lalage nigra)								1				
Fiery Minivet	(Pericrocotus igneus)			1					1		1		
Scarlet Minivet	(Pericrocotus flammeus)						1		1				
Green Iora	(Aegithina viridissima)								1			1	
Common Iora	(Aegithina tiphia)					1			1	1			
Lesser Green Leafbird	(Chloropsis cyanopogon)			1	1				1	1	1		
Greater Green Leafbird	(Chloropsis sonnerati)			1	1	1	1	UB	1		1		
Blue-winged Leafbird	(Chloropsis cochinchinensis)						1						
Asian Fairy Bluebird	(Irena puella)			1	1				1		1		
Puff-backed Bulbul	(Pycnonotus eutilotus)								1	1			
Black-and-white Bulbul	(Pycnonotus melanoleucos)				1				1	1			
Black-headed Bulbul	(Pycnonotus atriceps)			1	1			K	1		1		
Scaly-breasted Bulbul	(Pycnonotus squamatus)								1				
Grey-bellied Bulbul	(Pycnonotus cyaniventris)				1								
Straw-headed Bulbul	(Pycnonotus zeylanicus)								1	1			
Olive-winged Bulbul	(Pycnonotus plumosus)				1				1				
Red-eyed Bulbul	(Pycnonotus brunneus)			1					1	1	1	1	
Spectacled Bulbul	(Pycnonotus erythropthalmos)			1					1				
Grey-cheeked Bulbul	(Criniger bres)			1	1				1				
Ochraceous Bulbul	(Criniger ochraceus)				1	1	1						
Yellow-bellied Bulbul	(Criniger phaeocephalus)			1	1	1		K	1				
Hairy-backed Bulbul	(Hyosipetes criniger)			1					1				

SPECIES		PRISTINE						EXPLOITED				Legal Status
		M	R	LD	UD	HD	LM	Other	L	SC	T	C	
Streaked Bulbul	(Hypsipetes malaccensis)			1		1			1	1			
Ashy Bulbul	(Hypsipetes flavala)					1	1						
Rufous-tailed Shama	(Copsychus pyrropyga)			1	1	1			1				
Magpie Robin	(Copsychus saularis)							B					
White-rumped/White-crowned Shama	(Copsychus malabaricus)			1	1			UB	1	1	1		P
White-crowned Forktail	(Enicurus leschenaulti)			1	1	1			1				P
Chestnut-naped Forktail	(Enicurus ruficapillus)			1	1	1			1	1			
Chestnut-capped Thrush	(Zoothera interpres)								1				P
Black-capped Babbler	(Pellorneum capistratum)			1	1	1			1	1	1		
Short-tailed Babbler	(Trichastoma malaccense)			1	1	1			1	1			
White-chested Babbler	(Trichastoma rostratum)			1	1					1			
Ferruginous Babbler	(Trichastoma bicolor)			1	1				1	1			
Horsfield's Babbler	(Trichastoma sepiarium)			1	1				1		1		
Abbott's Babbler	(Trichastoma abbotti)								1				
Rufous-crowned Babbler	(Malacopteron magnum)			1	1	1			1	1	1		
Scaly-crowned Babbler	(Malacopteron cinereum)			1	1	1	1		1	1			
Moustached Babbler	(Malacopteron magnirostre)			1	1								
Plain Babbler	(Malacopteron affine)			1	1	1	1		1				
White-throated Babbler	(Malacopteron albogulare)			1				K					
Chestnut-backed Scimitar Babbler	(Pomatorhinus montanus)			1	1	1	1		1				
Bornean Wren-babbler	(Ptilocihla leucogrammica)			1									
Striped Wren-babbler	(Kenopia striata)			1	1	1	1		1				
Black-throated Wren-babbler	(Napothera atrigularis)			1	1		1	K	1				
Mountain Wren-babbler	(Napothera crassa)				1		1						
Small Wren-babbler	(Napothera epilepidota)				1	1							
Striped Tit-babbler	(Macronous gularis)			1	1			UB	1		1	1	

