ECOLOGY AND CONSERVATION OF THE ASIAN ELEPHANT IN SOUTH INDIA

With Special Reference to the Chamarajanagar and Satyamangalam Forest Divisions

by

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TECHNICAL REPORT 14

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R. SUKUMAR

CHAPTER - 1 : INTRODUCTION

TERMS OF REFERENCE OF THE ASIAN ELEPHANT SPECIALIST GROUP

The aim is to actively promote the positive and effective long term conservation of wild Asian elephants in healthy, viable, breeding populations, in as wide a representation of known elephant habitat types as possible.

The following objectives of the Group are under study:

A. The distribution and numbers of all remaining Asian elephant populations should be known as accurately as possible.

B. The pressures on all known populations should be assessed and monitored as far as possible by regard to the following indicators:

(i) Sufficiency of natural habitat. Is there enough? If so, at what rate, and in what is it being reduced? How serious is this for elephants? Is there, and of what type, man induced competition for elephant important resources?

(ii) Poaching for ivory. The existence and seriousness of this is to be investigated. Efforts should be made to acquire annual records for legal/illegal imports/exports/confiscations/sales of ivory from the Government agencies concerned.

(iii) Deaths and captures. Records should be acquired of exact numbers known to have been removed from the wild population annually through human agency and the reason given. Diseases and epidemics should be recorded.

(iv) Crop damage. This should be monitored and localities noted and its annual cost and seriousness assessed. Any deterrent activities (or lack of) by public or authorities should be recorded so that the Group can advise accordingly.

BACKGROUND TO THIS STUDY

During 1981-83, the IUCN/SSC Asian Elephant Specialist Group sponsored a number of projects on the Asian elephant with funding from the World Wildlife Fund - International. The main aim of these projects was to promote the long term conservation of the elephant in the Asian continent. Various project proposals were submitted to the AESG at the meeting held at Colombo in August 1980. This project (WWF Project No. 3032) on the ecology and conservation of the elephant in South India was later approved for funding by the IUCN/AESG. The field study was carried out between February 1981 and July 1983. Keeping the objectives of the AESG in mind, the principal aim of this study was to provide the scientific basis for evolving management policies for elephant conservation.

Prior to this study the available scientific information on Asian elephant ecology were mainly those of McKay (1973) and Olivier (1978). However, there were lacunae in quantitative information on certain aspects

such as population dynamics and the interaction between elephant and man, especially crop raiding. This study provides:

(a) a broad perspective on elephant ecology including habitat utilization and food requirements (information crucial for maintainance of habitat quality);

(b) a detailed framework on population dynamics (useful in monitoring trends in demographic patterns, disparity in sex ratio due to poaching, etc.);

(c) an analysis of elephant-human interactions including crop raiding and manslaughter by elephants, habitat manipulation and elephant slaughter by man (which information can be used in attempts to minimize these conflicts);

(d) an outline of the principles of elephant conservation and makes specific recommendations for its management in a portion of South India.

THE STUDY AREA

The largest elephant population in South India (and one of the most important in India and in Asia) ranging over the Nilgiris-Eastern Ghats region was the subject of this study. This was carried out at two levels:

(a) a broad survey of elephant status and distribution was carried out in this larger Nilgiris - Eastern Ghats region;

(b) a detailed study of elephant ecology and elephant - human interaction was undertaken in a 1200 km^2 portion of this region, namely, the Chamarajanagar Forest Division of Karnataka and the Satyamangalam Forest Division of Tamilnadu.

The field work schedule was as follows:

June - July 1980	-	Survey of the Eastern Ghats
September 1980	-	Survey of parts of the Nilgiris
Feb 1981 - July 1983	-	Detailed study in Chamarajanagar and Satyamangalam Forest Divisions based at Hasanur. Also visits to other places including Mudumalai, Bandipur, Upper Bhavani, Siruvani hills and Nagarhole.
Oct. 1983, Feb. and July 1984, June 1985	-	Visits to Mudumalai, Chamarajanagar and Satyamangalam.
October 1984	-	Survey of the Coimbatore Division (Nilgiris).

CHAPTER - 2 : STATUS AND DISTRIBUTION OF THE ELEPHANT IN SOUTH INDIA

The elephant is distributed over forested hilly tracts of the Western Ghats and adjacent Eastern Ghats in the southern states of Karnataka, Kerala and Tamil-nadu (Fig. 2.1). Its range lies between $15^{\circ}30'$ N to $8^{\circ}15'$ N and $74^{\circ}15'$ E to 78°E. The elephant's habitat encompasses a diversity of vegetation types from dry scrub, through deciduous forest to wet evergreen forest, with a corresponding variation in annual rainfall from 50 cm. to 500 cm. Elephants also range over altitudes going from only 100 m to over 2000 m above msl. Details of geography, climate, vegetation and elephant distribution are given by Nair et al. (1977), Nair and Gadgil (1978), Prasad et al. (1979), Nair et al. (1980), Daniel (1980) and Sukumar (1985). The more detailed information in the above publications will not be repeated here but only a brief account of elephant status and distribution given under the 9 main sub-regions.

1. North Kanara - Crestline of Karnataka Western Ghats

The North Kanara district of Karnataka is the northern limit of elephant distribution in South India.

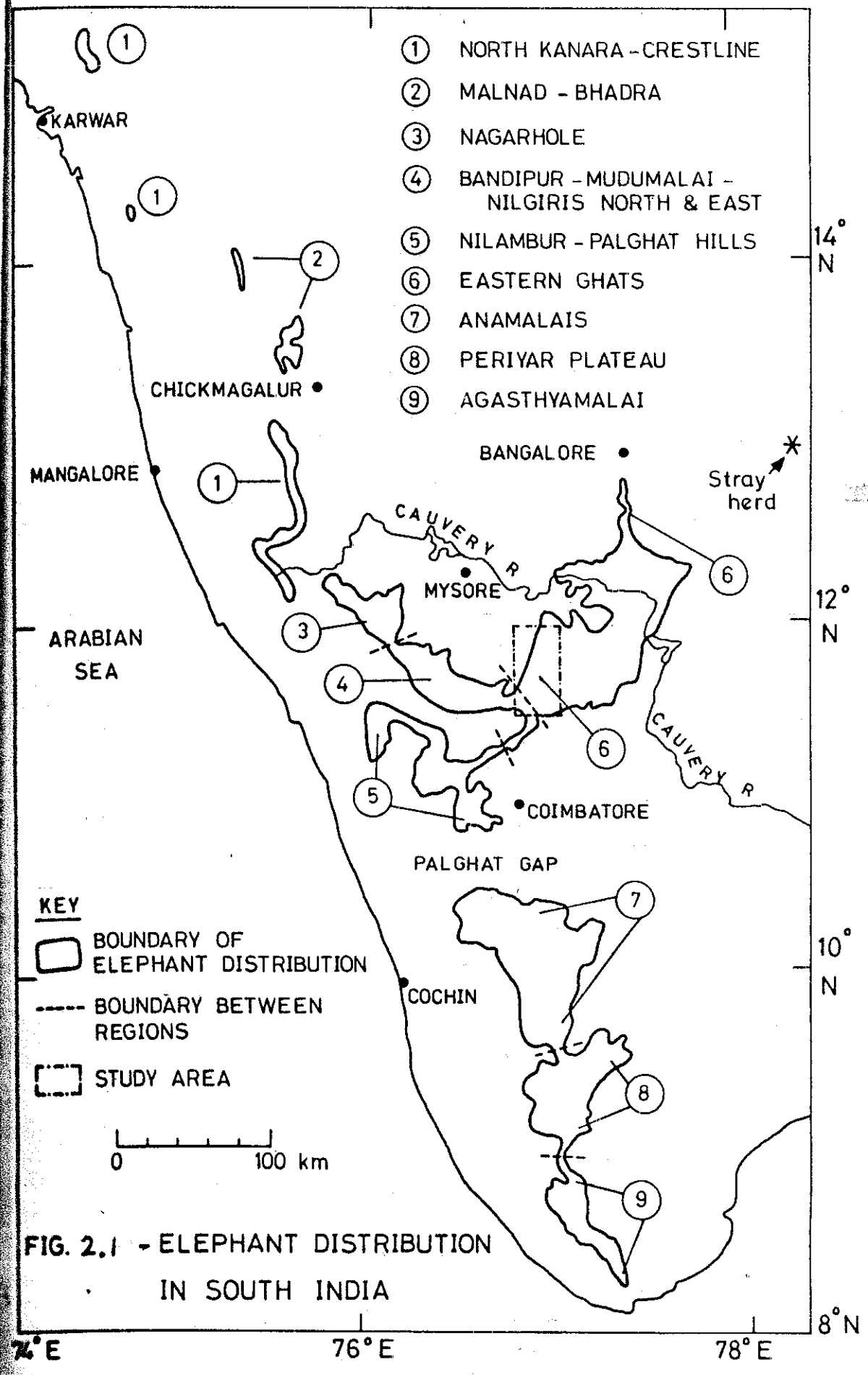


FIG. 2.1 - ELEPHANT DISTRIBUTION IN SOUTH INDIA

The elephants are scattered and occur at very low densities (Nair and Gadgil 1978). There has been considerable incursion into the forests by cultivation, mining and the giant Kalinadi hydroelectric project. In spite of the extensive forest area remaining, the Dandeli Wildlife Sanctuary alone covering 5729 km^2, the elephant population has declined sharply due to persecution by man. Only a few scattered herds numbering about 40 individuals survive in the region.

To the south of North Kanara, the crestline of the Western Ghats with its high rainfall evergreen forest and grassland extends as a narrow belt down to the Brahmagiri hills. Elephants occur at a very low density in this belt. Perhaps less than 60 elephants are found here.

2. Malnad plateau - Bhadra

The Malnad plateau lies to the east of the crestline, separated from it by a wide belt of coffee plantations and cultivation. Vegetation is mainly deciduous. An irrigation project on the Tunga-Bhadra rivers is situated here. The elephant habitat includes the Bhadra and Shettihally Wildlife Sanctuaries (area 827 km^2).

An earlier estimate of 70 elephants for this region may be low, considering the large area, the forest department census figure of 184 elephants and the high

incidence of crop raiding. Tentatively, this can be revised to 100 - 150 elephants.

3. North Wynad - Nagarhole - Kakankote

The deciduous forests of Kerala North Wynad, Nagarhole National Park and Kakankote (total area 1250 km^2) stretch from south of the Cauvery river to the Kabbini river. Extensive teak plantations are seen at Nagarhole. Important rivers are the Lakshmanathirtha and the Nagarhole. This is an important elephant region.

An earlier estimate of 300 elephants (Nair et al. 1980) is certainly low. This can be updated to 600-800 elephants.

4. Bandipur - Mudumalai - South Wynad - Nilgiris North and East

While the Kabbini reservoir has submerged the area between Kakankote and the Begur range of Bandipur, elephants still move across within a narrow 6 km corridor. The deciduous forests extending south from the Kabbini river to the slopes of the Nilgiris constitute one of the finest elephant habitats in South India. The perennial Moyar river is an important water source. This region includes the Bandipur National Park (874 km^2), Mudumalai Wildlife Sanctuary (321 km^2) and the Kerala South Wynad (251 km^2). In addition, the semi-arid Sigur plateau

east of Mudumalai and the northern and eastern slopes of the Nilgiris (700 km^2) are contiguous.

The density of elephants in Bandipur-Mudumalai is one of the highest in South India. Between 1200 and 1500 elephants may be present in the entire region.

5. Nilambur - Nilgiris West and South - Palghat hills

To the west and south of the Nilgiris are the well preserved wet evergreen forests, shola-grasslands and semi-evergreen forests of Nilambur, New Amarambalam, Upper Bhavani-Kundah, Silent Valley and Attapadi. In the Attapadi valley, where much of the land is under cultivation, there is an entire spectrum in vegetation from wet evergreen in the west to scrub in the east. The dry forests continue along the southeastern slopes of the Nilgiris in Coimbatore Division, through which flows the Bhavani river. South of Attapadi, the forested hills end at the Palghat gap.

The elephants of this region have been recently separated from the region to the north of the Nilgiris by tea plantations at Gudalur between Mudumalai and Nilambur on the west, while on the east the habitat narrows to a bottleneck along the Mettupalayam-Coonoor highway. Only a few elephants, usually lone bulls, may still rarely move between these two regions.

Elephants occur at a low density throughout this 1700 km^2 area. Only between 300 and 500 elephants may be found here.

6. Eastern Ghats (South)

The elephant range in the Eastern Ghats extends over the states of Karnataka and Tamilnadu. This region is contiguous with the Nilgiris on the southwest. The forested area of nearly 7000 km^2 is hilly with altitude varying from 250 to 1800 m. Vegetation is largely dry deciduous and scrub thicket but a patch of evergreen shola-grassland is found on the Biligirirangan hills above 1500 m. The elephants of this region may be considered under two sectors - a northern sector centered on the Cauvery river and extending south to the Palar river, and a southern sector to the south of the Palar.

Northern sector : The Bannerghatta - Anekal range is a narrow belt of scrub woodland extending south from the outskirts of Bangalore into the Kanakapura and Satnur ranges bordering the northern bank of the Cauvery. The adjoining forests of Tamilnadu constitute the Hosur and Dharmapuri Divisions. To the south of the Cauvery are the Hanur and Madeshwaramalai ranges. Along the Cauvery there is a 100 km stretch of virtually uninterrupted Hardwickia - Albizzia - Anogeissus dry deciduous forest, though due to the hilly terrain animals have access to

its waters only in certain places. This sector has an estimated 700 elephants.

Southern sector : South of the Palar river, the Bargur hills extend west to the Biligirirangan hills. The forest ranges covered include Bargur, Andhiyur, Satyamangalam and Talamalai (Tamilnadu), Ramapuram, Kollegal, BRT, Chamarajanagar and Punjur (Karnataka). About 1200 elephants inhabit this sector, a portion of which forms the study area of this investigation. The major threat to the habitat is from the numerous pockets of cultivation.

For the entire Eastern Ghats a reasonably accurate estimate is 1800 - 2000 elephants.

7. Nelliampathis - Anamalais - Palani hills

South of the Palghat gap, the great hill chain of Nelliampathis, Anamalais and Palanis forms a continuous elephant habitat. This includes the Parambikulam and the Anamalai Sanctuaries. Here again, an entire spectrum of vegetation types is available. In the Anamalais the habitat has been disturbed by a series of hydroelectric projects and its associated canals, impeding the free movement of elephants. Elephants are absent towards the eastern portion of the Palani hills which is largely under settlement.

The census figures of the forest departments indicate that 800 to 1000 elephants may be present in the region.

8. Periyar - Elamalai - Varushanad hills

From the High Ranges at the southern end of the Anamalais, the Periyar plateau stretches south till the Shencottah gap separates it from the Agasthyamalai hills. The reservoir on the Periyar river has provided the nucleus of the Periyar Tiger Reserve, a well known haunt of elephants. Unlike other similar projects this has not caused much habitat destruction. On the plateau vegetation varies from evergreen to moist deciduous, while dry forest is seen on the eastern slopes of the Srivilliputhur range of Madurai district.

From the estimate given by Vijayan (1980) for Periyar, it can be said that 700 to 900 elephants may inhabit the entire region.

9. Agasthyamalai - Ashambu hills

The Shencottah pass maintains a tenuous link between the Periyar plateau and Agasthyamalai, but elephants do not seem to move across the railway line and the highway in this corridor. South of the pass the elephant habitat extends almost upto the tip of the peninsula. This

region includes the Neyyar, Mundanthurai and Kalakkad Wildlife Sanctuaries. Hydroelectric and Irrigation projects, rubber and tea plantations are the main disturbances.

Since elephants are largely confined to the interior evergreen and semi-evergreen forest and grassland, their status is not very clear. A tentative estimate of 150 - 200 elephants has to be taken.

Summary of Population Estimates

1.	North Kanara - Crestline	100
2.	Malnad plateau - Bhadra	100 - 150
3.	North Wynad-Nagarhole-Kakankote	600 - 800
4.	Bandipur-Mudumalai-South Wynad-Nilgiri North and East	1200 - 1500
5.	Nilambur-Nilgiris West and South-Palghat hills	300 - 500
6.	Eastern Ghats	1800 - 2000
7.	Nelliampathis-Anamalais Palani hills	800 - 1000
8.	Periyar-Elamalai-Varushanad hills	700 - 900
9.	Agasthyamalai-Ashambu hills	150 - 200
	Total:	5750 - 7050

The earlier population estimates have been updated based on Forest Department census figures (see Appendix I) and personal estimates. I must emphasize here that some

of the earlier estimates were generally underestimates, largely because the magnitude of the geographical area of elephant habitat was not fully recognized. As more regions are surveyed and distribution maps prepared, undoubtedly the numbers have to be revised upwards. The experiences in censusing in Africa also show clearly that animal numbers are usually underestimated.

Of the above 9 regions, detailed maps at 1 : 50000 scale showing elephant distribution are now available for the following regions :

(a) North Wynad - Nagarhole - Kakankote (area 1250 km^2)

(b) Bandipur - Mudumalai - S.Wynad - Nilgiri N and E (area 2350 km^2)

(c) Eastern Ghats (area 7000 km^2)

(d) Nilambur-Nilgiris West and South - Palghat hills (area 1700 km^2).

Of these, the first three regions maintain habitat contiguity (total area 10600 km^2) and hence a single population of elephants (3600 - 4300 individuals). The last region is virtually cut off from the rest though a tenuous link is maintained, through which elephants may rarely cross over. This combined area of 12300 km^2 with 3900 - 4800 elephants is the largest and most important for long term conservation.

CHAPTER - 3 : THE MAIN STUDY AREA

Topography

The study area is situated between $12^{o}0'$ N to $11^{o}30'$ N and $76^{o}50'$ E to $77^{o}15'$ E. It comprises a forested area of 1130 km^2 spread over the Chamarajanagar and Kollegal Forest Divisions of Karnataka State and the Satyamangalam Forest Division of Tamilnadu State in South India. The cultivated enclaves occupy an additional 70 km^2 within the study area. A detailed map is enclosed at the end (also see Fig. 3.1). It is of strategic importance as an elephant range, being flanked on the west by the high elephant density areas of Bandipur-Mudumalai and on the east by the relatively extensive elephant habitat (though of lower density) of the Eastern Ghats. The study area itself is a medium density elephant zone.

The Biligirirangan hills are a double range rising from the southeast of the Mysore plateau. They run from north to south, from the town of Kollegal to Satyamangalam, for about 50 km, and are flanked by a series of lower hills, plateaus and valleys. The term Biligirirangan hills is now popularly confined to the northern portion falling within the State of Karnataka, while the

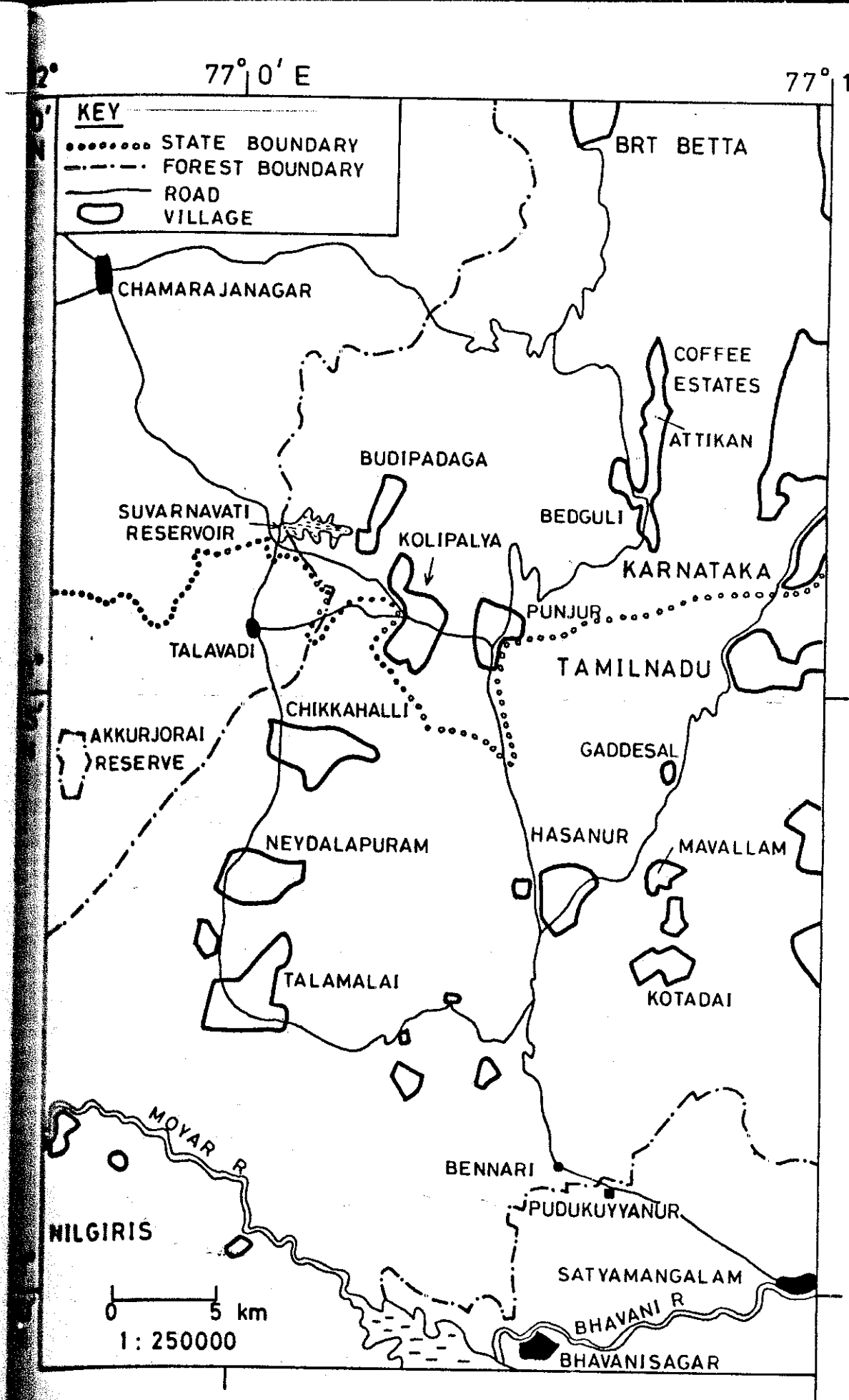


FIG. 3.1. MAP OF THE STUDY AREA.

southern parts extending into Tamilnadu are loosely included under the North Coimbatore plateau . Geographically, the entire range should be called by one term, as it is a single and continuous geological formation with only a political boundary intervening. It is in the wider sense that the term Biligirirangen hills is used here, while the name Biligirirangaswamy Temple or BRT Wildlife Sanctuary (324 km^2) is confined to the reserve so designated in Karnataka.

From the Mysore plateau with an average altitude of 750 m, the Biligirirangans rise a further 1000 m. The highest peak Kattari Betta reaches 1816 m above sea level. The two parallel central ranges, presenting a vista of grassland-evergreen sholas, feature a number of peaks above 1500 m, enclosing a valley once filled with dense semi-evergreen and moist deciduous forest of which only remnants are seen today. Both to the east and to the west the lower hills and valleys from 1250 m to 750 m become progressively drier the further away from the central ranges, with dry deciduous forest changing into degraded scrub forest. On the south the hills drop precipitously to the Coimbatore plains (250 m) where a strip of dry thorn forest is found at the foothills. On the southwest the hills merge into the Talamalai plateau (750 m), a mixture of dry forest, plantations

and cultivated enclosures, which further drops steeply into the Moyar valley or Gazalhatti pass (250 m). South-west of the Moyar river rises the imposing Nilgiris range which forms part of the great Western Ghat chain of Peninsular India. Geologically, the hills are formed by the Archean group of rocks, mainly the great gneissic series, believed to be 3000 million years old.

Hydrology

The region creates two drainage systems - a major one emptying into the Cauvery river and a minor one falling into the Moyar river.

Among the important streams to the west of the Biligirirangans are the Nirdurgi hilla and the Araikadavu halla with its tributary, the Minchikuli halla. At the junction of these two streams the waters are impounded by the Suvarnavati Reservoir (water spread 2 km^2) an irrigation project which discharges into the Cauvery through a channel. To the east are a number of small streams which drain into the Palar river, a tributary of the Cauvery. In between the two central ranges, the Attikan halla runs north and then east into the Gundal Reservoir.

The Moyar is a perennial river flowing eastwards

along the southern boundary of the Talamalai plateau. Although a few streams from this region, notably the Karuppanrayar pallam with its tributary the Dasara pallam, and the Doddacombai pallam drain into the Moyar their contribution is insignificant. Bulk of the Moyar waters originate in the Nilgiris. At the confluence of the Moyar river and the larger Bhavani river (flowing from the southern part of the Nilgiris) stands the Lower Bhavani Dam, an irrigation reservoir (water spread 80 km^2).

In the study area, the only perennial river to which elephants have direct access is the Moyar. This can be reached only through a few passes in the southern escarpment. Only a few herds are thought to descend to the Moyar valley through these routes, the rest largely remaining in the hills. None of the streams is truly perennial. Only the Araikadavu seems to maintain a little water even during summer except those following years of below average rainfall. This makes the valley along the Arakadavu a major elephant habitat during the dry season.

With all the perennial water sources such as rivers and reservoirs being confined to the fringes of the study area, the interior areas are largely scarce in water. Here, man-made and natural ponds are important for elephants. During the peak dry period from February

to April certain ponds are heavily utilized by elephants. A list of the important ponds, their location, seasonality and utilization is given in Table 3.1. In addition to these, there are numerous ponds within cultivated land which may be used at night by elephants.

Climate

The climate of the study area shows a diversity of atmospheric and hydrological conditions due to the varied relief and topography extending vertically from 250 m to 1800 m above msl. Among the bioclimatic zones the following are represented:

250 - 400 m altitude	-	Tropical moderate bixeric
400 - 1500 m	-	Tropical moderate
Above 1500 m	-	Tropical low montane.

The annual rainfall in the study area varies along altitudinal gradients. The sheltered Moyar valley (250 - 400 m) in the southwest is the driest tract with an average rainfall of only about 50 cm, while in the high altitude shola-grassland belt it may reach 200 cm. Figures for a few stations are given below:

Station	Altitude	Average annual rainfall
Bhavanisagar	250 m	72 cm
Chikkahalli	750 m	80 cm
Hasanur	900 m	98 cm
Bedguli	1250 m	133 cm
Attikan estate	1600 m	185 cm

Name	Location	Status	Utilization by elephants	Remarks
1. Somesvarana kere	Zone 3	Perennial	Mainly Apr - Sep	Spread of human settlement has partially cut elephant's access
2. Kyatedevaragudi kere	Zone 3	Generally perennial	Feb - Sep	Forest department settlement causes disturbance
3. Anakere	Zone 6	Semi-perennial	Heavy usage Mar - Sept	No conflict
4. Karapallam kere	Zone 12	Semi-perennial	Heavy usage Jan - Apr	Some disturbance from vehicular traffic on highway
5. Wilson tank	Zone 15	Generally perennial	Dec - Feb	Nearby Gaddesal village restricts elephant use to night
6. Hulikere	Zone 11a	Perennial	Low usage Dec - May	Disturbance from cattle pen
7. Alamalai kere	Zone 11b	Perennial	Nov-Feb	No major conflict
8. 3 ponds east of Chikkahalli-Neydalapuram	Zone 10	Semi-perennial	Oct - Feb	No major conflict
9. Badagali kere	Zone 9	Perennial	Oct - Feb	Some disturbance from nearby Kodipuram village
10. Pond near Gadaparapallam	Zone 16	Generally perennial	Oct - Feb	No conflict

The monthly rainfall data for Hasanur is shown in Fig. 3.2. During the study period, rainfall was normal over the area in 1981. In 1982 the area received only about half the normal amount. This was not a localized phenomenon but part of the general drought that prevailed over peninsular India.

Although many seasonal distinctions can be made by considering all the climatic factors, for the purpose of this study it is sufficient to define just 3 broad seasons. These are based mainly on the rainfall pattern and water balance in the environment.

(a) Dry season (January - April)

This period is characterized by negligible rainfall during January-February. Even though there is some rain in March-April, and especially April cannot be termed as a month of precipitation drought , it is still a period of hydrological drought i.e. low stream flow and pond levels.

(b) First rainy or wet season (May-August)

Beginning with the heavy pre-monsoon showers in May and the subsequent influence of the SW monsoon until August, a quantitative change in water availability is seen. This period can be termed as the first rainy or wet season.

(c) Second rainy or wet season (September-December)

Before the withdrawal of the SW monsoon there is a sharp increase in rainfall over the southern part of the study area. Throughout the area a peak in monthly rainfall is noticed in October (or sometimes in September). Although rainfall due to the NE monsoon is irregular during Nov-Dec, there is abundant water available in the streams and ponds. This period constitutes a second wet season.

VEGETATION TYPES AND DIVISION INTO HABITAT TYPES OR ZONES

With the aid of Survey of India maps (1:50000 scale) and satellite imagery, a detailed vegetation map was prepared by ground survey. As a first step the five basic vegetation types were identified.

1. Tropical evergreen shola-grassland
2. Tropical moist deciduous forest
3. Tropical dry deciduous forest
4. Tropical southern dry thorn forest
5. Man-made forest (plantations)

Of these types, the dry deciduous forest is predominant in the study area. It could be further divided into a number of sub-types characterized by their edaphic and biotic modifications. Based on various considerations 19 zones were identified. Table 3.2 lists the zones

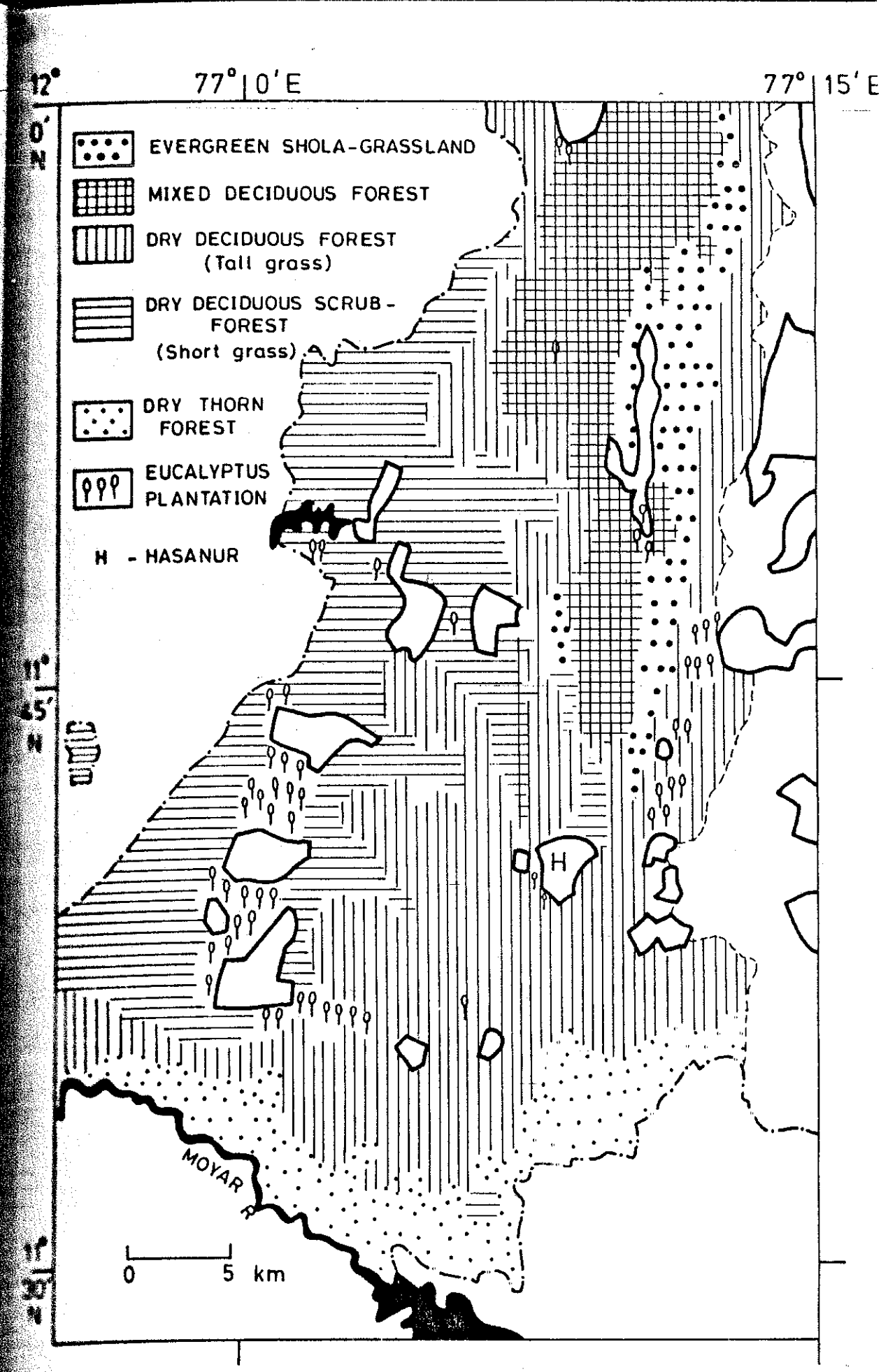


Fig. 3.3. VEGETATION TYPES OF THE STUDY AREA

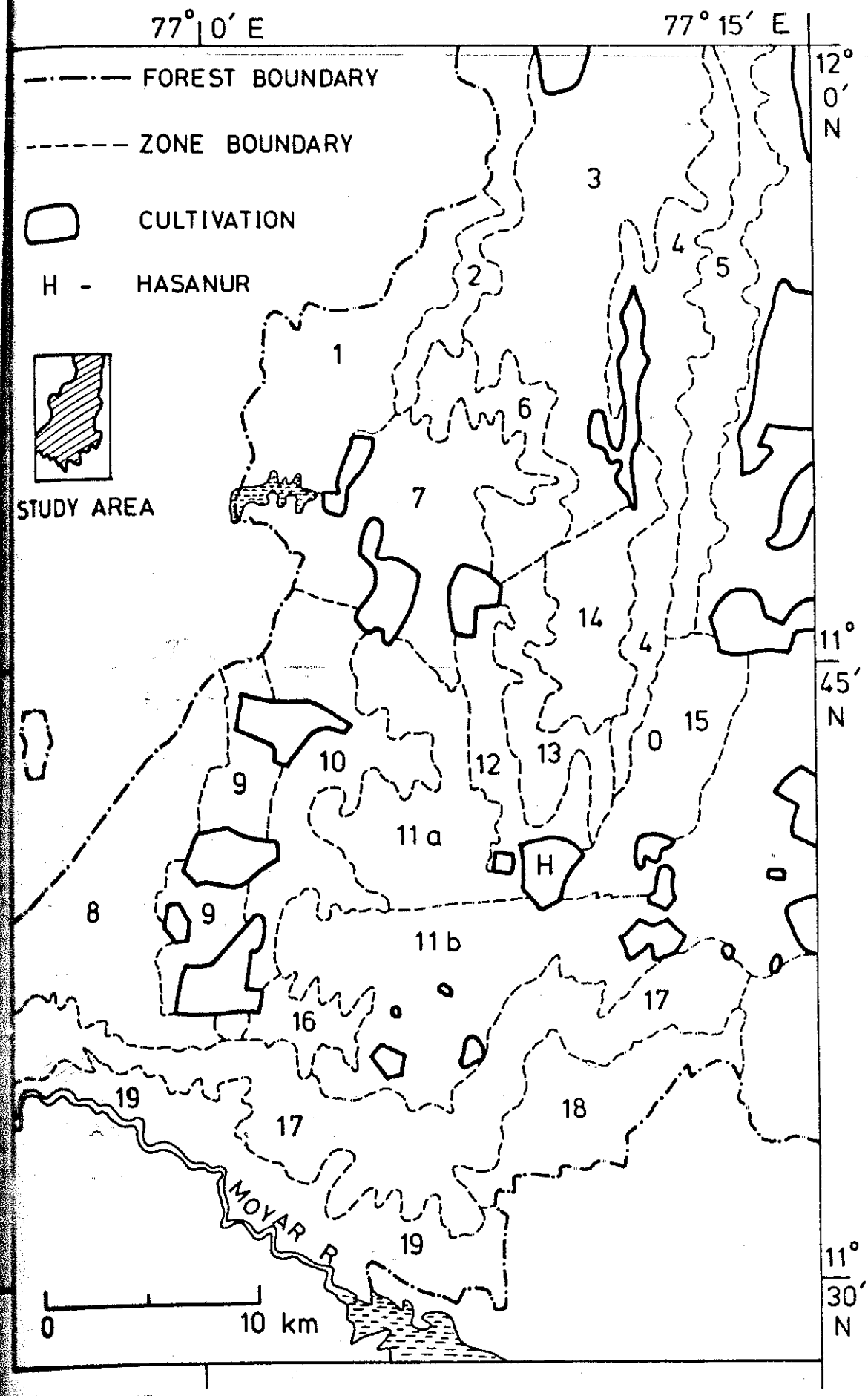


FIG. 3.4 ZONES OF THE STUDY AREA.

Table 3.2 : Classification of habitat types or zones in the study area

Zone Number	Area km^2	Vegetation type	Trees/ shrubs	Undergrowth grasses	Altitude metres	Topography
1	55	Dry deciduous woodland-scrub	Anogeissus, Acacia sundra, Lantana	Short grasses	700-800	Flat
2	32	Dry deciduous	Anogeissus, Terminalia spp.	Tall grasses Themeda triandra	800-1100	Sloping Westwards
3	125	Mixed deciduous	Terminalia Tomentosa, Kydia calycina, Anogeissus	Tall grasses Themeda cymbaria	1000-1400	Hilly
4	78	Evergreen shola-grassland	Elaeocarpus, Meliosma Microcarpa	Tall grasses Cymbopogon in the grassland	1400-1800	Hilly, steep
5	50	Dry deciduous	Anogeissus	Tall grasses, Phoenix humilis	1000-1400	Sloping eastwards
6	37	Dry deciduous	Anogeissus, Phyllanthus	Dendrocalamus tall grasses Themeda triandra	900-1100	Sloping, southwards and westward aspect
7	60	Ribarian fringing and scrub	Anogeissus, Zizyphus	Short grasses Bambusa along stream	800-950	Flat, small hillocks
8	76	Dry deciduous woodland-scrub	Acacia, Zizyphus	Short grasses	900-1000	Undulating

contd.

Zone Number	Area km^2	Vegetation type	Trees/ shrubs	Undergrowth grasses	Altitude metres	Topography
9	21	Eucalyptus plantation-scrub	Eucalyptus	Short grasses	850-900	Flat
10	53	Dry deciduous woodland-scrub	Anogeissus, Acacia	Short grasses	850-950	Flat
11	158	Dry deciduous northern part (11a area 52 km^2) more degraded	Anogeissus, Pterocarpus	Phoenix humilis, Dendrocalamus, Tall grasses Themeda, Cymbopogon	950-1300	Hilly
12	27	Riparian fringing deciduous	Acacia spp., Lantana	Bambusa along stream, short grasses, sedges	900-1000	Valley
13	28	Dry deciduous	Anogeissus	Tall grasses Themeda spp.	1000-1400	Hilly
14	32	Mixed deciduous	Terminalia tomentosa, Kydia calycina	Tall grasses Themeda cymbaria	1200-1350	Undulating valley
15	44	Dry deciduous	Terminalia, Kydia, Anogeissus, Phyllanthus	Tall grasses Themeda, Cymbopogon	1100-1300	Undulating
16	12	Eucalyptus plantation-grassland	Eucalyptus	Planted Bambusa Tall grasses Cymbopogon	900-1100	Undulating

contd.

Zone number	Area km^2	Vegetation type	Trees/ shrubs	Undergrowth grasses	Altitude metres	Topo-graphy
17	136	Dry deciduous	Anogeissus, Albizzia spp.	Tall and short grasses, Themeda	400-1100	Steep slopes, southward aspect
18	44	Dry thorn forest	Albizzia amara, Acacia latronum	Short grasses	250-400	Flat
19	62	Dry thorn forest	Albizzia amara, Acacia spp., Hardwickia, Gyrocarpus	Short grasses	250-400	Flat, valley

and the criteria used in their demarcation. Figure 3.3 shows the basic vegetation types and Fig. 3.4 the boundaries of the zones.

1. Tropical evergreen shola-grassland
[Zone 4, Area = 78 km^2]

At altitudes above 1500 m on the two central hill ranges receiving over 180 cm rainfall are found evergreen shola forests interspersed with open grasslands. On the inner faces of the two ranges, at lower elevations semi-evergreen forest was once the climatic climax, but beginning a century ago this type has been replaced with coffee plantations. Only remanants of the semi-evergreen type can be found today.

The principal trees in the shola forests are Syzigium cumini, Elaeocarpus serratus, Meliosma microcarpa, Cinnamomum zeylanicum, Canthium dicoccum, Ixora notoniana, Vibernum acuminatum, Symplocos laurina, Toona ciliata and Wendlandia thyrsoidea. Trees show a stunted growth due to the heavy winds. Branches are clothed with mosses, orchids and ferns. Among the shrubs can be mentioned Strobilanthes sp., Rubus racemosus and Maesa perrottetiana.

Outside the sholas, the open grasslands present a mixture of small shrubs, herbs and grasses. Cymbopogon is the common grass. Sanderson (1878) records that the

open downs are covered with dense lemon-grass, which attain a height of eighteen feet . Today, such a luxuriant growth cannot be seen. Cattle grazing and other biotic pressures have reduced grass cover to an extent that the open downs resemble short grasslands in many areas.

2. Tropical moist deciduous forest

In the valleys between the two central ranges, the moist deciduous forest must have dominated. But with the coffee plantations now occupying much of this region, this type is restricted to a narrow belt on the Karnataka side and the Minchikuli valley in Tamilnadu. A considerable portion of the BRT Sanctuary (Zone 3) must have been covered with moist deciduous forest as the climatic climax as evidenced now by the abundant growth of ferns on the forest floor during the wet season. Biotic pressures from timber felling, shifting cultivation and fire have resulted in a thinner, drier forest which is here termed as a mixed deciduous forest, intermediate between the true moist and the true dry types.