SPECIES		PRISTINE						EXPLOITED				Legal Status
		M	R	LD	UD	HD	LM	Other	L	SC	T	C	
Fluffy-backed Tit-babbler	(Macronous ptilosus)			1	1	1			1	1	1		
Grey-throated Babbler	(Stachyris nigriceps)				1		1						
Grey-headed Babbler	(Stachyris poliocephala)			1	1	1			1		1		
Black-throated Babbler	(Stachyris nigricollis)			1						1			
White-necked Babbler	(Stachyris leucotis)				1	1			1				
Chestnut-rumped Babbler	(Stachyris maculata)			1	1	1			1		1		
Chestnut-winged Babbler	(Stachyris erythroptera)			1	1	1		K,UB	1	1	1	1	
Rufous-fronted Babbler	(Stachyris rufifrons)								1				
Grey-and-brown Laughing-thrush	(Garrulax palliatus)						1						
Chestnut-capped Laughing-thrush	(Garrulax mitratus)						1						
Brown Fulvetta	(Alcippe brunneicauda)					1							
Chestnut-crested Babbler	(Yuhina everetti)						1		1				
White-bellied Yuhina	(Yuhina zantholeuca)					1	1		1			1	
Flyeater	(Gerygone sulphurea)					1			1				
Yellow-breasted Warbler	(Seicercus montis)						1						
Yellow-bellied Warbler	(Abroscopus superciliaris)					1	1	UB					
Black-necked Tailorbird	(Orthotomus atrogularis)			1	1				1				
Red-tailed Tailorbird	(Orthotomus sericeus)								1	1	1	1	
Red-headed Tailorbird	(Orthotomus ruficeps)					1			1	1	1	1	
White-throated Fantail	(Rhipidura albicollis)						1						
Spotted Fantail	(Rhipidura perlata)			1	1	1	1	K	1	1			
Grey-headed Flycatcher	(Culicicapa ceylonensis)			1	1	1	1		1		1		
Verditer Flycatcher	(Muscicapa thalassina)			1					1				
Pale Blue Flycatcher	(Cyornis unicolor)			1									
Malaysian Blue Flycatcher	(Cyornis turcosa)			1		1			1	1	1		
Large-billed Blue Flycatcher	(Cyornis caerulata)			1	1								

SPECIES		PRISTINE						EXPLOITED				Legal Status
		M	R	LD	UD	HD	LM	Other	L	SC	T	C	
Hill Blue Flycatcher	(Cyornis banyumas)								1				
Bornean Blue Flycatcher	(Cyornis superba)			1	1		1		1				
Rufous-chested Flycatcher	(Ficedula dumetoria)			1	1				1				
Pigmy Blue Flycatcher	(Muscicapella hodgsoni)				1		1						
White-throated Jungle Flycatcher	(Rhinomyias umbratilis)			1	1	1	1	K	1				
Rufous-winged Jungle Flycatcher	(Philentoma pyrhopterum)			1	1	1			1	1			
Maroon-breasted Flycatcher	(Philentoma velatum)				1	1							
Black-naped Monarch	(Hypothymis azurea)			1	1	1	1		1		1	1	
Paradise Flycatcher	(Tersiphone paradisi)			1	1	1			1		1		?
Velvet-fronted Nuthatch	(Sitta frontalis)			1	1	1	1				1		
Scarlet-breasted Flowerpecker	(Prionochilus thoracicus)			1	1			UB					
Yellow-rumped Flowerpecker	(Prionochilus xanthopygius)								1				
Yellow-breasted Flowerpecker	(Prionochilus maculatus)			1	1	1			1	1			
Yellow-vented Flowerpecker	(Dicaeum chrysorrheum)				1				1				
Plain Flowerpecker	(Dicaeum concolor)								1				
Orange-bellied Flowerpecker	(Dicaeum trigonostigma)			1	1						1	1	
Plain Sunbird	(Anthreptes simplex)								1				
Brown-throated Sunbird	(Anthreptes malacensis)			1								1	
Red-throated Sunbird	(Anthreptes rhodolaema)			1		1			1				
Ruby-cheeked Sunbird	(Anthreptes singalensis)			1	1						1		
Purple-naped Sunbird	(Hypogramma hypogrammicum)			1	1	1		UB	1		1	1	
Crimson Sunbird	(Aethopyga siparaja)			1		1							
Scarlet Sunbird	(Aethopyga mystacalis)												
Little Spiderhunter	(Arachnothera longirostra)			1	1	1	1	K	1	1	1	1	
Thick-billed Spiderhunter	(Arachnothera crassirostris)			1	1								
Long-billed Spiderhunter	(Arachnothera robusta)			1	1	1			1		1		