(a) Mixed deciduous forest

[Zones 3 and 14, Total area = 157 km^2]

The terrain covered by this forest type is undulating to hilly at elevations between 1200 and 1500 m, with a rainfall of 120 to 160 cm. In Zone 3 there is a

gradual transition from dry to moist type as one proceeds northwards and westwards. In the moister regions, Terminalia tomentosa is the dominant tree in the upper storey. Other common trees include Terminalia bellerica, Allophyllus rheedii, Gmelina arborea, Schleichera oleosa, Syzigium cumini and Trema orientalis.

Mention must be made of semi-evergreen patches with Michelia champaca. A huge M. Champaca (the doddasampagi) tree in Zone 3 is considered sacred by the Sholaga tribals.

In the drier areas Anogeissus latifolia becomes the predominant species along with Terminalia tomentosa, Emblica officinalis, Sterculia urens, Bombax ceiba and Lagerstroemia parviflora.

Among the species favoured by elephants in this vegetation must be mentioned Kydia calycina, Grewia tiliaefolia, Helicteres isora and Albizzia odoratissima. In the undergrowth straggling shrubs like Acacia caesia, A. pennata and A. sinuata are frequently seen but they are never in dense formation. Bambusa arundinacea flowered gregariously during 1972-74 and the dried clumps removed. Regenerating shoots of bamboo can be seen on the forest floor in places. By far the ground layer is dominated by the tall perennial grass Themeda cymbaria (90 percent of the grass biomass).

3. Tropical dry deciduous forest

A major portion of the study area is covered with dry deciduous forest in its various stages of degradation.

a) Mixed dry deciduous forest

[Zone 15, Area = 44 km^2]

The floristics are basically similar to the mixed deciduous forest described earlier, but trees showed a relatively stunted growth. Terminalia tomentosa, Anogeissus latifolia, Emblica officinalis, Kydia calycina and Grewia tiliaefolia are worth mentioneng.

b) Anogeissus dry deciduous type

[Zones 3,6,11,13 and 17, Total area = 391 km^2]

On hill slopes from 1000 to 1200 m with an annual rainfall of around 100 cm, due to constant fires the vegetation has come to be dominated by the fire-resistant Anogeissus latifolia. Other trees associated with this type are Terminalia chebula, Pterocarpus marsupium, Emblica officinalis, Feronia elephantum, Santalum album, Chloroxylon swietenia, Dalbergia paniculata, Diospyros melanoxylon and Premna tomentosa.

Among the tree species eaten by elephants are Zizyphus xylopyrus, Albizzia odoratissim,a Albizzia lebbeck, Semecarpus anacardium, Buchanania lanzan and Tectona grandis. Dendrocalamus strictus is the common bamboo.

The ground layer contains tall grasses such as Themeda triandra, T. cymbaria and Cymbopogon flexuosus. Phoenix humilis, a shrubby palm, is another indicator of frequent fires and is abundant in the more degraded, open regions such as Zone 11. On the slopes of the southern escarpment (Zone 17) the vegetation cover gradually changes from a mixed dry deciduous forest at 1000 m to a dry thorn forest near the foothills at 300 m.

c) Dry deciduous woodland and scrub

[Zones 1, 8 and 10, Total area = 184 km^2]

Constant lopping, felling, grazing and burning of deciduous woodland has produced a characteristic scrub vegetation. This type occurs all along the western belt of the study area adjacent to cultivation on flat or undulating terrain from 750 to 900 m. Rainfall is between 80 and 100 cm per year.

Though the floristic composition does not alter much, the plants show a shrubby growth only 3 to 6 m high in certain areas (Zone 1). In some of the better wooded regions (such as portions of Zone 10) trees such as Acacia suma, Albizzia spp., Terminalia spp., and Chloroxylon swietenia still occur. A pure dense crop of Anogeissus latifolia covers much of Zones 1 and 7. Other characteristic species are Lantana aculeata, Acacia sundra, Zizyphus spp., Xeromphis spinosa,

Flacourtia sp., Gymnosporia sp., Fluggea sp., Carissa carandus, Dodonaea viscosa, Capparis sepiaria, Capparis grandis and Toddalia asiatica. Grasses are invariably of the short variety.

d) Riparian fringing and associated dry deciduous forest [Zones 7 and 12, Total area = 87 km^2]

Along the banks of streams and rivers a narrow fringe of tall trees (gallery forest) can be distinguished. With a mixture of evergreen and deciduous trees relying on an ample supply of moisture this belt can be thought of as an edaphic climax. Since these belts of vegetation are too narrow to be designated as separate zones, in the present classification two zones have been demarcated based on the importance of streams as water sources for elephants. These zones include the narrow riverain belts with their associated dry deciduous vegetation.

The principal trees of the riparian belt are Terminalia arjuna, Syzigium cumini, Mangifera indica, and Pongamia glabra along with the thorny bamboo Bambusa arundinacea.

Between Punjur and Hasanur along the Araikadavu stream (Zone 12) the surrounding forest is a deciduous woodland with an extremely dense undergrowth, interspersed with small open patches. Trees include Acacia leucophloea, Albizzia odoratissima, Feronia elephantum,

Gmelina arborea, Zizyphus xylopyrus, Tamarindus indica, Pterocarpus marsupium and Anogeissus latifolia. Acacia suma grows gregariously in a small patch along the inter-state boundary and also in the Basavanattam area. Butea monosperma can be seen in the open areas, where the black clayey soil tends to be swampy during the rains. The undergrowth is very dense with the weeds Lantana aculeata and Eupatorium glandulosum. An important feature is the abundant growth of the shrub Acacia pennata and to a lesser extent A. torta, which the elephants consume in large quantities. The ground is clothed with short grasses and sedges.

In Zone 7 constituting the Nirdurgi stream and northern portion of the Araikadavu, the associated woodland is mostly reduced to deciduous scrub vegetation. Tree cover is sparse. An almost pure crop of regenerating Anogeissus latifolia is seen in many areas. Some Bambusa occurs on the stream banks.

4. Tropical southern dry thorn forest

[Zones 18 and 19, Total area = 106 km^2]

In the plains to the south and in the Moyar basin at altitudes between 250 and 400 m with an annual precipitation of less than 75 cm, the open, low forest is dominated by thorny, hardwood trees.

Numerous species of Acacia such as A. leucophloea, A. sundra, A. latronum and A. ferruginea are common. A. planifrons has been planted in Zone 18 and the eastern side of Zone 19. Albizzia amara is one of the most common plants and is subjected to heavy browsing by elephants. Other characteristic species of this type are Gyrocarpus jacquini, Dicrostachys cinerea, Zizyphus xylopyrus, Azadirachta indica, Erythroxylon monogynum, Xeromphis spinosa and Capparis sepiaria. Hardwickia binata is seen mainly in the western portion of the Moyar valley. Prosopis sp. dominates the open submergible front of the Lower Bhavani reservoir.

5. Man-made forests (Plantations)

There are numerous plantations of softwood, hardwood and small timber plants scattered throughout the study area.

a) Among the softwood species, Eucalyptus predominates while some Silver Oak (Grevillea robusta) is also found in Karnataka.

Eucalyptus is found in Zones 3, 7, 9 (almost the entire area), 12, 15 and 16. Silver Oak occurs in Zone 3. The total extent of softwood plantations is about 5200 hectares in the study area.

b) Teak plantations are seen only in Zone 3, occupying about 200 hectares.

c) Plantations of small timber, sandalwood and various other species are scattered over the Satyamangalam Division. About 1900 hectares of such plantations occur within the study area of the Division.

The Eucalyptus plantations in the Satyamangalam Division were raised as an alternative to bamboo plantations which failed largely due to biotic pressures. Clumps of stunted bamboo can be seen in the understorey. Otherwise the undergrowth in most plantations is invaded by Lantana and may also contain some elements of scrub vegetation. In the Dasarapallam - Talamalai region (Zone 16) the Eucalyptus plantations and surrounding areas have a good cover of the tall grass Cymbopogon flexuosus.

Land use pattern

About 16000 people live in settlements within the main study area. In addition about 50000 people living along the periphery also make an impact on the forest land. The major communities living here are the Sholaga tribals, Lingayats (agriculturalists and cattle breeders), Lambadies, Badagas, Irulas and Kurubas. A list of human settlements, area and population is given in Appendix II.

Most of the agriculture is traditional, dependent on the rains. Cultivation occupies the valleys and plateaus. The staple food is finger millet or ragi

(Eleusine coracane) cultivated during the second wet season (sep-Dec). Coffee plantations occupy the hill slopes about 1250 m in the central ranges of the Biligirangans.

This area has been a source of numerous products - timber, fuel wood, pulp wood and a variety of minor products such as honey, fruits and bark. Sandalwood is an especially valuable commodity available here. Hardwood (teak) and softwood (mainly eucalypts) plantations are raised by the forest department. Large herds of domestic livestock depend on the forest for grazing. Wildlife tourism is at a very low level. The Biligirirangaswamy temple and Bennari attract pilgrims, especially during the annual fair in April. The Mysore-Coimbatore highway (traffic volume 250 to 300 vehicles per day) and the Kollegal-Coimbatore highway (below 75 vehicles per day) pass through the area.

CHAPTER - 4 : ELEPHANT POPULATION NUMBERS

The number of elephants within the main study area (of 928 km^2) was estimated by various methods including a registration count of identified elephants, ground transects and the census figures of the Forest Department.

Registration Count

The number of elephants identified and photographed included 32 adult males (above 15 years) and 213 elephants in family herds giving a total of atleast 245 elephants. In this tally, however, a higher number of adult males were recorded than their true proportion in the population since males were easier to identify and photograph. To obtain an unbiased proportion of adult males in the population the data from all the sightings were taken. Out of 1331 elephants that were sexed, 89 or 6.7 percent were adult males. By a method based on the sex ratio it was estimated that on an average 486 elephants utilized the main study area.

Ground Transects

The density of elephants in different zones at bimonthly intervals were calculated by ground transects. The density multiplied by the zone area gives the average

number of elephants utilizing the zone during a 2-month period. The total number of elephants in the main study area is given below for 1982.

Month	Number of elephants
Jan-Feb 1982	620
Mar-Apr	420
May-Jun	365
Jul-Aug	450
Sep-Oct	450
Nov-Dec	655

The seasonal fluctuations are due to movement of elephants into and away from the area. The average number works out to 493 elephants/928 km^2 area, giving a mean crude density of 0.53 elephant/km^2.

CENSUS FIGURES OF THE FOREST DEPARTMENT

The census figures for all the Forest Divisions of the 3 states are given in Appendix I. For those Forest Ranges which formed part of the study area the figures are summarized below. These pertain to the census of 30 April 1983.

Forest Range	Total number of elephants in the range	Number of elephants within main study area
Kollegal	129	c. 20
BRT	295	c. 200
Chamarajanagar	191	191
Punjur	184	184
Talamalai	87	59
Satyamangalam	165	37
	1051	691

For the main study area of 928 km^2 the figure of 691 elephants reported gave a density of 0.74 elephant/km^2, which is only slightly higher than the maximum density of 0.71 elephant/km^2 estimated for Nov-Dec 1982 by the zonal density method, but higher than the average density of 0.53 elephant/km^2 estimated for the whole year. This higher density was due to the concentration of a large number of elephants in Zone 3, near BRT Betta. The perennial tank here was an important water source during this period of drought.

When the entire area of the 6 Forest Ranges is considered, the figure of 1051 elephants within an area of 1996 km^2 yieldsa density of 0.53 elephant/km^2. This corresponds exactly to the average elephant density for the more restricted 928 km^2 study area calculated from the bimonthly zonal density estimates for 1982. No doubt this could be a coincidence, but it certainly supports the estimates made independently by other methods.

CHAPTER - 5 : ELEPHANT POPULATION DYNAMICS

More than knowing the exact number of animals in an area, it is important and profitable to know the trends in the population whether it is increasing, declining or stable. With a long lived species such as the elephant the trends may not be obvious until data over a long period become available. Certain demographic parameters such as the age of maturity, fertility, juvenile and adult mortality, and also attributes such as physiological condition may be used as indicators of the overall health of the population (Hanks 1981). In this study I have estimated some of these demographic parameters and constructed population models using the Leslie matrix method. Sub-adult elephants were aged by determining their shoulder heights by photography and relating the heights to mean growth curves (Sukumar 1985). Adult elephants were aged based on morphological features in comparison with known aged captive elephants.

Age and Sex structure

Elephants were placed in 12 age classes. An average age structure for 1981-83 is depicted in Fig.5.1. A summary of the average age and sex structure is given below.

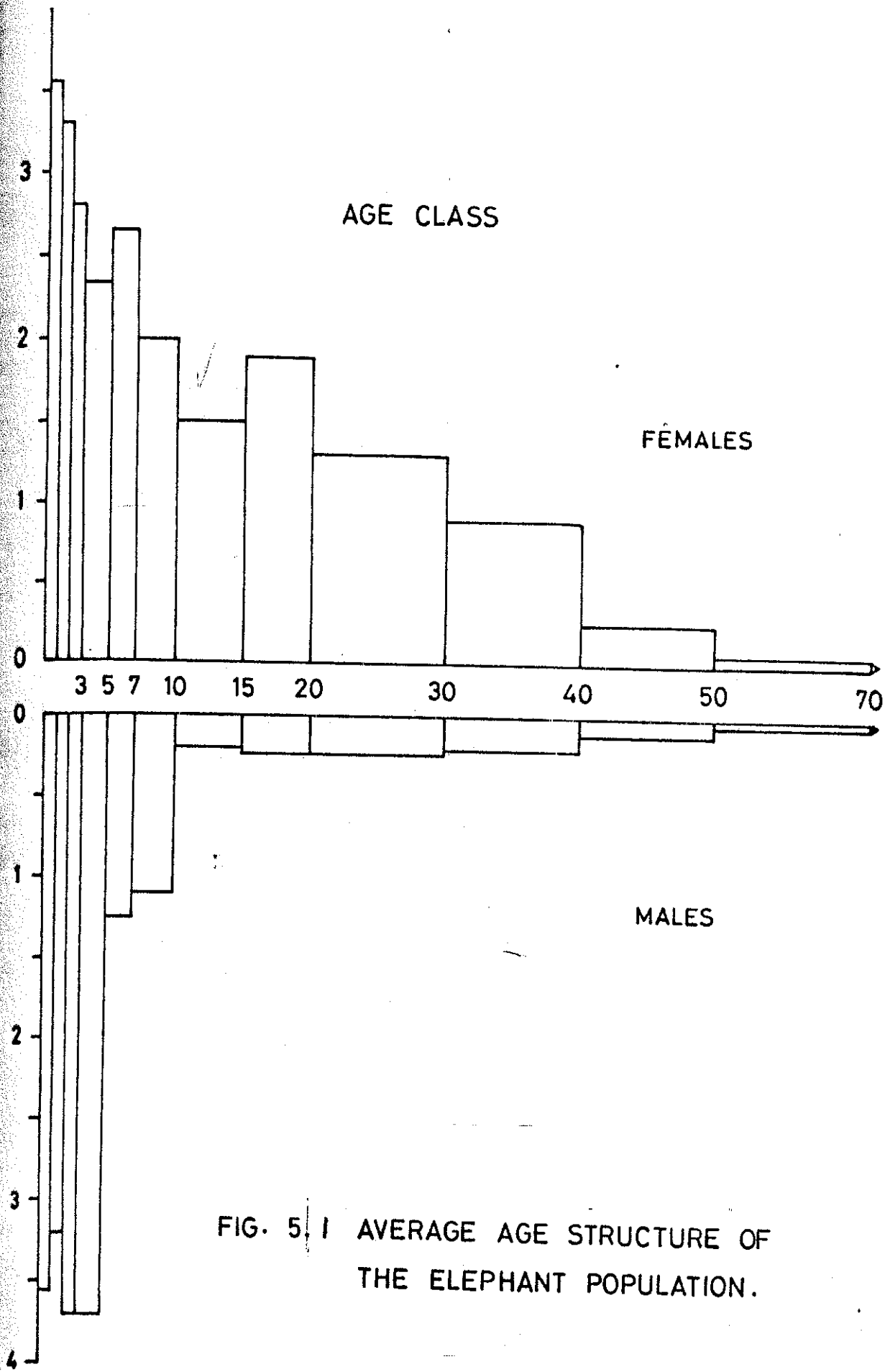


FIG. 5.1 AVERAGE AGE STRUCTURE OF THE ELEPHANT POPULATION.

Age and class	Percentage of the population		Sex ratio
	Male	Female	M : F
Adult (above 15 years)	7.0	35.4	1 : 5.1
Sub-adult (5-15 years)	6.8	18.6	1 : 2.7
Juvenile (1-5 years)	14.6	10.5	1 : 0.7
Infant (below 1 year)	Combined 7.1		

The incidence of tuskless male elephants (makhnas) is quite low. Only 2 (8.3 percent) out of 24 registered adult bulls were makhnas. Since tuskers have a higher mortality rate from poaching, the proportion of makhnas among juveniles would be still lower.

Fertility

For the wild elephant population the age of first calving in females was estimated to be 17-18 years. Reproduction could continue until about 60 years, since the oldest cows were seen to have young calves.

The birth rate showed annual fluctuations with a period of 3 years. The number of calves below 1 year was related to the number of distinctly identified mature females. The data for 3 years are given below:

	1981	1982	1983
Number of females above 17.5 years	36	39	26
Number of calves below 1 year	8	13	2

If mature females are taken as those above 17.5 years when they begin calving, then there were a minimum of 23 calves per 101 females, indicating a fertility rate of 0.228 births/mature female/year or a mean calving interval of 4.4 years. There are small discrepancies in the data owing to the different sample sizes for the three years. Notably, the year 1983 (which was sampled only until June) with its low birth rate gets a lesser weightage than other years. A weighted average yields a calving interval of 4.8 years.

Another approach to estimating the mean calving interval was to age the last two offspring of certain well identified female elephants. The difference in age between the two offspring represents one instance of calving interval. Only those offspring below 9 years were considered. Fourteen such mother-offspring units gave a mean calving interval of 4.6 years. The shortest calving interval recorded was about 3 years and the longest 6.5 years.

Since the mean calving interval calculated by the two methods closely agree, a figure of 4.6 to 4.8 years can be taken as reasonably accurate for the study population.

Mortality

To get an accurate measure of mortality in wild

populations is rather difficult. Based on the number of elephants found dead in the study area during 1981-82, some minimum estimates of mortality were made. Juvenile (below 5 years) mortality rates were relatively low for both males and females. For sub-adults and adults, the minimum annual mortality rates were around 2 percent for females and 12 percent for males.

This crude estimate does not tell anything about age-specific differences in mortality. From other approaches it was deduced that juvenile mortality could be 5 percent for females and twice as high for males. In the past the male mortality (above 10 years) could have averaged 10 percent per annum, but during 1981-82 it was atleast 15 percent per annum. Female mortality was generally low; a higher rate was indicated during 15-20 years which may be associated with the increased risk of first pregnancy. Also the death rates increased above age 40 years.

A detailed exposition of mortality is given elsewhere (Sukumar 1985). The causes of mortality are discussed later in Chapter 12. About 20 percent of all female deaths and 70 percent of male deaths were directly due to man. While the female deaths were in defence of crops, the killing of males was largely to poach the tusks.

Population modelling

Based on the Leslie matrix method, a simulation of future population trends was carried out using a computer. The parameters used in the simulations were as follows:

Age structure:

The average age structure for 1981-83 given in Fig. 5.1 was taken as the initial population.

Fertility:

Age at first calving	: 17.5 years
Age of menopause	: 60 years
Mean calving interval	: 4.7 years

Mortality:

For male and female elephants, three separate sets of mortality patterns - low, medium and high - were considered. All the 9 possible combinations (low male-low female mortality, low male - medium female mortality, etc.) were used in the simulations.

The results are summarized here (see Sukumar 1985 for detailed results).

a) With the parameters of fertility and mortality operating in the population during 1981-83, the population was either growing at a very slow rate (less than 1 percent per annum) or nearly stable.

b) The maximum growth rate that can be expected in the long term in the population given favourable conditions is around 2 percent per annum.

c) The adult sex ratio clearly showed a tendency towards further disparity. The initial ratio (1981-83) of adult male : adult female was 1:5. With the current high mortality of males (primarily due to poaching) the ratio would widen to between 1:10 and 1:20 within about 10 years (i.e. 1991-92). If the levels of poaching have increased after 1983, then this disparity would be reached even earlier. Some field work carried out during 1985 indicated that the trends in the sex ratio as predicted by the computer simulations are, in fact, becoming a reality. During 1981-83 the percentage of adult males (above 15 years) in the population was close to 7 percent, but in 1985 this seems to have dipped below 3 percent due to continued prevelance of poaching.

Discussion on population dynamics

The parameters of fertility and mortality can be indicators of the demographic vigour of the population. The calving interval of 4.7 years recorded in the study area compares well with the most productive African elephant populations at Kruger, Mkomasi central and Lake Manyara (Laws et al. 1975, Douglas-Hamilton 1972). This indicates that mature females have a high fertility.

Hanks (1981) suggested that subnormal foetal development and an increase in juvenile mortality are indications of declining demographic vigour. Fortu-

nately, in the study area and adjoining regions the available evidence indicates that juvenile mortality was at relatively low levels. From birth to age 5 years, the annual mortality was only about 4-5 percent in female and 8-9 percent in male elephants. Annual female mortality from 5 to 40 years was also at a low 2-3 percent and, as shown by the simulations, this could be an important factor in maintaining a positive or a zero growth rate in the population.

The high mortality in male elephants due to killing by man is a cause for some concern. Apart from the possible effect of a disparate sex ratio on the fertility of the population, the genetic consequences of too few breeding males will also have to be considered. This aspect is elaborated in Chapter 13.

CHAPTER - 6 : MOVEMENT PATTERN AND HABITAT UTILIZATION

Elephants are far ranging animals. Their movement behaviour is obviously an important consideration in planning for conservation. Two aspects were considered in this study - the home range size and the seasonal utilization of different vegetation or habitat types.

Home range sizes

The annual home range sizes of certain identified bulls varied from 170 km^2 to 320 km^2. Female herds had an approximate home range of 250 km^2. There could be considerable variation among elephant bulls and herds in range size, which can be determined only through radio-tracking. In general, annual home range areas seem to encompass between 150 and 300 km^2 in the study area.

Seasonal distribution patterns

The seasonal distribution patterns superimposed on a map of the study area are shown in Fig. 6.1.

a) Dry season distribution (Jan-Apr)

As expected some of the riverine vegetation zones had the highest elephant concentrations during the dry

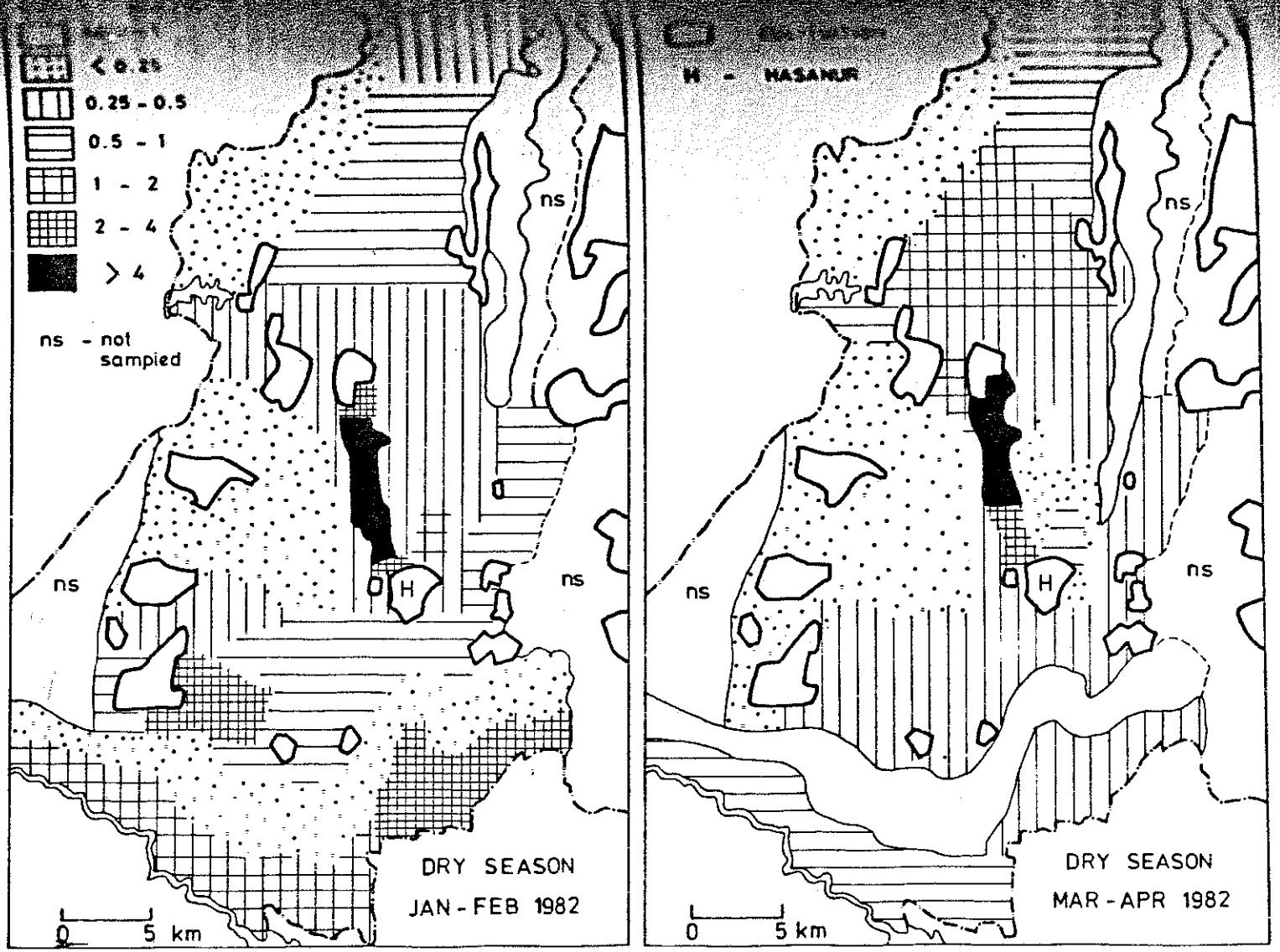


FIG. 6. 1 SEASONAL DISTRIBUTION PATTERN OF ELEPHANTS.

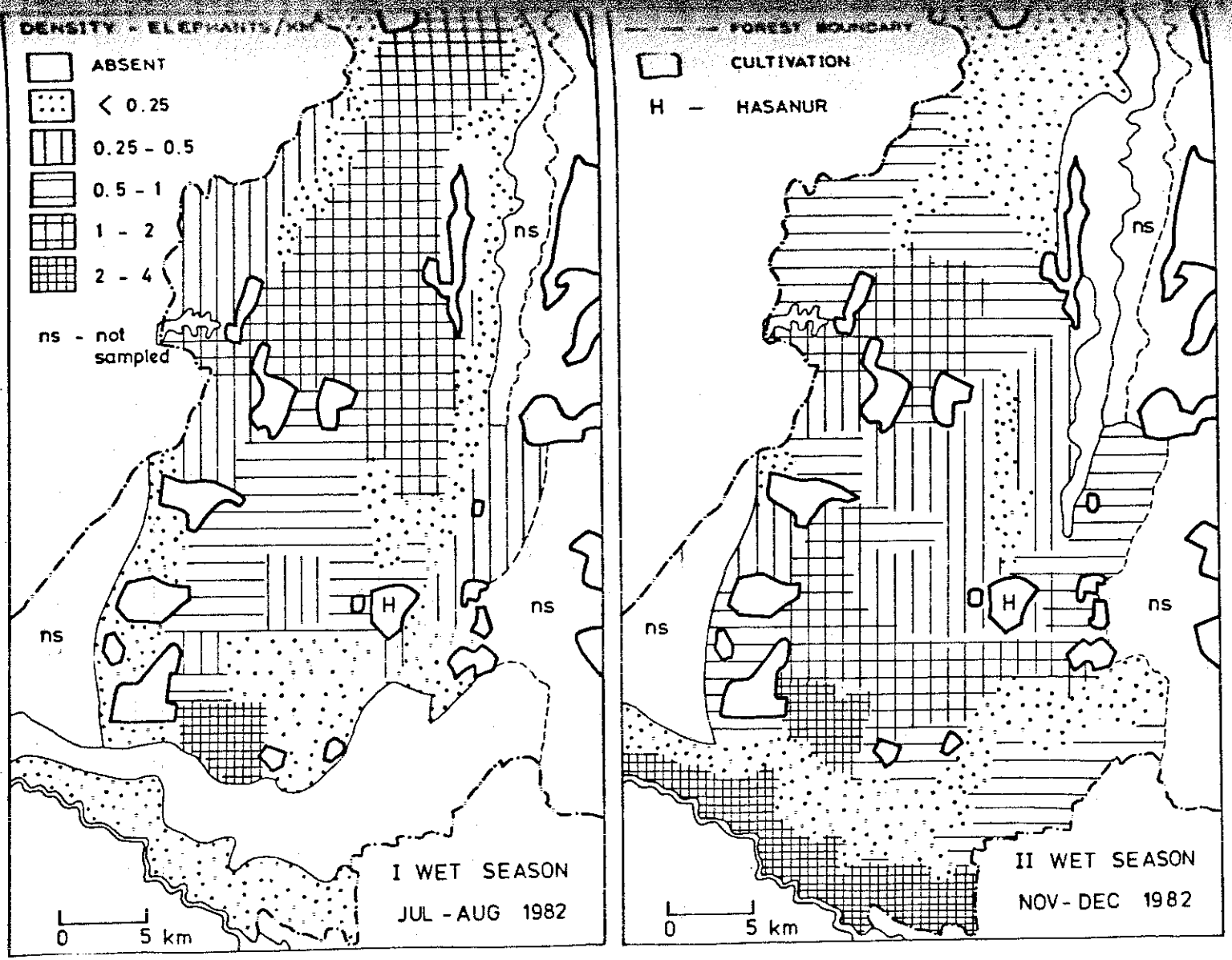

DENSITY - ELEPHANTS/KM²
ABSENT
< 0.25
0.25 - 0.5
0.5 - 1
1 - 2
2 - 4
ns - not sampled
ns
ns
ns
H
I WET SEASON
JUL - AUG 1982
0
5 km
FOREST BOUNDARY
CULTIVATION
H - HASANUR
ns
ns
ns
H
II WET SEASON
NOV - DEC 1982
0
5 km

FIG. 6.1 (contd.)

season. Zone 12 had a density of about 4 elephants/km^2 during 1981 and 1982 when some water was available in the Araikadavu stream. In the Moyar valley (Zone 19), there was a high concentration during the early part of the dry season, but elephants began dispersing from March onwards. The thorn forest in the plains (Zone 18) was also utilized intensively during Jan-Feb but not afterwards.

Considerable number of elephants were also present in some of the tall grass-dry deciduous forests. The grassland-Eucalyptus Zone 16 and the deciduous forests of Zones 11b and 14 showed high to medium densities during Jan-Feb, while the BRT sanstuary (Zones 3 and 6) had medium densities in Mar-Apr. All other zones showed a low density or virtual absence of elephants during this season.

b) First wet season distribution (May-Aug)

After the pre-monsoon showers in Apr-May, elephants dispersed from the riverine habitats occupied during the dry months. For instance, in Zone 12 there was a sharp fall in density to between 0.5 and 1.0 elephant/km^2, a mere fraction of the dry season concentration. There were few elephants in the Moyar river valley (Zone 19) during May-Aug. But elephants utilized one riverine-Scrub habitat (Zone 7) at a higher intensity than earlier.

The tall grass - dry deciduous zones now experienced an influx of elephants. This was most noticable in the BRT Sanctuary (Zones 3 and 6), where 1 - 2 elephants/km^2 was reached. Since elephants were now diffused over a wider area, no single habitat type or zone had very high densities such as occurred during the dry period.

There was also evidence that between May and August, the total elephant numbers in the main study area was reduced due to movement to outside areas. Such seasonal excursions were mainly from the Moyar valley (Zone 19) southwards and westwards into the Nilgiri hills and from the BRT Sanctuary (Zone 3) eastwards into the Kollegal Range (Zone 5) and elsewhere. There could also have been some movement from the Talamalai Range (Zones 16 and 8) further west into the Bandipur region.

c) Second wet season distribution (Sep-Dec)

Beginning in September there was a distinct movement from the BRT Sanctuary (Zone 3) southwards into the lower elevation short grass-browse habitat of Zone 7. Elephants also increasingly occupied the scrub woodlands of Zones 10 and 8. In late October there began an influx into the Moyar valley (Zone 19) from the Nilgiris and probably also from the north through a few passes in the steep mountains.

In Sep-Oct the situation was still somewhat diffused, but by Nov-Dec certain well-defined concentrations could be seen. These included a high density of 2-4 elephants/km^2 in Zone 7 (in 1981, lower in 1982) and Zone 19, and about 2 elephants/km^2 in Zone 16 and adjacent areas of Zones 8 and 11b. Elephants also moved into Zone 18 beginning in November. These may have been peripheral elements from Zone 19 and also others from the hills to the north which came through a route east of Kotadai village.

Annual differences in movement pattern

There may be annual differences in movement pattern depending on fluctuations in rainfall, extent of burning, etc. The patterns described above were true for 1981 and 1982. In 1982 the annual rainfall was only about half the normal amount. Environmental effects were not evident immediately, but later the dry season of 1983 was an especially harsh period. During Jan-Apr 1983 there were very few elephants in Zone 12 (Punjur-Hasanur valley) since there was practically no water in the Araikadavu stream. This was in sharp contrast to the dry season of 1981-82 when very high densities were recorded in Zone 12. Correspondingly in 1983 there was an increased influx of elephants into the northern portion of Zone 3 near BRT Betta, since the perennial tank here was an important water source.

Seasonal use of vegetation types

The proportion of elephants in the broad vegetation types in relation to their availability during 1982 is shown in Fig. 6.2. The zones have been classified under four basic types:

1. Short grass-predominantly browse areas [Zones 1,7,8,9,10,12,18 and 19]
2. Mixed tall grass-browse deciduous forest [Zones 2,3,5,6,11,13,14,15 and 17]
3. Evergreen shola-grassland [Zone 4]
4. Grassland (only Zone 16 which has been modified by plantations, but taken as representative).

During the early part of the dry season (Jan-Feb) the browse habitats were clearly used more than their proportional availability. With the onset of pre-monsoon showers (Mar-Apr) the use of browse habitats declined progressively. During the first rainy season (May-Aug) the mixed deciduous forest with tall grasses were generally preferred. But after the second heavier rains (Sep-Dec) elephants moved once again largely into browse habitat. High altitude evergreen shola-grasslands were largely shunned, but the lowland grassy areas such as parts of Zone 16 were used in greater proportion than availability. In the Mudumalai Sanctuary a similar preference for the swampy grasslands was noticed during the dry season.

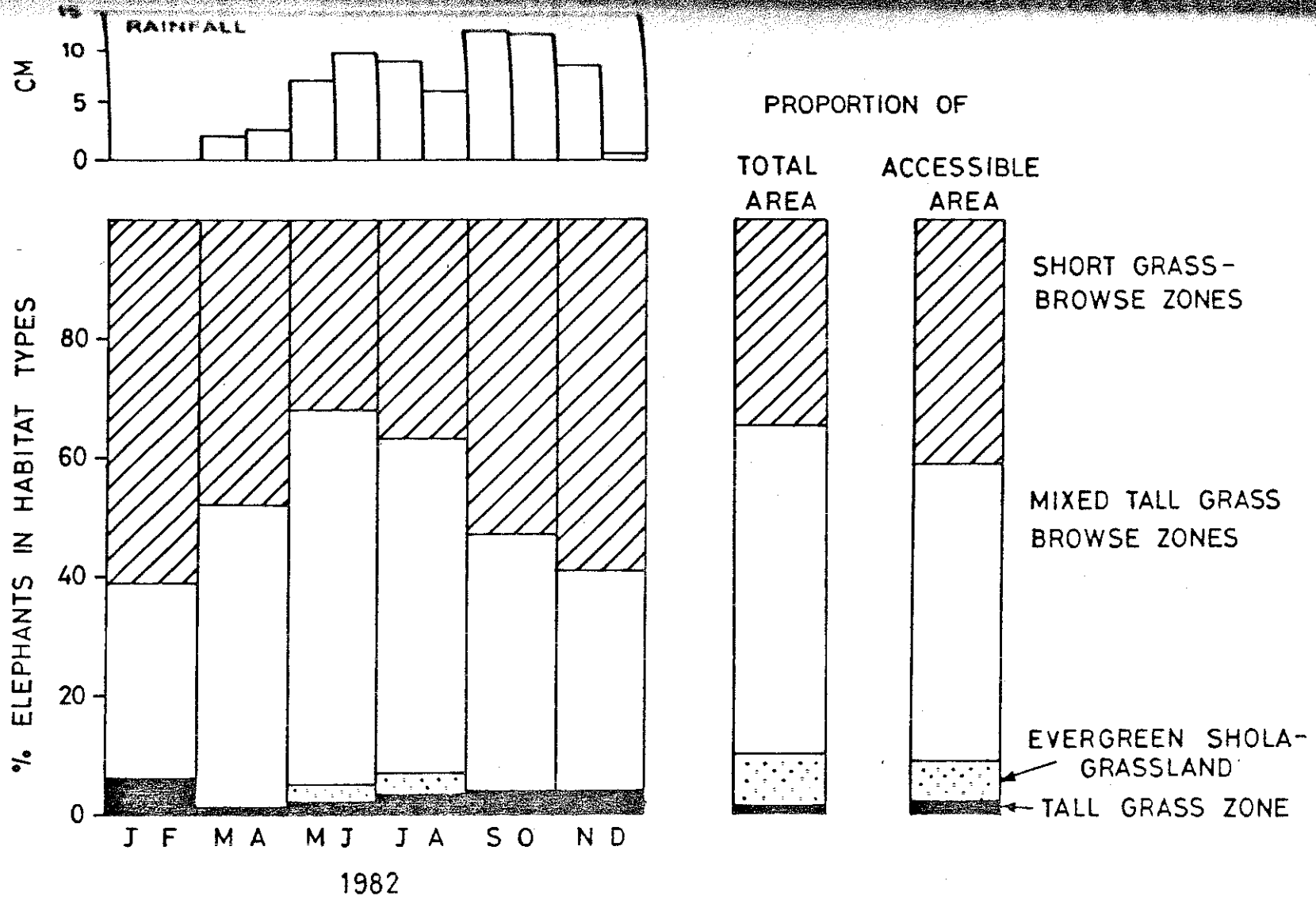


FIG. 6.2 SEASONAL USE OF HABITAT TYPES BY ELEPHANTS.

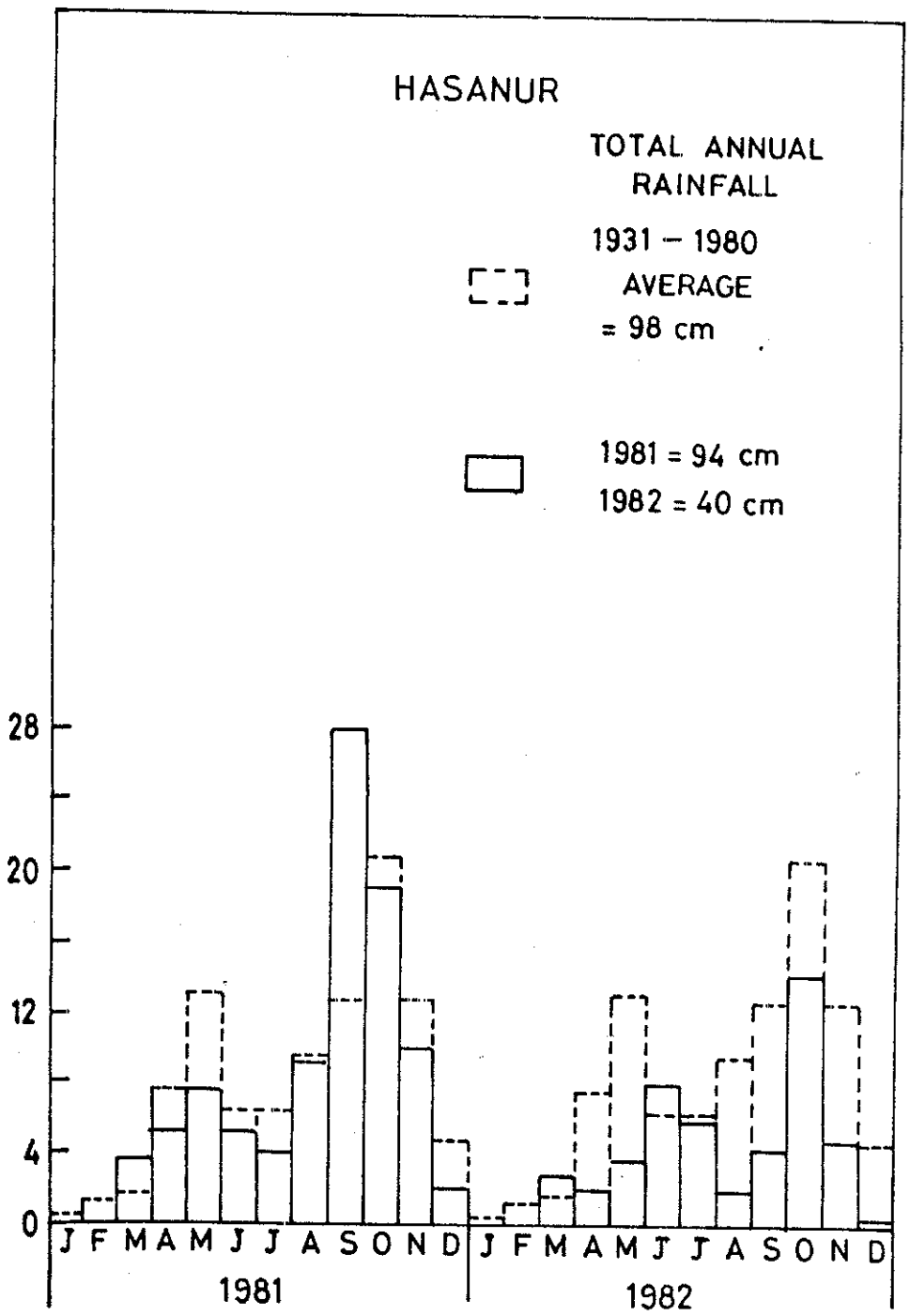


FIG. 3.2 MONTHLY RAINFALL

Ranking of habitat preference

The crude density of elephants in the study area is about 0.5/km^2. During any particular season, an ecological density greater than 0.5/km^2 in a zone can be taken as a positive preference for that zone, while a density less than this can be considered as a negative preference. Although habitat preference varies with season, certain types or zones are consistently preferred while others are largely avoided.