SPECIES		PRISTINE						EXPLOITED				Legal Status
		M	R	LD	UD	HD	LM	Other	L	SC	T	C	
Spectacled Spiderhunter	(Arachnothera flaviqaster)				1				1				
Yellow-eared Spiderhunter	(Arachnothera chrysogenys)								1		1		
Grey-breasted Spiderhunter	(Arachnothera affinis)			1	1	1			1				
Pigmy White-eye	(Oculicincta squamifrons)					1	1						
Hill Myna	(Gracula religiosa)	1		1	1				1		1	1	P
Bornean Bristle-head	(Pityriasis gymnocephala)			1									P
Bronzed Drongo	(Dicrurus aeneus)			1	1	1	1		1	1			
Grey Drongo	(Dicrurus leucophaeus)						1						
Greater Racket-tailed Drongo	(Dicrurus paradiseus)			1	1	1			1	1	1		
Dark-throated Oriole	(Oriolus xanthonotus)			1		1	1		1		1		
Black-and-crimson Oriole	(Oriolus cruentus)						1						
Crested Jay	(Platylophus galericulatus)			1	1	1	1		1	1	1		
Malaysian Treepie	(Dendrocitta occipitalis)						1						
Black Magpie	(Platysmurus leucopterus)			1	1				1				
Crow	(Corvus Sp.)			1					1	1		1	

Names and order follow Smythies (1981)

Key to habitats:

B Beach Vegetation
M Mangrove/nipah
R Riparian (riverine)
LD Lowland Dipterocarp Forest
UD Upland Dipterocarp Forest
HD Highland Diperocarp Forest
LM Lower Montane Forest
K Kerangas (Heath) Forest
UB Forest on ultrabasic-derived soils
L Logged Dipterocarp Forest
SC Shifting Cultivation
T Tree plantation
C Mature cocoa plantation

Legal Status:

P - Protected. A license must be obtained from a Game Warden before these birds may be caught, hunted etc.
Other birds are not similary protected.

APPENDIX 5

RESIDENT BREEDING BIRDS IDENTIFIED ONLY IN NON-FOREST HABITATS ON SURVEYS

Large Egret	(Egretta alba)
Reef Egret	(Egretta sacra)
Blue-breasted Quail	(Coturnix chinensis)
Slaty-breasted Rail	(Rallus striatus)
White-breasted Waterhen	(Amaurornis phoenicurus)
Common Moorehen	(Gallinula chloropus)
Little Green Pigeon	(Treron olax)
Spotted Dove	(Streptopelia chinensis)
Lesser Coucal	(Centropus bengalensis)
Buffy Fish Owl	(Ketupa ketupa)
White-collared Kingfisher	(Halcyon chloris)
White-breasted Wood-swallow	(Artamus leucorhynchus)
Yellow-vented Bulbul	(Pycnonotus goiavier)
Yellow-bellied Wren-warbler	(Prinia flaviventris)
Pied Fantail	(Rhipidura javanica)
Crimson-breasted Flowerpecker	(Prionochilus percussus)
Scarlet-backed Flowerpecker	(Dicaeum cruentatum)
Philippine Glossy Starling	(Aplonis panayensis)
Dusky Munia	(Lonchura fuscans)
White-bellied Munia	(Lonchura leucogastra)
Chestnut Munia	(Lonchura malacca)

(Swifts, Apodidae and Swallows, Hirundinidae, omitted).

APPENDIX 6

NON-RESIDENT BIRDS IDENTIFIED DURING THE FAUNAL SURVEY

Intermediate Egret	(*Egretta intermedia*)
Cattle Egret	(*Bubulcus ibis*)
Plover	(*Charadrius* Sp.)
Common Sandpiper	(*Actitis hypoleucos*)
Common Kingfisher	(*Alcedo atthis*)
Black-capped Kingfisher	(*Halcyon pileata*)
Blue-throated Bee-eater	(*Merops viridis*)
White Wagtail	(*Motacilla alba*)
Yellow Wagtail	(*Motacilla flava*)
Siberian Blue Robin	(*Erithacus cyane*)
Sooty Flycatcher	(*Muscicapa sibirica*)
Blue-and-white Flycatcher	(*Cyanoptila cyanomelana*)
Mugimaki Flycatcher	(*Ficedula mugimaki*)

APPENDIX 7 - VALUE OF EXISTING AND PROPOSED CONSERVATION AREAS IN TERMS OF MAJOR CONSERVATION ATTRIBUTES

	EXISTING CONSERVATION AREAS				PROPOSED CONSERVATION AREAS				
CONSERVATION ATTRIBUTE	SEPILOK V.J.R.	CROCKER RANGE F.R.	KINABALU N.P.	TAWAU HILLS N.P.	SILABUKAN	DANUM VALLEY	TANJUNG LINSANG	KUMAMBU	GUNUNG LOTUNG
RHINOCEROS					3	2			
TEMBADAU					2	1	2	3	
ELEPHANT					3	1			
ORANG-UTAN	2	1	1		2	3		1	
ESTUARINE CROCODILE							3		
FAUNA: SUB-TOTAL	2	1	1		10	7	5	4	?
"UNIQUENESS"	3	2	3	1	3	2	2	2	2
SIZE	2	3	3	3	3	3	2	1	3
PLANT GENE POOL	2	2	2	2	2	2	1	1	2
WATERSHED PROTECTION		1	1	1		1			1
SOCIO-ECONOMIC POTENTIAL	2	2	2	1	2	2	2	2	1
HABITAT: SUB-TOTAL	9	10	11	8	10	10	7	6	9
TOTAL SCORE	11	11	12	8	20	17	12	10	9

Explanation of Table

The relative importance of each major existing and proposed conservation area on mainland Sabah is assessed by assigning a numerical value to features, or attributes, considered most important in a system of conservation areas for Sabah's wildlife. Five large animal species are considered and five other aspects of conservation importance.

Fauna (rhinoceros, tembadau, elephant, orang-utan, estuarine crocodile)

3 = very important for conservation of the species.

2 = with high potential to contribute to conservation of the species.

1 = believed to be of limited value.

"Uniqueness": 3 = area has at least one outstanding feature not represented elsewhere (Sepilok - Orang-utan and Conservation Education Centres; forest research.
Kinabalu - the mountain and its endemic species.
Silabukan - the last substantial area of eastern lowland dipterocarp forest with full complement of fauna).

2 = not unique, but with one or more rare features.

1 = no special features.

Size: 3 = expected to remain part of a continuous forested area of at least 80,000 ha.

2 = 2,000 - 80,000 ha.

1 = less than 2,000 ha.

Plant Gene Pool: 2 = rich (assessed on species diversity and size of the area).

1 = poor.

Watershed Protection:

1 = the area should be protected for its importance as a watershed; logging could be highly deleterious to development downstream.

Soci-economic Potential:

(recreation for local people; tourism; agro-forestry; applied research; student field work and education; economic benefits, e.g. fisheries).

2 = high potential for at least three of the benefits listed.

1 = potential for less than three of the benefits.