I have qualitatively ranked the different zones in the study area based on the average elephant association round the year. A zone having a high elephant density during the dry season is ranked higher than a zone with a similar density during the wet season. The ranking is also based on an assessment of food and water availability in the zones. A plus sign indicates a definite positive preference, a negative sign a clear avoidance. No sign has been given for zones where the average annual density of elephants is close to 0.5/km^2.

a) Riverine vegetation in valleys, where plenty of high quality browse is available, is a highly preferred habitat.

Zone 12 (+) > Zone 19 (+) > Zone 7 (+)

b) Scrub woodland vegetation is only moderately used by elephants. Some of the more degraded areas are used

only as passages to more favourable habitats.

Zone 18 > Zone 1 ≥ Zone 10

c) Tall grass deciduous forests may be preferred or shunned depending on the habitat status.

Zone 3 (+) > Zone 6 (+) > Zone 11b > Zone 11a (-) > Zone 13 (-)

d) Steep hill slopes are not favoured by elephants

Zone 2 (-) > Zone 17 (-)

e) Evergreen shola-grassland vegetation is only sporadically utilized

Zone 4 (-)

f) Eucalyptus plantations with grassland are preferred while those in the scrub zones are avoided.

Zone 16 (+) > Zone 9 (-).

Apart from having to obtain sufficient water, the elephant movement strategy is geared to optimizing its dietary intake. This is discussed in Chapter 7.

CHAPTER - 7 : NATURAL FEEDING HABITS

The elephants is known to be a generalist feeder, consuming a large variety of browse and grass species. This basic study provides a list of plant species consumed, the proportion of browse and grass in the diet, seasonal preferences and the quantity consumed. Information on diet can be profitably used in planning for habitat preservation.

The plants consumed

Though a generalist feeder, the most commonly eaten plants are from only 4 botanical taxa - the order Malvales and the families Leguminosae (especially the sub-family Mimosae), Palmae and Gramineae. These taxa account for 72 (64 percent) of the recorded food species. Appendix III gives a list of plants consumed in the main study area. Of these under 25 species from the four taxa mentioned above constitute over 80 percent of the elephant's diet.

Proportion of browse and grass in the diet

The proportion of time spent in browsing and grazing seasonally in each of three broad vegetation categories - short grass with predominantly browse zones, mixed browse and tall grass zones, and predominantly tall grass zones - is given in Table 7.1. In the evergreen shola-grassland vegetation zone no observations were made

Table 7.1 Proportion of time spent in browsing and grazing

Habitat type/Zone	Jan-Apr (Dry) Browse : Grass	May-Aug (I Wet) Browse : Grass	Sep-Dec (II Wet) Browse : Grass
Short grass - Predominantly browse zones	90 : 10	87 : 13	71 : 29
Mixed browse- tall grass zones	45 : 55	27 : 73	*
Predominantly grassland	19 : 81	+	6 : 94
Weighted seasonal proportion in study area	69 : 31	46 : 54	56 : 44

*+ Data insufficient for valid analysis since relatively few elephants were present in such habitats. Intermediate values of

* 40 : 60 and + 12 : 88 have been taken.

since elephants rarely used this area. Based on the elephant occupancy in these habitat types, a weighted average proportion is also given.

Within a broad habitat type elephant foraging largely reflects the availability of plant categories.

a) In browse zones, both during the dry season and the first rainy season, a very high proportion of the diet (85-90 percent) was browse, while grazing was restricted to sedges and grasses growing along streams. Only after the heavier rains in Sep-Oct did the short grasses grow sufficiently to be worth consuming on energy budget considerations.

b) In the mixed deciduous forests with tall grasses of Themeda and Cymbopogon, there was only marginally more grazing than browsing during the dry months. But the new growth of grass after the first rains promoted significantly more grazing (73 percent) especially on Themeda. During the second wet season grazing on tall grass declined but the data is insufficient to confirm this.

c) In grassland zones, grazing obviously remained at a high level (above 80 percent) throughout the year. The lowland grassland is restricted to a very small area (12 km^2) in Zone 16 which has been partly modified by Eucalyptus plantations. Although elephants utilize the

area intensively from Nov-Feb, the overall contribution of grass from here is low. In the more extensive shola-grasslands it can be expected that elephants would primarily graze. But due to the very low utilization of this habitat type, the contribution of grass is negligible.

d) Overall, during the dry season the importance of browse (69 percent) is clear. Feeding on grass (54 percent) picks up during the first wet season. Once again after the second heavy rains feeding on browse (56 percent) increases in the natural habitat. However, the consumption of cultivated millet and cereal crops during this season would increase the total intake of grass.

Relative composition of browse plants in the diet

Important browse plants which constituted atleast 2 percent of the browse diet in a zone are given in Table 7.2. Only 5 representative zones where sufficient observations were made are shown. These include 3 predominantly browse zones (Nos. 12, 18 and 19) and 2 mixed browse and tall grass habitats (Nos. 3 and 11).

The bulk of the browse diet is constituted by the Malvales, Leguminosae, Palmae and bamboos. Their importance varies with the vegetation type. The Malvales are abundant in the better preserved mixed deciduous forests as in Zones 3, 14 and 15. Kydia calycina,

Table 7.2 - Proportions of important browse plants consumed in different habitats

Plant species	ZONE 3	ZONE 11	ZONE 12	ZONE 18	ZONE 19
MALVALES					
. Kydia calycina	56.1	R	-	-	-
2. Helicteres isora	12.6	-	-	-	-
3. Grewia tiliaefolia	17.9	9.9	2.3	-	-
LEGUMINOSAE					
4. Atylosia albicans	-	5.3	-	-	-
5. Tamarindus indica	-	R	8.4	5.0	R
6. Hardwickia binata	-	-	-	-	7.5
7. Dicrostachys cinerea	-	-	R	9.0	R
8. Mimosa rubicaulis	-	3.0	R	-	-
9. Acacia leucophloea	-	R	3.4	14.4	15.0
0. Acacia latronum	-	-	-	13.1	R
. Acacia suma	-	-	12.4	-	-
2. Acacia sundra	-	-	R	20.3	12.2
3. Acacia ferruginea	-	-	-	3.6	-
4. Acacia torta	R	14.4	5.6	-	-
5. Acacia pennata	-	10.6	26.4	-	-
6. Albizzia amara	-	-	-	23.0	50.0
OTHER DICOTS					
7. Capparis sepiaria	-	-	2.3	-	-
8. Commiphora caudata	-	-	-	R	2.0
9. Zizyphus xylopyrus	R	5.3	3.4	5.4	8.8
0. Tectona grandis	R	3.8	R	-	-
PALMAE					
. Phoenix humilis	-	11.4	-	-	-
BAMBOOS					
22. Bambusa arundinacea	3.0	6.8	14.6	-	-
23. Dendrocalamus strictus	R	10.6	R	-	-
Total percentage of above species(approximate)	92%	82%	81%	96%	96%

Only those species which constitute atleast 2% of the browse diet in a zone have been included

R : Recorded as eaten but in negligible quantity (below 2%) in the zone

- : Not found in the zone or not recorded being eaten.

Grewia tiliaefolia and Helictres isora were consumed roughly in proportion to their availability. In a degraded deciduous forest as in Zone 11, the browse diet was more varied with numerous families being represented. The short grass-browse zones are characterized by the Leguminosae, particularly the Mimosae such as Acacia and Albizzia. In Zone 12, the shrub Acacia pennata was the major food item while significant amount of Bambusa arundinacea was also consumed. Acacia suma was utilized mainly in Jan-Feb. In the dry thorn forests of the plains (Zone 18 and 19), Albizzia amara was browsed heavily followed by Acacia leucophloea and A. sundra. Other important browse plants included Dicrostachys cinerea, Acacia latronum and Hardwickia binata. Among the Rhamnaceae, Zizyphus xylopyrus is widely distributed and consistently consumed. The Anacardiaceae form another edible group but their contribution was low in the study area.

Quantity of food eaten

It was estimated that elephants consume between 1.5 and 2 percent dry weight (6-8 percent fresh weight) of their body weight as food every day. An average elephant in a family herd weighing 1600 kg would require 24 to 32 kg fodder, while an adult bull of 4000 kg would need 60 to 80 kg fodder daily.

Discussion on diet

The elephant's seasonal preference for grass or browse is related to their palatability and nutritive value. After the pre-monsoon showers in Apr-May, the new flush green grass is low in silica/fibre but high in protein (10 percent dry weight). Elephants feed intensively on grass especially in the fire burnt areas during May-Aug. Later, during the second awet season (Sep-ODec) the grasses become progressively fibrous and silicaceous. Elephants now consume the basal succulent portion of tall grasses, which however contains only 2 to 4 percent protein. Browse intake now increases and becomes clearly important during the dry months (Jan-Apr). Browse plants contain 8 to 20 percent crude protein in the dry season.

To a certain extent elephants are adapted to a low quality, coarse diet. The high crowned molar teeth are capable of grinding the bark of trees or fibrous grasses. Compared to the smaller mammals, elephants can tolerate a diet of lower protein content. Though a non-ruminant, the elephant derives considerable energy from the fermentation of cellulose in the caecum and colon. Feeding on bark may provide an adequate quantity of certain minerals such as calcium. Elephants also feed preferentially on sodium-rich plants and soils.

CHAPTER - 8 : IMPACT ON THE VEGETATION AND CARRYING CAPACITY

A central concept in population ecology is that of the carrying capacity , defined as the biomass of density of one or more species that a given area can support with its resources of space, food, etc. Much of the early theoretical framework, based on the logistic equation, was developed and tested using organisms growing under laboratory conditions. In the experimental situation the carrying capacity is considered to be the density of a species when the population growth rate is zero. In nature the situation is much more complicated.

For a large herbivore, in which population regulation through natural predation can be ruled out, it is likely that food is a limiting resource. The regulation of elephant populations is of particular concern because of their potential impact on the vegetation. African elephants have been implicated in the conversion of large areas of woodland into grassland (see Laws, 1970 for a review). The elephant problem has been a subject of intense and often emotional debate. One view is that destruction of trees on such a scale is unacceptable and culling is necessary to maintain a healthy elephant population and habitat status. The

other view favours a laissez-faire policy of letting a natural ecosystem regulate itself with no human interference. It is in this context that food resource production and consumption, impact of the elephant on the habitat and carrying capacity have to be examined for the Asian elephant. The investigations I made on these aspects are preliminary. Long-term studies are needed to provide precise answers.

A fundamental and precise approach is to prepare a balance sheet of the primary production and the herbivore requirement or consumption (e.g. Sinclair 1975). The food plants of the elephant and the quantity of each species required have to be known. Net primary production of these species in the given area has to be estimated. What is important is not the total production but that fraction available to the animal. This aspect will be elaborated later.

While the above approach can be taken in grasslands, a forest ecosystem is far more complex. Estimation of shrub and tree productivity is a formidable task. Instead of going into actual productivity, the problem can be approached indirectly by assessing the impact of elephants on the woody plants (e.g. Vesey-Fitzgerald 1973). The factors to be considered include the distribution, density and structure of the woody vegetation, the

intensity and effect of browsing, and the ultimate influence of utilization on plant succession or decline. In other words, the aim is to assess whether at current levels of elephant utilization the woody vegetation is showing a healthy regeneration or suffering a decline.

Grass production

Grass production was estimated in two sites during 1982 by the harvest method. In Zone 3, the average net primary production was 183 gm/m^2 (dry weight), while in Zones 11 and 16 it was 81 gm/m^2. These figures refer to only those areas in the zones under effective grass cover. This was about 90 percent in Zone 3, but in a degraded habitat such as Zone 11 is only 50 percent of the area. The production during 1982 was low since the rainfall was only half the normal amount. During a year of normal rainfall the production of grass would be twice as high. It must also be mentioned that low to moderate grazing pressure and fire actually stimulate grass productivity.

Factors influencing food availability

As mentioned earlier, the apparent abundance of plant biomass can be misleading. The production taken as a mean value over the year is not always available as food for various reasons.

a) Many plants are nutritious only during certain

seasons. For instance, grasses have a high protein content (8-10 percent dry weight) only during the wet season. During the dry season this value drops below 4 percent, the minimum level necessary for most ungulates to maintain their body weight. However, a large herbivore like the elephant is less affected by the drop in protein value compared to smaller herbivores.

b) At certain times, the plants or plant parts are high in secondary compounds such as tannins and toxic cyanogenic glycosides. Such seasonal limitations in resource availability are very important considerations (Sinclair 1975). Figures of annual production of resources are irrelevant.

c) The entire plant is not necessarily food. Even in a largely edible plant such as grass, elephants selectively consume the top portion during the early wet season and later switch over to the basal portion. The biomass ratio of these two portions are roughly equal in tall grasses. This feeding behaviour alone restricts availability to about 50 percent of the grass biomass produced at any given time. Further, a certain proportion is naturally wasted while feeding.

In woody plants an even smaller proportion (leaves and bark) is available for consumption. Even this is not available from the entire plant but only from that portion within reach of the elephant (below 5 m height).

Table 9.1 - Frequency of crop raiding by adult bulls

VILLAGE	MAR 1981	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN 1982	FEB
1. Hasanur	0	0	I	II	II	0	II	VI	VI	VI	III	0
2. Punjur	0	0	0	I	0	0	II	V	V	V	0	0
3. Kolipalya	0	0	0	I	0	0	I	VI	V	II	0	0
4. Gumtapuram	0	I	I	I	-	-	-	-	-	-	-	-
5. Chikkahalli	I	0	0	I	0	0	I	IV	II	II	I	0
6. Neydalapuram	I	0	I	I	I	0	I	I	III	IV	III	0
7. Talamalai	I	0	I	0	I	0	0	I	V	IV	II	II
8. Bejjaluhatti	0	0	0	0	0	0	0	0	0	0	0	0
9. Mavanattam	0	0	0	0	0	0	0	0	I	II	0	0
10. Gaddesal	0	0	0	III	III	II	0	0*	0*	0*	0	0
11. Mavallam	0	0	0	0	0	0	0	0	0	I	I	0
12. Pudukuyyanur	0	0	0	0	0	0	0	0	0	I	II	0

- Data not gathered but some raiding Oct - Dec.

* Ragi not cultivated in 1981

Number of days of raiding per month : 0 - Absent, I - 1 to 5 days, II - 6 to 10 days, III - 11 to 15 days, IV - 16 to 20 days, V - 21 to 25 days, VI - above 26 days/month.

Table 9.2 - Frequency of crop raiding by family herds

VILLAGE	MAR 1981	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN 1982	FEB
1. Hasanur	0	0	0	0	0	0	0	0	0	II	I	0
2. Punjur	0	0	0	I	I	0	II	IV	IV	III	0	I
3. Kolipalya	0	0	0	I	I	I	I	IV	III	II	0	0
4. Gumtapuram	0	0	I	II	-	-	-	-	-	-	-	-
5. Chikkahalli	I	0	0	0	0	0	0	II	II	I	I	A
6. Neydalapuram	0	0	0	0	I	0	0	0	III	III	I	0
7. Talamalai	0	0	0	0	0	I	0	II	IV	III	I	I
8. Bejjaluhatti	0	0	0	0	0	0	0	0	0	0	0	0
9. Mavanattam	0	0	0	0	0	0	0	0	I	I	0	0
10. Gaddesal	0	0	0	0	0	0	0	0*	0*	0*	0	0
11. Mavallam	0	0	0	0	0	0	0	0	0	0	I	0
12. Pudukuyyanur	0	0	0	0	0	0	0	0	0	I	II	0

\- Data not gathered but some raiding Oct-Dec.

* Ragi not cultivated in 1981

Number of days of raiding per month : 0-Absent, I - 1 to 5 days, II - 6 to 10 days, III - 11 to 15 days, IV - 16 to 20 days, V - 21 to 25 days, VI - above 26 days/month.

was cultivated for this staple crop. Intensive raiding began during the last week of September when the ragi plants began flowering in the fields of Punjur, Kolipalya and Hasanur. While at Punjur herds or a few lone bulls raided fields with a frequency of roughly 20-25 days in a month during October and November, Kolipalya and the adjoining Mudahalli suffered damage practically every night during these months from either bulls or herds. During December when the ragi harvest began the raids became less frequent especially at Kolipalya, with practically no raids by January.

Hasanur experienced a raiding pattern quite distinct from that of other villages. From the end of September to the end of November there were no instances of raiding by herds. Only adult male elephants came into the fields every night. From 30 November 1981 a single herd of 17 elephants, which had come from the north through Zone 12, visited a farm adjacent to Hasanur at Binakanhalli for 8 consecutive days in sub-groups before moving in a southwestern direction. They did not cause much damage because the grain stalks in the ragi field here had been harvested leaving only the stems for the elephants to feed. Raiding by adult males at Hasanur continued regularly until mid-January.

On the western sector at Chikkahalli raiding was

at a peak during October by mainly bulls and, to a s lesser extent, by herds. Raiding frequency tapered off during subsequent months. South of Chikkahalli raiding gathered momentum in November at Neydalapuram and Talamalai, continued at a high frequency during December and decreased during January. Sporadic raiding occured at Talamalai during February, largely by bulls and twice by herds for the harvested ragi heaped for drying.

The small settlement at Mavanattam was visited in late November and early December by one adult bull and a couple of small herds. Nearby Bejjaluhatti did not experience any raiding. In the west of the study area, Gaddesal did not cultivate ragi that year and thus the question of raiding did not arise. Mavallam was only visited a few times late in the ragi season by adult bulls.

In the plains to the south, raiding by bulls and herds began in the bordering villages including Puduku-yyanur in late November or early December, but was generally at a low frequency. There was no raiding between March and October.

Group size in raiding elephants

The group size frequency of raiding female herds was similar to that observed in the natural habitat.

Groups varying in size from mother-offspring upto around 30 individuals raided fields in the study area. However, among the adult male elephants there was a distinct tendency to form larger groups before entering cultivation. In the forest most of the sightings of bulls were of solitary ones, but during crop raiding they came more often in groups of 2, 3 or 4 individuals.

Quantity of crops consumed

A detailed study of the contribution of crops to the diet has been made (Sukumar 1985) of which only details relevant here are reported.

In ragi fields about 60 percent of the plants in the damaged area are consumed on the average; the rest being merely trampled. The mean quantity of ragi plants that an adult bull consumed per day of raiding was 44 kg (dry weight) in Punjur - Hasanur and 30 kg in other villages. The upper limit it could consume was around 75 kg (dry weight, or 300 kg fresh weight) in one night's feeding. For an average elephant in female herds the mean quantity consumed per day of raiding was 24 kg in Punjur-Kolipalya and 11 kg in other villages.

The total quantity of crops consumed each month from 10 enclaves of cultivation by 200-250 elephants in herds and 15-20 bulls is shown in Fig. 9.1 . For the

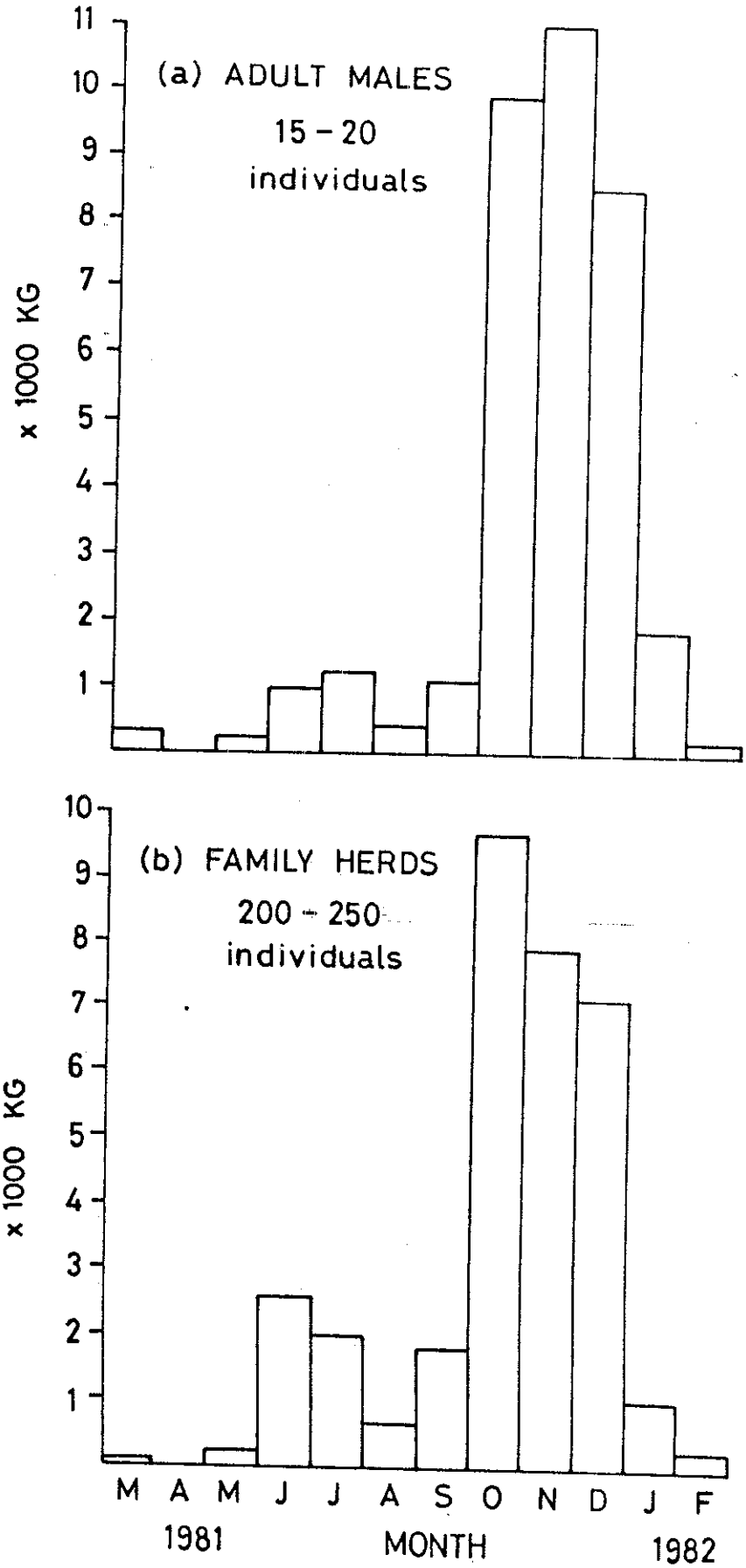


FIG. 9.1 QUANTITY OF CROPS EATEN BY ELEPHANTS.

entire year it was estimated that cultivated crops contributed 1.7 percent (by weight) of the food requirements of female herds and 9.3 percent of the requirements of adult bulls on the average. Certain notorious crop raiding bulls obtained upto 20 percent of their annual needs from cultivation.

Quantity of crops damaged and the economic loss

The mean quantity of ragi grain lost to an adult bull per day of raiding is given below.

1) Punjur and Hasanur - 60 kg of ragi grain per bull for each day of raiding the ragi fields. This is based on a sample of 30 days of raiding involving 59 bulls.

2) All other villages - 28 kg of ragi grain per bull for each day of raiding, based on 26 days of raiding involving 45 bulls.

A similar analysis for family herds gave the following figures:

1) Punjur and Kolipalya - 22 kg of ragi grain per elephant for each day of raiding (11 nights of raiding; total of 106 elephants).

2) All other villages - 12 kg of ragi grain per elephant for each day of raiding (16 nights of raiding; total of 148 elephants).

For other millet and cereal crops such as sorghum, maize and paddy no averages were calculated due to relatively few instances of raiding. Instead , the total quantity lost to elephant damage was assessed. Table 9.3 gives the quantity of each crop lost in the study villages between March 1981 and February 1982.

In all the villages the total loss of millet and cereal crops included ragi (683 quintals of grain), sorghum (58 q), maize (32 q), paddy (35 q) and samai (17 q) while 65 coconut trees and 202 banana plants were destroyed. The economic value of the crops damaged in one year amounted to Rs. 189,600 (Table 9.4).

a) Taking the total land area (both cultivated and uncultivated) of 4545 hectares for these villages, this amounts to a loss of Rs.42 per hectare of land within elephant habitat. I estimated that about 70 percent or 3200 hectares was under some form of cultivation in a year. This means a loss of Rs.59 per hectare of cultivated land.

b) The total number of people living in the villages is about 12000 (2200 households). Thus a per capita loss of Rs.15-80 was incurred.

c) If only the land owners are considered, there are about 900 families owning land in these villages. The

Table 9.3 - Quantity of crops damaged by elephants (Mar 1981 - Feb 1982)

VILLAGE	RAGI		SORGHUM AND MAIZE	PADDY	COCONUT	BANANA	OTHERS
	Bulls quintals	Herds quintals	quintals	quintals	trees	plants	
1. Hasanur	218	1	8	30	10	40	Sa, Jf
2. Punjur	86	76	3	5	26	65	Sa,Hg,Jf
3. Kolipalya	36	84	40	0	3	?	Sg
4. Chikkahalli	29	24	1	0	2	0	Sg
5. Neydalapuram	20	32	8	0	9	2	Mn
6. Talamalai	18	52	0	0	15	90	Sa,Hg
7. Mavanattam	2	2	0	0	0	0	-
8. Gaddesal	0	0	30	0	0	5	-
9. Mavallam	3	0	0	0	0	0	-
	412	271	90	35	65	202	

Damage to millet and cereal crops refer to number of quintals of grain

OTHERS : Sa - Samai, Hg - Horsegram, Sg - Sugarcane, Jf - Jackfruit, Mn - Mango.
Also niger plants trampled in ragi fields.

Table 9.4 - Economic value of crops damaged by elephants (Mar 1981 - Feb 1982)

Village	Millets and cereals	Plantation crops	Total value
	Rs	Rs	Rs
1. Hasanur	50975	5900	56875
2. Punjur	35400	6350	41750
3. Kolipalya	30700	1400	32100
4. Chikkahalli	11000	2000	13000
5. Neydalapuram	11700	5950	17650
6. Talamalai	15050	6450	21500
7. Mavanattam	800	0	800
8. Gaddesal	5175	150	5325
9. Mavallam	600	0	600
		Total	189600

loss incurred by each family averaged Rs.210. The maximum loss incurred by a farmer was in the range of Rs.5000 to Rs.5500 in the villages of Hasanur and Punjur.

d) The damage caused by 15-20 adult bulls was valued at Rs.117,600 (or Rs.6720 per bull) and that by 200-250 elephants in family herds was Rs.72000 (Rs.320 per elephant in a herd).

In addition to the above direct losses, the farmers would have invested atleast Rs.10000 in purchase of batteries for flashlights and firecrackers. If each cultivator (or his employee) spent 1 hour per night during 100 nights keeping a watch for elephants, this would amount to 9Q000 manhours lost. The wage potential of this time period is Rs.90,000.

The proportion of the potential yield of millet crops lost due to damage by elephants is given below for a few villages.

Crop	Village	Percentage depression due to elephant
Ragi	Punjur	8
	Kolipalya	7
	Hasanur	14
	Talamalai	7
Sorghum	Kolipalya	20-25
Maize	Gaddesal	20

Methods to keep away elephants and their behavioural responses

a) Fire crackers : Only a few farmers use fire crackers to scare elephants. Elephants have largely learnt to recognize such psychological bluffs. On certain nights when I had the occasion to witness fire crackers being used against crop raiders, I noticed that the elephants ignored these displays and continued their feeding. Morris (1958) described how bamboo gun rockets were successfully deployed by him to chase elephants from his crop fields in the Biligirirangans. This device does not seem to be used at present in the region.

b) Shooting : Firing with guns over the elephant may be more effective, but here again the response may not always be the same. I have seen raiding elephants ignore even gun shots. Only when directly fired upon did they leave the field.

c) Loudspeakers : In a coconut farm at Sangama (Kanakapura range) a taperecorded jumble of noises played through a loudspeaker was effective in keeping away a raiding bull elephant.

d) Vehicles : A tractor or a jeep fitted with spotlights is fairly effective in dislodging elephants provided the vehicle can be taken close enough to the animal. But once the vehicle is withdran the elephant may come back.

e) Trenches : Trenching has largely proved ineffective in keeping away elephants. Rarely are well designed trenches dug. The minimum specifications needed to prevent elephants from crossing are 7 ft. deep, 7 ft. across at the top and 5 ft. across at the bottom. Elephants often locate the places where the trench falls short of these specifications and manage to cross over. Even otherwise they may fill up a trench by digging the soil with their forefeet. The few trenches I inspected were all deficient and elephants had crossed every one of them. Improperly maintained trenches quickly get filled and are rendered ineffective.

f) Electric fence : Occasionally, farmers run a strand of wire along the periphery of the field and illegally electrify it from the 230 V mains. Animals coming into contact with the wire usually suffer a fatal shock. A few elephants die each year in this manner. The high voltage electric fence of the non-fatal type was first used in a coffee estate in the Biligiriranganas many decades back but this was later discontinued. This design has been revived in recent years.

Most farmers do not attempt anything more than merely shouting and shining flashlights. Platforms built on tree-tops are usually used by them to keep guard at night. In many fields, flimsy thatched structures are built on the ground and people keeping watch from here are highly vulnerable to attack by elephants.

Causes of crop raiding

a) Raiding and movement pattern : Elephants have certain distinct patterns of movement by which they utilize the optimum habitats during different seasons. It is natural that during the course of such movements they would come into contact with tracts of cultivation in these habitats, There was a clear relation between the movement pattern and the crop raiding pattern of elephant herds. The family herds usually raided the fields in their vicinity in the course of seasonal movements. By contrast, many adult bulls were more deliberate raiders and seemed to adopt a movement pattern which kept them near cultivation for considerable periods of time.

b) Competition for water : In regions where water is a scarce resource, elephants often utilize small irrigation reservoirs or village ponds at night. If they have to traverse a tract of cultivation to reach the water source it is very likely that they would also damage crops on their way. A few examples will illustrate this point. Elephants moving towards the Suvarnavati reservoir (Punjur Range) were seen to cross the villages of Kolipalya, Mudahalli and Budipadaga, in the process damaging the standing crops here. Those coming to the Chickondalli reservoir near Hunsanhalli village (Kanakapura Range) from the north or east have to cross or skirt past cultivation and consequently this area suffers frequent damage.

In the Ramapuram Range there is a 15 km stretch of cultivation all along the southern bank of the Minnattu halla. Elephants inhabiting the dry forest to the north come to this stream for water. They may cross the stream and trample the standing crops on their way to the forest in the south. Of course, the opposite situation is also possible. Elephants may enter cultivation primarily for the crops and incidentally utilize the waters of a nearly pond or reservoir.

c) Habitat reduction and fragmentation : Elephants not only range over large areas on a seasonal basis but may also move over considerable distances every day. If the natural habitat is large enough such daily movements may not bring the elephant into contact with any cultivation. In regions with numerous pockets of cultivation there is hardly room for monoeuvrability. The larger the area of an enclave, the longer would be its boundary with the forest. Thus, there is a higher probability that an elephant would make contact with a larger enclave than with a smaller one due simply to chance alone. The frequency of raiding in larger villages would be higher than in smaller ones and this was certainly true.

The villages of Punjur and Kolipalya (Punjur Range) have expanded in recent years and impeded the free movement of elephants between the BR hills and a Talamalai Range of Tamilnadu. Elephants use the narrow 1.5 km corridor

between these villages during certain seasons. This funneling increases their contact with cultivation and consequently these villages suffer heavy damage to crops.

The acute problem of crop raiding in the Bannerghatta - Anekal - Kanakapura sector can be attributed to the drastic reduction in habitat. The forest cover has been reduced to a long, narrow strip of scrub only 1 to 2 km wide in places. Since elephants are highly mobile animals there is a high probability that they would encounter cultivation once they move through this belt. Herds have even strayed into the town of Anekal a number of times in recent years. Crop raiding and manslaughter are common in this region especially between November and January. On 28 Jan 1985 a herd of 9 elephants from Bannerghatta strayed into a college campus in the suburbs of Bangalore.

d) Degradation of habitat : Large scale exploitation of edible plants such as bamboo may reduce the carrying capacity of the habitat and force the elephants to seek their requirements from cultivated land. However, habitat degradation by itself cannot be the primary cause of crop raiding. Elephants resort to raiding even when there is clearly a surplus of food plants in the natural habitat.

e) Palatability and nutritive value of crops : The ultimate cause of crop raiding is that elephants, geared to optimizing their dietary intake, find the cultivated

crops more palatable than the wild food plants. The grasses are a major component in their diet. Elephants would naturally prefer the cultivated grasses (millets and cereals) which are more succulent and palatable than the fibrous, silicaceous wild grasses. Analysis of the wild and cultivated grasses also showed that the latter provided significantly more protein, sodium and calcium (Sukumar 1985). For instance, the sodium content of ragi (0.94 mg/gm) was much higher than of any of the wild plants analysed (below 0.27 kg/gm). There is evidence that elephants have the sensory ability to detect minerals such as sodium and calcium. This could be an important factor governing their choice of food plants.

CHAPTER - 10 : MANSLAUGHTER BY ELEPHANTS

The elephant is potentially the most dangeoous of the large mammals in the Indian jungles.

How frequent is manslaughter by elephants? What are the circumstances in which people are killed ? Are some elephants more prone to kill than others ? During this study I obtained details of 151 cases of manslaughter which throw some light on these questions.

The people killed

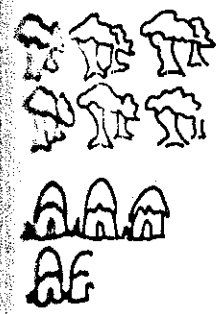
A majority of the people killed were adult men (77%). Only a few cases recorded were of adult women (18%) and children (5%). The victims largely hailed from villages in or near elephant habitat and included farmers, graziers and labourers. Occasionally passers-by get killed; on closer enquiry they were sometimes nomads or mentally deranged people.

In the study area alone 18 people were killed by elephants between Jan 1981 and June 1983. Based on reports of mansaaughter from other regions, I estimate that between 30 and 50 people are killed by elephants every year in South India. About half the cases go unreported officially.

(A) THE PEOPLE KILLED

n = 129

MEN	76.7 %
WOMEN	17.8 %
CHILDREN	5.4 %



(B) PLACE OF ENCOUNTER

n = 120

FOREST	55.8 %
CULTIVATION	44.2 %

(C) THE ELEPHANTS RESPONSIBLE

n = 59

BULLS	81.4 %
COWS	10.2 %
HERDS	8.5 %

FIG. 10.1 MANSLAUGHTER BY ELEPHANTS.

The elephants responsible

To determine the sex of the elephant responsible without any doubt is often impossible, as this knowledge may be restricted to the victim. In a few cases the sex may be indicated by circumstantial evidence; for example, an extremely large footprint invariably pointing to an adult bull, a gored injury to a male tusker, and numerous footprints of various sizes indicating the involvement of a herd (but not necessarily a female elephant).

The only instances where the sex of the elephant is proved beyond doubt is when people accompanying the victim witness the event. Out of 59 cases, both recent and old, where this has been determined, an extremely significant proportion (81 percent) involved sub-adult or adult male elephants.

Considering that there are fewer sub-adult and adult males than females in the population, it is clear that male elephants are far more prone to manslaughter behaviour. Even among bulls there is wide individual variation in aggressive tendencies. It is true that only some of them are habitual killers. In the study area there were two identified rogues , with a history of aggression and killing. In Dec. 1982 and Jan 1983, an adult tusker was involved in 4 or 5 killings near Gudalur in the Nilgiris.

Place, time and circumstances of encounter

Encounters between elephant and man take place in the forest or in cultivated land. Out of 120 cases in which the place was known, 67 cases (56 percent) occurred in the forest while a significant 53 incidents (44 percent) took place in human settlements.

Incidents in the forest usually involved firewood gatherers (often women) or cattle graziers. People walking along forest roads are also at risk. Such may be labourers going to work, pilgrims visiting a small shrine inside the forest, naturalists trying to photograph elephants or just people on their way to a village. There have been stray instances of nomads, mentally unsound people, a drunkard and even a deaf person getting killed. The undergrowth in a forest being fairly dense, people often tend to walk along paths which, in the first place, have been created by the constant use of elephants. Given the poor visibility (sometimes only 5 to 10 m), elephant and man meet unexpectedly at close range. If an elephant,s immediate reaction is to charge there is neither time nor place for exit. Since people venture into elephant forests on foot only during daytime, all the recorded incidents also pertained to various times of the day.

In contrast killings within settlements almost invariably took place during night by crop raiding adult

male elephants. Certain adult bulls respond aggressively to any attempt to chase them away from crop fields. A light shone on them often evokes a charge. This aggressive interaction developed within cultivation could be carried over in the natural habitat. While people sitting up tree-top planforms were safe, those who were foolish enough to guard the fields from temporary thatched structures at ground level were highly vulnerable to attack. An elephant may be allergic to the barking sound of dogs. Farmers sometimes use dogs to warn them of the presence of raiding elephants. If the elephant chases the dog, it would naturally tend to run back to its master, bringing behind it an enraged elephant which might redirect its aggression on the man.

CHAPTER - 11 : HABITAT MANIPULATION BY MAN

Man has made a tremendous impact on the elephant's habitat by reducing the area available to it, and further exploiting the habitat for his needs of timber, fuel wood, food, water, grazing land for livestock, etc. Some of these influences in the study area will be described here.

Reduction in natural forest area

During the period 1880-1980 it was estimated that the expansion of human settlements occupied 170 km^2 in the main study area. This works out to about 15 percent loss of natural habitat, nearly half of which occurred after 1950. The loss of habitat was due to expansion of settlements in the following areas:

(a) opening of coffee plantations in the central ranges

(b) shrinkage in the Hardanahalli RF of Chamarajanagar division

(c) resettlement of Tibetan refugees in Kollegal range

(d) expansion of Punjur-Kolipalya-Budipadaga

(e) resettlement of villagers from the submersion area of lower Bhavani reservoir in the Satyamangalam division.

Timber and fuel wood extraction

Important timber plants in the area include Dalbergia latifolia (rosewood), Terminalia tomentosa, Tectona grandis (teak, not common or of good quality), Pterocarpus marsupium, Albizzia odoratissima and Grewia tiliaefolia. In the Satyamangalam Division, some selection felling is being carried out in the Minchikuli valley (Zone 14). In Chamarajanagar division apart from selection felling, two sites were clear felled in 1981-82 for planting teak. The current working plan for Chamarajanagar division by Setty (1972) envisages an annual selection working of 493 hectares over 30 year period of the plant (1973-74 to 2003-04). If this is implemented a total area of 14800 hectares or 44 percent of the area of the division would be worked. But considering that felling compartments are confined only to the good mixed deciduous forests of the hills (Zone 3 and adjacent), practically the entire area will be affected.

Apart from the forest department's working of small timber, the illicit removal of wood by the villagers for their domestic use and for sale has further affected the natural vegetation. The areas which have been considerably degraded into semi-scrub mainly by small timber removal include Zones 1, 7, 9 (planted later with Eucalyptus), parts of 10, and 18. In Zones 1 and 7,

almost pure, regenerating stands of Amogeissus latifolia (a plant useless as food) testify to the effects of clear felling and fire. Zone 18 shows clear signs of over damage to vegetation - the combined effect of wood cutting by people and browsing by elephants.

Bamboo extraction

The two bamboo in the area are Bambusa arundinacea and Dendrocalamus strictus, the former confined to stream banks and moist localities, and the latter occurring in the drier regions.

In B. arundinacea the entire cohort in a region flowers gregariously; thus the standing biomass in a locality follows a cyclic pattern with a period of 45-50 years. This has important implications for the food supply of dependent herbivores. In the years immediately following the gregarious flowering in a region, the standing fresh biomass would be extremely low, until the new seedlings attain sufficient growth which might vary between 5 and 10 years. On the other hand, since the entire population of D. strictus in an area does not flower at the same time, there would always be sufficient green biomass in vegetative stage. In the Satyamangalam and Chamarajanagar Divisions, B. arundinacea flowered gregariously in 1927-28 and again in 1972-74.

During 1980-83 the quantity of bamboo removed from

the Satyamangalam Division is given below:

1980-81 - 10224 tons (air-dry)
1981-82 - 1564 tons
1982-83 - 4459 tons

These quantities are far below what was originally thought could be supplied to the major consumer - the Seshashayee Paper and Board Ltd. at Erode. This drastic reduction is partly a reflection of the depletion of bamboo in the Division. The gross area and the effective area under bamboo as estimated by Joseph (1969) and Kala (1979) are given in Table 11.1. During this 10-year period the effective area under bamboo in the Satyamangalam Division came down from 33908 ha. to 9625 ha. or just 28 percent of the earlier area. Since Bambusa flowered during this period the reduction could be partly explained by its death. But it was Dendrocalamus that originally constituted the bulk of the effective area (32234 out of 33908 ha.) which has drastically declined. Comparable figures for Chamarajanagar Division have not been obtained but trends are roughly similar.

Grass extraction

The tall grasses of the genera Themeda and Cymbopogon are extracted as raw material for paper pulp manufacture. In Satyamangalam Division the quantities removed were 421 tons (air dry) in 1981-82and 799 tons in 1982-83. In

Table 11.1 - Effective area under bamboos in the Satyamangalam Forest Division

	Area in hectares		Total
	Bambusa	Dendrocalamus	B + D
Year : 1969			
Talamalai Range			
Dense zone	70	1174	1244
Sparse zone	58	1390	1448
Satyamangalam Range			
Dense zone	1105	18487	19592
Sparse zone	441	11183	11624
	1674	32234	33908
Year : 1979			
Talamalai Range			
Dense zone			325
Medium zone			1200
Sparse zone			1500
Satyamangalam Range			
Dense zone			1000
Medium zone			2500
Sparse zone			3100
			9625

From Joseph (1969) and Kala (1979)

Chamarajanagar Division about 2000 tons were extracted annually until 1982, but was subsequently discontinued. The levels of exploitation amounted to only 5 to 10 percent of the net annual primary production in most of the zones.

Minor forest produce collection

The collection and sale of the so-called minor forest products is regulated by the forest department. Rights of collection are given to the Tribal co-operative society. A list of products removed is given in Table 11.2.