APPENDIX 8

SABAH NAMES FOR COMMONLY-KNOWN MAMMALS

LATIN AND ENGLISH NAMES	MALAY	MURUT TAGAL	MURUT SAPULUT	LUNDAYAH	TAMBUNAN KADAZAN	TAMPARULI KADAZAN	RANAU KADAZAN	ULU KINABATANGAN (TONGUD)	ORANG SUNGEI SUGUT	SULUK
Echinosorex gymnurus MOONRAT	TIKUS BULAN	SIMPUN					TAMPARULIK	TETOU	TATAU	
Cynocephalus variegatus FLYING LEMUR	KUBONG		OPUYUT	KUBUNG		TAGAUT, TAGAWAT	TANGAH	LANGAH		
Manis javanica PANGOLIN	TENGGILING		BUKKUH	AREAM	TENGGILING	BULUKON	BOHUKON	BOLUKUN		TANGGILING
Tupaia spp TREE SHREW	TUPAI MUNCONG	MOWOU		TOKILONGUN		TANTAD-BURUI	LONGKIHAI TANTABURUI	TANGKIS		
Nycticebus coucang SLOW LORIS	KONGKANG	LOTUNG	LOTUNG	FUGAH		TANDUYU-TONG	TONDEIYU-TONG	INDUYUTONG	IMPAYUTUNG	
Tarsius bancanus TARSIER	KERA HANTU	SIMPELILI	SIMPELILI	IKAU		TINDOKUT-RUKUT	RUKUT	SIRUKUT-RUKUT	RINUKUT	
Macaca fascicularis LONG-TAILED MACAQUE	KERA	KALA		TOKOYON, KUYAD		KERA	KARA	KARA	KARA	AMUK
Macaca nemestrina PIG-TAILED MACAQUE	BEROK	BASUK		BEDCUK		GEBUK	GOBUK	GEBUK	GEBUK	AMBUK
Presbytis hosei GREY LEAF MONKEY	LUTUNG	MONOSOP, PENDULAU	TOHOROH	BERANGA		MONOSOP	MONOSOP	SAMPONG, WANGAN	TAGAROG	
Presbytis rubicunda RED LEAF MONKEY	LUTUNG	KULASI	KULASI	KELASI		MARAGANG	MARAGANG	MARAGANG	KULASI	
Presbytis cristata SILVERED LEAF MONKEY	LUTUNG							SINGKAK	SINGKAK	SINGKAK
Nasalis larvatus PROBOSCIS MONKEY	LUTUNG BANGKATAN		BAKALO	BEKALEH		RUNGUYUN	SIKUK	BANGKATAN, BILADAN	BAKARA	BAKARA
Hylobates muelleri GIBBON	WAKWAK	TABILIG, KALAWAT	KALAWAT	KELABAT		KALAWAT	KALAWAT	KALAWAT	KALAWAT	KALAWAT
Pongo pygmaeus ORANGUTAN	ORANGUTAN	KAHUI	KAHUI	MAYAS		KOGIU	KOGIU	KOGIU	KOGIU	OLANGUTAN
Thecurus crassispinis THICK-SPINED PORCUPINE	LANDAK	KAROMOK	KARUI	TERUTONG		BOUTUN	BUTUN	UTUN	UTUN	LANDAK
Hystrix brachyura COMMON PORCUPINE	LANDAK	KARAMOK	KARUI	TERUTONG			BUTUN	UTUN	UTUN	LANDAK
Trichys lipura LONG-TAILED PORCUPINE	LANDAK	LITIS		AFAN		LISIS	LISIS	LISIS	BEBAS	LANDAK

LATIN AND ENGLISH NAMES	MALAY	MURUT TAGAL	MURUT SAPULUT	LUNDAYAH	TAMBUNAN KADAZAN	TAMPARULI KADAZAN	RANAU KADAZAN	ULU KINABATANGAH (TONGUD)	ORANG SUNGEI SUGUT	SULUK
Petaurista petaurista RED GIANT FLYING SQUIRREL	TUPAI TERBANG				TAGAWAT		TAGAUT	SUNGKOG		
FLYING SQUIRRELS (medium sized)	TUPAI TERBANG							LANGA		
FLYING SQUIRRELS (small sized)	TUPAI TERBANG							TOMPIN		
Exilisciurus spp PIGMY SQUIRRELS	TUPAI KERICEK	KAITAN			BELIAI	MONTOK		TIGI		
Small Sundasciurus spp LITTLE SQUIRRELS	TUPAI				MONTOK		TOMPIN	TANGKIS		
Sundasciurus hippurus HORSE-TAILED SQUIRREL	TUPAI						MONGGO-LOTON	TANTAG		
Small Callosciurus spp BANDED SQUIRRELS	TUPAI			LABO		BASING	BASING	BASING		BASING
Callosciurus prevostii BLACK SQUIRREL	TUPAI GADING	SALOM		LABOITOM	MONGGO-LUTON	MONGGO-LUTON	SAMPUAN	SAPUAN		
Ratufa affinis GIANT SQUIRREL	TUPAI KERAWAK	MANGGAS	MANGGAS	SIGAR	MANGGAS	MANGGAS	MANGGAS	MANGGAS		
Lariscus spp STRIPED GROUND SQUIRREL	TUPAI					KONGKOTUNG	MONTOGOK	MONTOK		
Rheithrosciurus macrotis TUFTED GROUND SQUIRREL		YAMU			BAABU		BABUT	YAYAMU		
Rattus spp RATS	TIKUS	TALAU					many names			AMBAU
Helarctos malayanus HONEY BEAR	BERUANG	BAWANG	BAWANG	BERUANG		BOUVANG	BORUWANG	BAWANG	BELWOT	BELUANG
Martes flaviqula YELLOW-THROATED MARTEN	PULUSAN	KAKAA			TONI			KAKAA		
Melogale orientalis FERRET BADGER	PULUSAN LAMRI	SIMBONG				SIMBONG	SIMBONG			
Mydaus javanensis MALAY BADGER	TELUDU	TURU	TURU	SUDU			TUDU	BILUD	TUDU	SADUI
Amblonyx cinerea and Lutra spp OTTERS	MEMERANG		TIRUNG	DANGEN	BONGOL		BONGOL	RONGON		DONGOL

LATIN AND ENGLISH NAMES	MALAY	MURUT TAGAL	MURUT SAPULUT	LUNDAYAH	TAMBUNAN KADAZAN	TAMPARULI KADAZAN	RANAU KADAZAN	ULU KINABATANGAH (TONGUD)	ORANG SUNGEI SUGUT	SULUK
Viverra tangalunga TANGALUNG CIVET	TANGALUNG						TINGURUN-URUN	SINGURUT-GURUT	TINGGALONG	TINGGALONG
Paradoxurus hermaphrodibus COMMON CIVET	MUSANG	BUSAN			MIHAUN		OMUNIN	MUNIN		MUSANG
Paguma larvata MASKED CIVET	MUSANG						MANGULOK	PARAGASU		
Arctogalidia trivirgata THREE-STRIPED CIVET	MUSANG	BINANGKI			KIRABAS		KILABAS	TANTAG		
Arctictis binturong BINTURONG	BINTURONG	MALONGKONG		FAYUH	PASUI	PASIU	PASIU	PASIU	PASUI	
Hemigalus derbyanus BANDED CIVET	MUSANG				LAGOI	TINTUKAD-TUKAD	TINTUKAD-TUKAD	SINTUKAD-TUKAD		
Herpestes spp MONGOOSES	BAMBUN						TULOK	BUDUT-LAPAD		
Neofelis nebulosa CLOUDED LEOPARD	HARIMAU DAHAN	KUIR	TANTANINON	KUIR			TANGANG-ANSAD	INANASAD, MONDOU	NANANSAD, MONDOU	HARIMAU
Felis spp WILD CATS	KUCING HUTAN	TUBANG			TAMPU, TALOM		TOMPU	OMPU		
Elephas maximus ELEPHANT	GAJAH	GAJAH	KIMMAYOK	GAJAH		GAJAH	GAJAH	GADINGAN	GADINGAN	GAJAH
Dicerorhinus sumatrensis RHINOCEROS	BADAK	TAMBAYU-NGAN, KEMANCUR	TAMBAYU-NGAN	TEMADCUR		BADAK	BADAK	TAMPAK	LONGOUN	BADAK
Sus barbatus BEARDED PIG	BABI HUTAN	ULAK	ASIH	BAKAA		BAKAS	BAKAS	KULUS	BAKAS	BAVUI
Tragulus napu LARGE MOUSEDEER	NAPUH	PELANUOK, PERUAN	PELANDOK	PELANWAK, PALANUK	TIMBALABUG	PALANUK	PALANUK	PALANAK BALABUG	PELANUK TIMBANG	PILANDUK
Tragulus javanicus SMALL MOUSEDEER	PELANDOK	PELANUOK, PERUAN	PELANDOK	PELANWAK PALANUK LAKET		PALANUK	PALANUK	PALANUK PIPIT	PELANUK PIPIT	PILANDUK
Muntiacus muntjak BARKING DEER	KIJANG	TUHOU	TUHOU	TALAU	PAUS, GANTADUN	PAUS	PAUS	PERUKAH	PERUKAH	KIJANG
Cervus unicolor PAYAU	PAYAU, RUSA	TAMBANG	TAMBANG	PAYOR, PAYO		TAMBANG	TAMBANG	PAYOU	PAYOU	USA
Bos javanicus TEMBADAU	BANTENG	MASALONG	KAHISAN	KALIO		BAMBARAS, TAMBADAU	TEMBADAU	KALASIU	KALASIU	LINSANG

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