Grazing by domestic livestock

According to the figures of the Forest Department the number of grazing licenses issued during 1982-83 in the Satyamangalam Division were as follows:

Range	Cows	Buffaloes	Sheep
Satyamangalam	11193	749	4985
Talamalai	13220	1233	5322
	24413	1982	10307

Livestock densities work out to 21/km^2 in Satyamangalam Range and 36/km^2 in Talamalai Range. These figures must be taken as the minimum density; there are always unlicensed livestock taken along with the licensed ones for grazing in the forest. In the Chamarajanagar Division,

Table 11.2 – Collection of some minor forest produce in the Satyamangalam Division

Plant product	1980-81 tons	1981-82 tons	1982-83 tons
1. *Phoenix humilis* leaves	26	628	594
2. *Terminalia chebula* fruits	41	34	61
3. *Tamarindus indica* pods	56	19	25
4. *Phyllanthus emblica* fruits	269	180	124
5. *Feronia elephantum* fruits	9	10	2
6. *Zizyphus jujuba* fruits	28	4	7
7. *Mangifera indica* fruits	0	15	5
8. *Sapindus emarginatus* fruits	6	18	20
9. *Acacia sinuata* pods	1	0	4
10. *Cassia auriculata* bark	2	1	0
11. *Cassia fistula* bark	0	0	20
12. *Acacia sp.* bark	0	0	53

livestock densities are comparable to the above figures in some areas, but in Zone 3 (the core of the BRT sanctuary), grazing is negligible.

Fire

The study area has a long history of man-made fire (Sanderson 1878). No records are available as to the extent of fire in previous years. From 1981 to 1983 fires occurred mainly between February and April almost exclusively in the tall grass deciduous forests. During this period there were practically no fires in the short grass-browse zones. The most extensive fires occurred in Zones 2, 3 and 6 in the Chamarajanagar Division and to smaller extents in Zones 11, 15, 16 and 17 in the Satyamangalam Division. This can be attributed to the higher standing biomass of tall grasses in the Chamarajanagar area. Fires were generally grass fires and not canopy fires. Most of the fires were deliberately caused by the local people.

The dominance of Themeda cymbaria and T. triandra in the deciduous forests is certainly the result of frequent fires. Phoenix humilis, a palm with a short stem, is a plant characteristic of fire prone areas with poor soil (e.g. Zone 11). Among trees, the fire-resistant Anogeissus latifolia is dominant in the dry deciduous forests. In many areas almost pure stands

of Anogeissus can be seen.

Plantations

Between 1955 and 1981, the total area opened for plantations in the Satyamangalam Division was around 5800 hectares which is 4.3 percent of the total area of the Division. Of these the miscellaneous plantations occupying an area of 2510 ha. include a wide variety of species - Tamarindus indica, Acacia arabica, A. planiforns, A. ferruginea, Ailanthus excelsa, Bombax malabaricum, Pterocarpus marsupium, Terminalia chebula, Pongamia glabra, Azadirachta indica, Albizzia lebbeck and Santalum album. About 1900 ha. of the miscellaneous plantations fall within the study area. In 1962, what began as a Bamboo Plantation Project eventually became a Eucalyptus project. Early attempts at raising bamboo failed largely due to biotic pressures and fire. Such areas were converted into fairly successful Eucalyptus plantations. The total area occupied by these Eucalyptus-bamboo plantations (including a few earlier ones) in 1981 was 3239 ha., all of which fall within the study area. As a whole plantations occupy 5140 ha. or about 7.2 percent of the portion of the Satyamangalam Division coming within the study area.

In the Chamarajanagar Division, the extent of softwood plantations opened between 1956 and 1977 in

Table 11.3 - Area of plantations in the Satyamangalam and Chamarajanagar Divisions

Forest Division	Area in hectares	
	Eucalyptus plantations	Miscellaneous plantations
Satyamangalam Division		
Satyamangalam Range	1009	1208
Talamalai Range	2230	1351
	3239	2559
	Softwood (Eucalyptus + Grevillea	Hardwood (mainly teak)
Chamarajanagar Division		
Chamarajanagar Range	641	?
Punjur Range	592	?
BRT Range	605	?
	1838	c. 200

3 ranges (Punjur, C. Nagar and BRT) was about 1900 ha. These include pure Eucalyptus and mixed softwood plantations. Silver oak (Grevellia robusta) is one softwood species raised in the area. Among hardwood trees, teak is the most important in the division. The total plantation area in the 3 ranges in 1982 was around 2100 ha. or 6.2 percent of the reserve forest area of the Chamarajanagar Division. New plantations were being still raised in 1981-83. Two sites were clearfelled during 1981-82, one near the Kinnare colony and the other near BRT Betta to plant teak. Lately, new Eucalyptus plantations are being confined to the drier, lower elevation tracts in line with the new policy of the Forest Department. The Working Plan by Setty (1972) alloted 15726 ha. or 47 percent of the total area of the 3 Ranges of the Chamarajanagar Division for the Industrial plantation Working Circle. If such a programme is implemented it would drastically change the natural ecology of the region,

CHAPTER - 12 : ELEPHANT SLAUGHTER BY MAN

A considerable number of elephants are killed by man, either in defence of crops or for poaching the tusks. The elephant in South India faces a more serious threat from poachers, than in other regions. With over 90 percent of the males being tuskers (compared to 50 percent in NE India and 10 percent in Sri Lanka), the majority of them die at the hands of poachers.

In the present study the role of man in elephant mortality in the States of Karnataka and Tamilnadu was evaluated. Reliable information from the other southern state, Kerala, was not available; thus some speculations have been made.

The post-mortem certificates maintained by the Forest Department were scrutinized. Complete official records were obtained for the years 1979-1982 in the following Forest Divisions.

Karnataka - Mysore, Bandipur, Chamarajanagar (Study area), Kollegal and Mandya.

Tamilnadu - Hosur, Dharmapuri, Erode, Satyamangalam (Study area), Mudumalai, Gudalur, Nilgiris North, Nilgiris South, Coimbatore Central and Anamalai.

In addition, partial records were also obtained

for these Divisions for 1975-1978 and 1983. The official record represents the minimum number of elephants dying in a given period; the actual number is certainly higher. The main bias in official statistics is the under-representation of male elephant deaths due to poaching. During 1981-82 an attempt was made to collect information on such cases of poaching which did not get recorded. These were either personally confirmed or obtained from reliable sources, mainly the forest department personnel themselves. Records of 396 elephant deaths were obtained for the period 1975-83 and classified under the following categories.

1) Female elephants
   a) Natural death
   b) Death due to gun shot or electrocution in defence of crops
2) Male elephants
   c) Natural death
   d) Gun shot or electrocution in defence of crops
   e) Gun shot, tusks intact, attempted poaching
   f) Gun shot, tusks poached.

Elephants killed in South India

a) Karnataka

The reported cases of poaching in 5 Forest Divisions - Mysore, Bandipur, Chamarajanagar, Kollegal and Mandya - in 1981 and 1982 were 13 and 19 cases respectively, with an

additional 4 males shot each year in attempted poaching. To the best of my knowledge unrecorded cases of death due to poaching were mainly from the Kollegal Division. It would seem that over 80 percent of the discovered poaching incidents in Karnataka go on record.

For the entire state the number of male deaths due to gun shot (both poaching and unsuccessful attempts) in 1982 was about 40 elephants. I do not have complete figures for all the Forest Divisions in Karnataka for other years, but the available records indicate that poaching was at similar levels between 1981 and 1983, but reduced considerably during the first half of 1984 as a result of heightened vigilance by antipoaching squads.

b) Tamilnadu

While 11 cases of poaching were reported in 1981, only 1 case is on record for 1982. To my personal knowledge during these two years there were atleast 18 poaching incidents which went unreported in 4 Forest Divisions alone - Erode, Satyamangalam, Coimbatore Central and Mudumalai. I do not have any such figures for other areas, but circumstantial evidence indicates that poaching was prevalent elsewhere. In June 1981 a gang of poachers was arrested in the Srivilliputhur forest of Madurai South Division. They confessed to having shot a number of elephants though no case is on record. In

March 1983 six poachers were arrested and 5 pairs of tusks seized from them near the Anamalai Wildlife Sanctuary. Here again no poached carcass has been recorded in the two years prior to their arrest. As a conservative estimate about 30-40 tuskers were killed annually by poachers while an additional 5-10 elephants died in attempted poaching or in defence of crops in the State of Tamilnadu during 1981-82.

c) Kerala

For Kerala no reliable official figures of poaching were obtained. It is well known that during the late 1970s poaching was rampant in the Periyar Tiger Reserve. A gang of 200 poachers (ivory and timber) once operated here. The very low number of male elephants in the Periyar population testifies to the high mortality they suffered. The adult sex ratio is 1 male : 20 or more adult females. It is possible that poaching declined here in the early 1980s due to the paucity of tuskers. But poaching is certainly prevalent in other regions of Kerala including Parambikulam Sanctuary.

For South India as a whole, I estimate conservatively that between 100 and 150 tuskers were shot every year by poachers during 1975-83. While the tusks have been recovered in only about 10-20 percent of the cases, atleast 100 pairs were annually lost to poachers.

Proportion of elephant deaths due to man

The proportions of deaths due to various causes among male and female elephants with suitable corrections are shown in Table 12.1 and 12.2. Overall, man is responsible for between 64 and 73 percent of male elephants deaths, the remaining dying of natural causes. A disquieting feature is that even young bulls only 5-6 years with a pair of tusks weighing 2 kg. are falling prey to poachers. Man is also responsible for 19 to 22 percent of female elephant deaths, all of these due to gun shot or electrocution in defence of crops.

The people responsible and their mode of operation

The ivory poaching organization has atleast three links - the person who shoots the elephant and extracts the tusks, the middleman who handles the tusks in transit and the ivory dealer who purchases the tusks for further processing.

a) The people who actually kill the elephant and remove the tusks hail from villages inside or adjacent to the forest. Such may be poor tribals or marginal land owners who have a thorough knowledge of the geography of the area. The hunters may be organized into a large group (upto 30 people have been seen in the study area) or a number of small groups all catering to the same middleman. Such groups may spend most of their time combing the

Table 12.2 - Causes of death in elephants (1981 - 1982)

	FEMALE ELEPHANTS		MALE ELEPHANTS			
	Natural death	Crop defence	Natural death	Crop defence	Attempted poaching	Poaching
TAMILNADU						
Number of elephants	14	7	23	4	1	60
Sex specific %	66.7%	33.3%	26.1%	4.5%	1.1%	68.2%
KARNATAKA*						
Number of elephants	20	1	17	0	8	36
Sex specific %	95.2%	4.8%	27.9%	0%	13.1%	59.0%
TOTAL						
Number of elephants	34	8	40	4	9	96
Sex specific %	81.0%	19.0%	26.8%	2.7%	6.0%	64.4%

*The records for Karnataka pertain only to 5 Forest Divisions (see text)

forest and shifting their camp regularly, returning to their villages only occasionally or when some tusks have been obtained.

The smaller, ill-organized groups shoot with only muzzle-loading guns while the better organized poachers may use modern rifles. Poachers often keep watch at a water hole for elephants to appear and then track them into the forest before shooting them. Some poachers have even used trained dogs to track and separate sub-adult males from the herd. Tusks are carried out of the forest on foot. Only rarely may vehicles be used inside the forest for poaching elephants. For their work they receive only a fraction of the market value of ivory - perhaps only a tenth of the value.

b) The middleman is the crucial link in the illegal ivory trade. He is usually a middle-class man who resides in a small town close to the area of poaching. It is he who initiates the tribals or villagers into poaching and collects the booty. He also has contacts with ivory dealers in the larger cities who are willing to purchase the tusks.

c) The ivory dealer who finally purchases the tusks from the middleman may be a genuine licensed dealer (who is willing to use loopholes in the law to purchase local ivory) or a smuggler who illegally exports the

ivory. Not much seems to be known about the identity of such people.

Some examples I know illustrate this link in poaching. One was a relatively small gang of 5 poachers (2 Sholaga tribals and 3 Lambadis) who hailed from the village of Kolipalya-Irayanpur in the Chamarajanagar Forest Division close to Tamilnadu border. They operated within a radius of 15 km. in the Satyamangalam Division of Tamilnadu. Tusks were handed over to two middlemen at Talavadi (the panchayat or village headquarters), who sold them in Mysore city. Another middleman (probably a relative of the Lambadis) from Komarayanur near Bhavani town also marketed the tusks. Some of them were nabbed in October 1982 by the forest department staff posing as customers.

A much better armed and organized gang of poachers is known to hail from Gopinatham and adjoining villages in the Kollegal Forest Division of Karnataka. This group may consist of upto 30 men operating over a much wider area including the Mandya, Kollegal and Chamarajanagar Divisions of Karnataka and the Erode, Satyamangalam, Nilgiris North and Coimbatore Central Division of Tamilnadu. A well identified middleman from Karungalur near Mettur town is known to have handled most of the ivory procured by this group during the past decade. Kerala

is the major market for their ivory. This organization has successfully managed to evade any deterrent prosecution.

Another gang of poachers from the Kollegal taluk (Keerapathy, Bidarahalli and other villages) in Karnataka also hands over the tusks to receivers in the Mettur taluk of Tamilnadu. These poachers were arrested in Aug. 1985 by the Karnataka Forest Department, though the receivers are still at large.

Poachers take advantage of loopholes in inter-state laws by operating outside their home state and enjoying relative immunity from arrest. There has been a tendency for each state to blame the neighbouring state for poaching within their territory. The truth is that every state has its own share of ivory poachers. While poachers from Kerala operate in the border areas of Karnataka and Tamilnadu, in the Periyar Reserve it is Kerala which is at the receiving end from poachers coming from adjacent Tamilnadu. It has already been mentioned how poachers from Karnataka operate within their own state and across the border in Tamilnadu.

Poaching and the Ivory Trade

Of the 7200 ivory craftmen in India, atleast 3600 of them hail from Kerala and Mysore in the South. Ivory from Indian elephants has never been sufficient to

sustain the demand of carvers. African ivory has been imported for the past many centuries. From 1875 to 1881 about 250 tons of ivory were imported every year (Martin 1980). During 1960-71 this had declined to 37 tons annually. By 1979 the imports had come down to 5 tons (Prasad 1981).

Between 1974 and 1980 the average quantity sold or auctioned by the three southern states came to only a little above 1 ton per year as follows:

State	Quantity sold per year	Years of sale
Karnataka	430 kg	1975-78
Kerala	200 kg	1974-76
Tamilnadu	430 kg	1978-80

Since 1982 the auctioning of ivory has been stopped by Tamilnadu.

What is the contribution of the illegal trade in tusks from poached elephants ? I have already mentioned that between 1975-1983 atleast 100 tuskers have been poached every year in South India. This would have given an annual yield of 190 tusks (assuming that some elephants were one-tusked). The mean weight of a poached tusk was estimated to be 9.5 kg (Sukumar 1985). Thus the 190 tusks would have yielded 1800 kg. ivory. At the 1982 price of Rs. 1500 per kg., the total annual value of the

poaching trade is Rs.2,700,000. This should be taken as a conservative figure. In view of the low quantity of legal ivory released by the Forest Departments, the ivory obtained from poachers assumes great significance for the trade in South India.

CHAPTER - 13 : PRINCIPLES OF ELEPHANT CONSERVATION

In this chapter, I shall discuss certain principles of elephant conservation in broad terms which can be used as guidelines in management planning. In the next chapter, I shall make specific recommendations for management of the Nilgiris-Eastern Ghats region.

Minimum viable population size

Any animal population in the wild undergoes normal fluctuations in response to extrinsic or intrinsic factors. It is well known that a species whose population dips below a certain viable size is prone to extinction due to stochastic events such as a disease epidemic or adverse climate (Shaffer 1981, Soule and Wilcox 1980). This viable size varies from one species to another.

There is also the consideration of the genetic viability of a population. In small populations the gene frequencies change randomly from generation to generation with a fixation or a loss of alleles. This process is known as genetic drift. Ultimately, this leakage of alleles leads to an increase in homozygosity (Frankel and Soule 1981). The central question in conservation

genetics is the relationship between genetic variation and the fitness of the species. This can be considered both on a short-term and a long-term scale.

In the short-term the most serious consequence of an increased homozygosity is inbreeding depression (Ralls et al., 1979, Soule and Wilcox 1980, Frankel and Soule 1981). The immediate effect of intensive inbreeding is a loss of fitness - lowered fertility, higher juvenile mortality, depressed growth, etc. Based on experiences with breeding of domestic mammals, it has been suggested that a minimum of 50 effective breeding individuals is needed to keep inbreeding depression to a negligible level of below 1 percent inbreeding per generation (Franklin 1980).

The issue of long-term fitness of a population, in terms of evolutionary potential, is still rather speculative. There have been attempts to derive the minimum population size above which the effects of genetic drift can be countered through natural selection or by gain from mutation (Franklin 1980, Frankel and Soule 1981). From both angles a figure of about 500 effective breeding individuals has been derived. Populations maintaining this effective size can be expected to remain viable from an evolutionary viewpoint.

A clarification has to be made here regarding the effective population size . The census figure N for a

species constitutes the genetically effective population size N_e only under idealized conditions such as an equal sex ratio of breeding individuals, an equal number of progeny per mating pair per generation and no fluctuation in population size. Of these the most important issue for elephants is the sex ratiol Due to a higher mortality of male elephants (compared to females) due to natural causes and poaching, the sex ratio of adults is usually unequal. At best it may be 1 male : 2 females; at worst it may go upto 1:20 or even more disparate as in parts of South India. The more unequal the sex ratio, the greater will be the amount of genetic drift. The formula for calculating the effective population size N_e is given by

$$N_e = \frac{4 N_m N_f}{N_m + N_f}$$

where N_m and N_f are the number of breeding males and females respectively. The more skewed the sex ratio, the lower will be the value of N_e.

What are the implications of conservation genetics theory for the elephant populations in India. In South India the largest population inhabiting the Nagarhole-Nilgiris-Eastern Ghats belt consists of 3600-4300 elephants. Of these 7 percent were adult males and 35 percent adult females. Thus, there were atleast 252

males and 1512 females capable of breeding. Using the formula given above this translates into an effective population size of 840 breeding individuals - a comfortable level to counter the loss of genetic variation through drift. Unfortunately, the same is not true of other elephant populations in south India. Large populations do exist in the Anamalais and the Periyar plateau, but rampant poaching especially in the latter area has drastically reduced the number of male elephants resulting in a highly disparate sex ratio. These populations certainly have sufficient numbers to counter inbreeding depression. Similarly other populations such as in Bhadra-Malnad may maintain an effective size of over 50 individuals.

In northeast India the three large populations are those in the Arunachal Pradesh-north Assam region, the Kaziranga-Naga hills, and the Garo hills - Khasi hills of Meghalaya. Since 50 percent of the male elephants are makhnas (Tuskless males) the sex ratio is not likely to be as highly skewed as in south India due to pressure from poaching, though the frequency of makhnas could increase in the population.

Minimum viable area and habitat integrity

This leads to the related concept of the minimum viable habitat area necessary for the long-term survival of a species. The principles of island biogeography as

enunciated in the classical work of MacArthur and Wilson (1967) have been extended to the design of terrestrial nature reserves (Wilcox 1980). The fundamental principle is that in a smaller island area the rate of extinction of species will be higher than in a large area. In an insular habitat the species most vulnerable to extinction are usually the K-selected ones with low reproductive rates and those at the summit of trophic levels. The question of new colonization of habitat patches, while possible for taxa such as birds, does not usually arise in the case of elephants. It is a matter of either having one large elephant population ranging freely over a large area, or allow it to break up into a series of smaller populations in fragmented patches. Clearly for the elephant a single large area is desirable.

What would be the minimum viable area for the conservation of the elephant This is related to the minimum viable population size and to the carrying capacity of the habitat. Assume that the minimum size needed is 500 breeding individuals and with the prevailing sex ratio (1 adult male : 5 adult females) this translates into a total population size of 2200 elephants. Further assume that the crude carrying capacity of a given area is 0.5 elephants/km^2 and the population is close to this level. A minimum area of 4400 km^2 would be needed for its long-term conservation. This area

would vary with different values of the parameters; the above typical situation is merely to give an idea of the scale at which one should think when planning reserves for elephant conservation.

For a species with a large home range and a need for seasonal movement from one habitat type to another, further human encorachment reducing and fragmenting the habitat would affect the conservation prospects. Habitat reduction also intensifies the incidence of crop raiding by elephants. Agents of habitat fracture in South India are mainly agriculture and dams. In the Eastern Ghats the numerous enclaves of cultivation have made large dents on habitat integrity. All over the Western Ghats tea and coffee plantations have made considerable inroads into the natural habitat. These are mainly responsible for the discontinuity in elephant distribution in South India. In recent years a portion of the elephant habitat on the southwest of the Nilgiris (Nilambur-Attapadi) has been virtually cut off from the larger Nilgiri-Eastern Ghats region by tea plantations in the Gudalur division. Hydroelectric and irrigation dams are common all over the Western Ghats. These have submerged river valleys which are prime habitats for elephants. Many such projects, as in the Anamalai hills of Tamilnadu-Kerala, have also disrupted the traditional movement pattern of elephants and served to

localize herds to smaller areas.

It has been suggested that a disease epidemic is likely to cause the extinction of an entire animal population in a large area. If distributed over numerous smaller habitats, the species as a whole would still survive even if one population becomes extinct. This point is valid. But it is not a justification for fragmenting a large area if the option to retain it intact is available. The Asian elephant today exists over a broad area of the Indian subcontinent in a number of discrete populations. It is in that sense buffered against extinction through an epidemic in one region. Thus an effort should be made to keep intact as many large areas as possible along with a number of smaller viable ones. Then one would not run the risk of keeping all the eggs in one basket .

Maintenance of Habitat Quality

The habitat has to provide the basic resources of food and water for elephants. In most areas elephants have to share these resources with people. Human manipulation of the habitat has in many areas altered the vegetation structure from primary or climax stage to secondary or early seral stages. What are the consequences of this change for elephants ?

It is well known that the highest herbivore densities

are often found in habitats manipulated by man. For instance, in the Serengeti region man's impact through burning of the grassland and grazing of domestic livestock is ancient. The highest animal densities are found in such areas of past and present pastoral activity (Bell 1971). Conversion of a climax vegetation such as the evergreen rain forests to secondary forms causes a corresponding increase in elephant density (Oliver 1978). In a climax rain forest the bulk of the plant biomass is trapped in the upper canopy and unavailable for animals. In secondary vegetation, pioneer and light demanding r-selected plants such as grasses, bamboos and Kydia calycina provide abundant food for elephants.

A model depicting the changes in carrying capacity and elephant density along two gradients in vegetation is shown in Fig. 13.1

a) Across forest types : Elephant density increases from evergreen forest through the semi-evergreen type only until the deciduous forest. Beyond this there is a decline as the vegetation progressively changes into poor scrub.

b) Within forest types : The process of change from climax to early seral stage does not elicit the same response in the different vegetation types. The highest relative increase in carrying capacity may occur in the evergreen forest, but beyond the deciduous forest it is

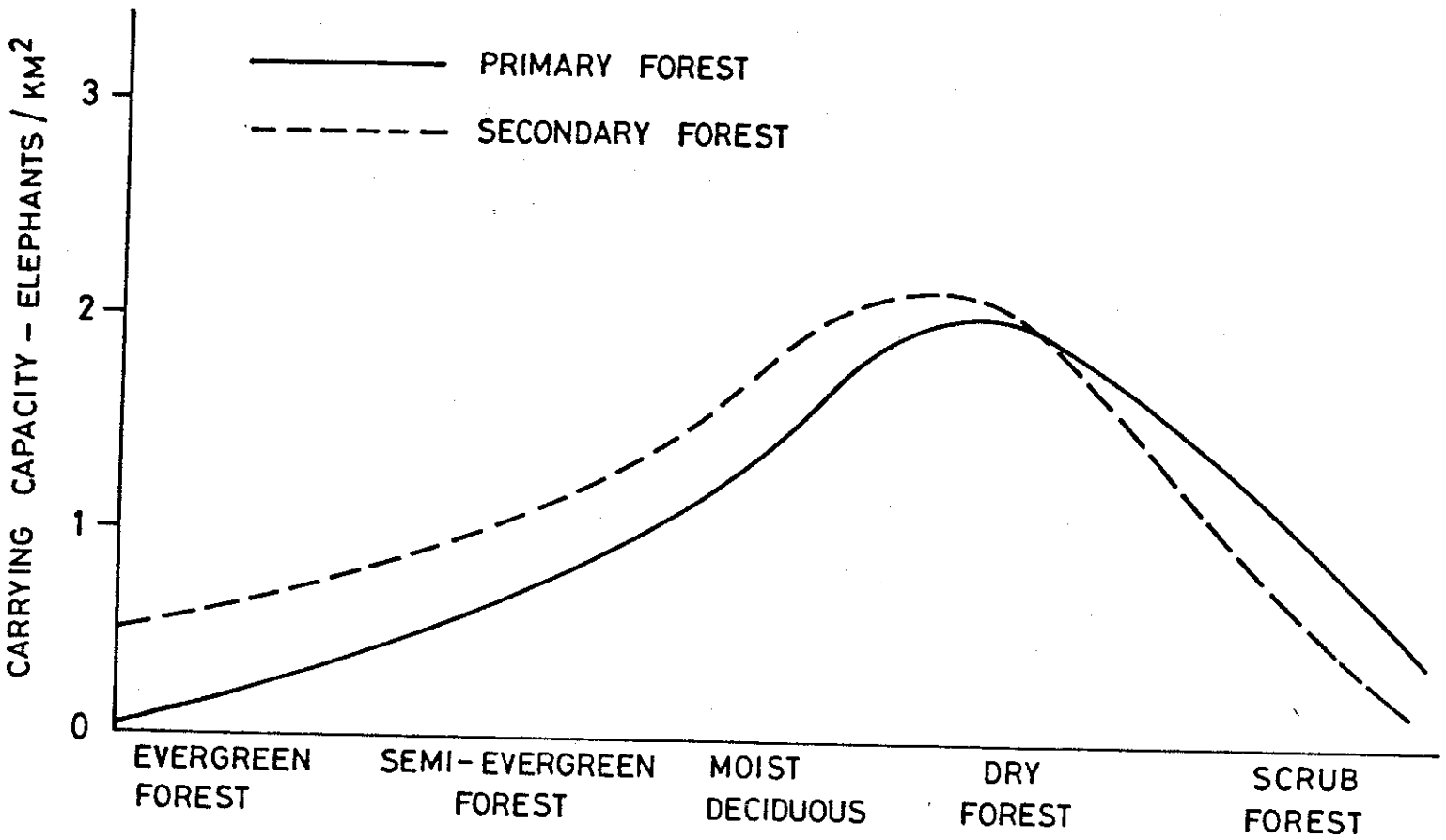


FIG. 13.1 CARRYING CAPACITY OF PRIMARY VERSUS SECONDARY FOREST.

unlikely that this trend would continue. Xerophytic vegetation is characteristically short statured and ensures a high proportional browse availability for elephants. Further exploitation of the dry zone scrub would reduce the carrying capacity. This model, of course, does not take into consideration other factors such as water availability. A scrub habitat along a perennial river may support a higher density than a dry deciduous forest with scarcity of water.

Undoubtedly, the optimum environment for elephants is one with a diversity of habitat types. This would include the moist and dry deciduous forest, scrub thickets (which provide abundant leguminous browse shrubs such as Acacia spp.), riverain or gallery forest and patches of swampy grasslands. Alluvial floodplains of large rivers are also favoured when associated with a habitat mosaic. This diversity in habitat types enables the elephant to optimize its diet depending on seasonal changes in plant phenology. A pure grassland is a sub-optimal habitat since elephants also need browse.

It is often inevitable that elephant and man have to share the habitat and resources. Human land-use need not always be incompatible with the elephant's need. It is not possible to generalize for all areas; each situation has to be considered separately.

(a) Selective feeling of timber trees is not detrimental to the elephant. In certain moist vegetation types this may actually create a more favourable habitat. However, it would be prudent to leave a certain proportion of the area untouched (atleast 50 percent) and work only the remaining portion for timber.

(b) Clear felling of forest and disturbance to the undergrowth invariably results in invasion by noxious weeds such as Lantana and Eupatorium. This is undesirable as both these weeds are not consumed by herbivores and further suppress the growth of native plants. With the intensive exploitation of bamboo in many areas, it is possible that Lantana may now be occupying its niche. In many monoculture plantations of teak and Eucalyptus the undergrowth is chocked with these useless weeds.

(c) Many monoculture plantations have a lower carrying capacity than the natural forest. Grevellia plantation is an example since this plant is not eaten. Elephants may adapt themselves to certain plantations such as teak, provided the understorey vegetation has sufficient food plants. The Nagarhole National Park has a high elephant density even in the teak plantations. This should not be taken as a justification for raising plantations on a large scale elsewhere. In many instances other disturbances associated with plantations may depress herbivore densities.

Though elephants feed to a certain extent on the bark of Eucalyptus, the prime deciduous forests should not be replaced by monoculture plantations of Eucalyptus. Such plantations certainly have a much lower food availability since the undergrowth is also invaded by weeds. Eucalyptus may be used to revegetate the highly degraded dry regions, especially in the border of forest and village.

(d) During forestry operations often the shrubs and young trees are cleared leaving only the mature trees. These gaps are planted with other species. It is usually reasoned that the natural tree cover has not been disturbed. Such an argument is not valid since it is the young trees and shrubs removed which are preferred by elephants. I must strongly emphasize this point since shrub Acacia, Albizzia, Zizyphus, Grewia, etc. necessary for elephants are often removed. Such dense scrub thickets (usually Acacia spp.) provide elephants with significant quantities of browse.

(e) Exploitation of tall grasses may be permitted to a limited extent especially along road sides during the dry season. This might reduce the risk of fire and also act as natural fire breaks. Excessive exploitation may cause destruction of saplings, open the undergrowth for weeds and lead to a depletion of nutrients from the ecosystem.

(f) The role of fire in altering the plant community needs further study. Burning of grassland in the African savannas helps in maintaining a high diversity and density of grazing ungulates. In the deciduous forests of South India, too, elephants prefer to feed on freshly growing grass in burnt areas after the rains commence. However, the effect of fire on the woody vegetation has to be also considered. In particular, the deflection of the woody plant succession towards a fire climax may be undesirable if unpalatable trees such as Anogeissus latifolia become dominant because of their resistance to fire.

(g) Should wildlife managers purposely manipulate the habitat so as to maintain a high carrying capacity for elephants I personally consider human attempts at management of natural habitats and animal populations unnecessary except under certain pressing circumstances. As argued earlier, habitat manipulation is likely to increase carrying capacity only in evergreen-moist deciduous vegetation. Tropical evergreen forests represent a relatively stable climax with their own unique assemblage of plants and animals. It is unwise to disturb this community for the sake of increasing elephant numbers. In the dry deciduous and xerophytic vegetation any conversion to secondary forms will not benefit the elephant.

The indiscriminate creation of water holes is also

not desirable. This may artificially boost the population size of elephants for a certain period, but also result in increased crop raiding, damage to trees and eventually a crash in numbers during a severe drought. Elephant populations must be allowed to regulate themselves at the carrying capacity levels of the natural habitat. Where elephants range over a sufficiently large area, it is not necessary to manipulate the habitat even if this means that they will exist at only a low (but viable) density. If elephants are confined within a small area, then some management may be justified to maintain a viable population size.

CHAPTER - 14 : RECOMMENDATIONS FOR CONSERVATION

The main aim of this study was to analyse elephant-man interaction and explore means by which elephant and man could co-exist with only a minimal conflict of interests. The only way the elephant could survive in the long-term in a developing country with a tremendous human population living mostly at subsistence levels is through its acceptance by the people who share its habitats and resources. Any grandiose plan for the conservation of wildlife without adequate provision for human interests is doomed to fail. Conservation in developing countries often has to be a compromise between scientific idealism and practical reality.

In this chapter, I shall make certain specific recommendations for management of the main study area (Chamarajanagar and Satyamangalam Forest Divisions). A few issues pertaining to the larger Nilgiris-Eastern Ghats region will also be mentioned. Some recommendations for the provision of corridors for elephant movement in the Nilgiris have already been made by Davidar and Davidar (1981) and these will not be repeated here.

I. CONSERVATION OF THE ELEPHANT POPULATION

(a) Preservation of habitat integrity

The Nagarhole-Nilgiris-Eastern Ghats belt with a continguous forest area of over 10000 km^2 offers one of

the best prospects for the long-term conservation of the elephant. Habitat continuity has to be maintained throughout this region. Any future land-use should ensure that corridors are available for the free movement of elephants.

In the main study area the critical placea are the following:

Satyamangalam and Nilgiris North Divisions (Tamilnadu)

Moyar valley corridor :- The Moyar valley is an important link between the elephant habitats of the Nilgiris and the Eastern Ghats. In fact, it is the meeting place of two distinct geographical formations - the Western Ghats and the Eastern Ghats of peninsular India. There is a plan for a major highway through this valley linking Satyamangalam with Mudumalai which has been held up by the Forest Department. Further, a railway line has been proposed between Mettupalayam and Chamarajanagar. This line, for which a survey has been carried out, would run through the valley and up the steep face of the Eastern Ghats for a distance of 80 km. Its economic viability seems to be very low. If these projects are carried out they would cause considerable disturbance to this critical habitat. Also the railway line would be an obstruction to elephants moving down from the Eastern Ghats to the valley for the perennial waters of the Moyar.

Chamarajanagar and Kollegal Divisions (Karnataka)

Kolipalya-Punjur corridor :- The narrow 1.5 km strip of jungle between the villages of Kolipalya and Punjur (Zone 7) is heavily utilised by elephants moving between the Punjur Range and Talamalai Range. The Chamarajanagar-Satyamangalam highway also passes through this area. This corridor has to be preserved at all costs; if necessary some marginal lands from these villages may be acquired for widening it. Uncultivated land at Punjur may also be acquired and the owners compensated.

At present a small dam is under construction on agricultural land at Mukanpalya-Kolipalya. There are plans to supply water through a canal or pipes to adjoining villages including Punjur. It must be ensured that these do not obstruct the movement of elephants. I must strongly emphasize that the corridor between Kolipalya and Punjur is used by 100-200 different elephants in the course of their seasonal movements.

Budipadaga-Mudahalli corridor :- Elephants going to the Suvarnavati reservoir often use the corridor between Budipadaga and Mudahalli (Zone 7). The Forest Department is presently raising plantations within fenced plots. Elephants sometimes break these fences in their passage. Due provision has to be made for their free movement.

Bekkatur-Arabikere corridor :- The elephant habitat to

the east of the Biligirirangans in the Kollegal Range has been sliced by a long belt of cultivation extending from the town of Kollegal southwards to Bailur (nearly 50 km distance) at the interstate border. The Doddasampagi RF of Kollegal Range has been virtually separated from the Ramapuram Range. Only a narrow 1 km forest corridor now exists between the villages of Bekkatur and Arabikere along the Kollegal-Satyamangalam highway. This corridor has to be retained.

In other parts of the Nagarhole-Nilgiris-Eastern Ghats, some critical areas are the following:

Karnataka

Kakankote-Begur :- The Kabbini reservoir and resettlements have left only a 6 km corridor between the important elephant regions of Nagarhole and Bandipur along the Kabbini river. This stretch is a very high density elephant area especially during the dry season. Large numbers of elephants cross over between Kakankote and Begur. A plan to situate a luxury hotel in this stretch has been wisely shelved. This corridor must be preserved at all costs.

Mangala village - Moyar gorge :- To the east of Bandipur, the forest boundary along Mangala village extends south right upto the edge of the Moyar river gorge. There is potential for considerable movement of elephants between

the Moyar RF of Bandipur and the Talamalai RF along the northern side of the Moyar river gorge. A corridor of atleast 200-300 m must be retained here along the southern portion of Mangala village (since the gorge is an obstruction for elephants).

Kerala

Nilambur-New Amarambalam :- The link between the Nilambur and the New Amarambalam forests is fairly narrow and confined to the SW slopes of the Nilgiris. There is the danger that further development along the Gudalur-Calicut highway could sever this link.

Tamilnadu

Mudumalai-Nilambur :- The opening of tea plantations in the Gudalur Division has severed the forest link between the Benne RF of Mudumalai and the Nilambur RF (Kerala). Elephants are reported to move through the plantations and the small forest patches remaining. Recommendations for a corridor have been made by Davidar and Davidar (1981) but the feasibility of such a long, narrow corridor is in doubt if provision is not made to prevent elephants from straying into the adjoining plantations/cultivation.

Masinagudi-Singara and Revenue forests in Sigur Range :- The recommendations of Davidar and Davidar (1981) for declaring the revenue forests in this area into reserve forests must be implemented to prevent the severing of the existing corridors.

Mettupalayam-Coonoor road :- The habitat narrows to a bottleneck along this highway. The possibilities of acquiring some cultivated land at the foothills must be examined so that the corridor can be widened.

(b) Maintenance of habitat quality

Not only must sufficient area be set apart for elephants, the quality of the habitat should also be maintained close to optimum conditions. It is also important to maintain a diversity of habitat types. The following zones need special attention.

Grassland habitat of Dasarpallam (Zone 16 - Sathy Division):- One habitat type practically absent in the area is the swampy grassland (such as the Vyals of the Nilgiri Wynad). The only region that comes closest to a lowland grassland is the Dasarpallam area of Talamalai Range. This zone has been partly planted with Eucalyptus. It is strongly recommended that after the present Eucalyptus crop is harvested there should be no further planting. This entire zone of 12 km^2 should be maintained as a grassland, if necessary by suitable manipulation to prevent excessive regeneration of woody plants.

Riverain habitat of the Punjur-Hasanur valley (Zone 12 - Sathy and Chamarajanagar divisions):- The valley along the Araikadavu stream between Punjur and Hasanur is a prime habitat with the highest overall

elephant density in the study area. The necessity for maintaining this habitat intact cannnt be overemphasized. This valley (especially the water in the stream) is a life line for the elephants here. During 1981-83 some Eucalyptus plantations were raised here both on the Karnataka side (Punjur range) and the Tamilnadu side (Satyamangalam division). All further clearing of the undergrowth and planting with Eucalyptus should be stopped here. The open patches are natural features existing for over a century and should not be used for plantations. Apart from the critical water source, the dense growth of numerous species of Acacia provides abundant food resources for elephants. To the immediate south of Punjur the uncultivated hillock with poor scrub may be planted with suitable species.

Mixed deciduous forests of BRT Sanctuary

(Zone 3 - Chamarajanagar Division) :- The core of the BRT sanctuary contains a relatively well preserved mixed deciduous forest. In recent years these have been cleared for raising plantations of teak, silver oak and Eucalyptus near BRT Betta, Bedguli and Kinnare colony. It is advisable to stop raising plantations any further in this area.

(c) Regulation of forestry operations

1) Raising of Eucalyptus plantations may continue in the lower elevation scrub habitats. These include Zones 1

and 7 (Chamarajanagar Division), and Zones 8 and 9 (between Talavadi and Talamalai in the Satyamangalam Division). Further area should not be cleared in Zone 15 (Satyamangalam Range) for raising Eucalyptus.

2) The bamboo resources have been clearly overexploited in the entire area. To allow healthy regeneration it must be ensured that the contractors strictly follow the standard silvicultural practices. It may be necessary to stop commercial exploitation for a period. Detailed recommendations on bamboo exploitation are given by Prasad and Gadgil (1981).

3) Collection of most of the minor forest produce may be allowed. However, the removal of bark of Acacia spp. has to be stopped.

4) The present levels of grass exploitation amount to only 5-10 percent of the primary production. Firm recommendations on this issue cannot be made without further study on all the consequences. Extraction in different habitats has to be regulated so as to cause only a minimal disturbance to the wildlife. It is recommended that grass is not removed from the Dasarpallam area (Zone 16) of Talamalai Range, since elephants utilize this habitat during the early dry season (Jan-Feb) when the cutting is usually done.

d) Fire protection

Fire may be a necessary evil in the tall grass deciduous forests. If an area does not burn for a few consecutiveyears, the accumulated grass biomass may actually fuel a more intense fire later. Elephants also largely avoid the unpalatable grass in unburnt areas. Since practically no quantitative information is available on the ecological effects of fire in the forests of South India, I cannot make firm recommendations. Perhaps it would be advisable to let areas burn by rotation every 2 or 3 years.

e) Reduction in competition for water

A limiting factor for elephants in the study area is water. Many of the important water sources are adjacent to cultivation where elephants and people come into conflict. In the BRT Sanctuary there are two ponds where human occupation is threatening the elephant's access to the waters.

1) The large Somesvarana tank at BRT Betta (Zone 3) is a perennial water source that does not dry up even during a drought. This tank has been used by elephants for centuries. The tank has been partitioned into two smaller tanks by a bund. The importance of this source was clearly seen during the drought of 1982-83. During Apr-May 1983 there was a heavy influx of elephants into

this area when most of the other sources and dried up. Elephants were forced to use the smaller pond on the southeast only in the late evening or at night. In recent years human settlements (which could have been easily made elsewhere in BRT Betta) have encircled a large portion of the tanks restricting the elephants access to the smaller pond at only one place. The forest department maintains a nursery nearby. Further release of land arounid the tank should be stopped and the corridor to the waters preserved.

2) The pond at Kyatedevaragudi is another source often used by elephants. Here also in recent years there has been an increase in settlements by the Forest Department. People often chase away elephants coming to the pond. The nursery and some residential quarters may be shifted to Kinnare colony.

In a few places the Forest Departments may also undertake deepening of existing ponds (see Table 3.1) or creation of new ponds. I do not recommend the creation of check-dams or ponds on a large scale. I have observed that many check-dams constructed in sanctuaries have silted up in a short while and hold absolutely no water during the dry season due to the poor choice of location. Further, some have been constructed in areaswhere they are not necessary. For instance, in the Mudumalai Sanctuary there are check-dams

(without water) very close to the perennial Moyar river. This is merely wasteful expenditure. The concentration of ponds in the tourism zone of Bandipur National Park is already very high and no ponds need be further opened.

f) Tourism in sanctuaries

All new infrastructure for tourism in sanctuaries/ national parks should be located outside the forest. In recent years the tourism infrastructure has increased considerably in Mudumalai sanctuary, especially at Theppakadu. The resident human population is also increasing. There should be a freeze on further tourism development. The practice of allowing entire bus loads of visitors inside the sanctuary must be stopped. Tourists should not be allowed to get down from vehicles (except at watch towers) or indulge in shouting and other antics which would disturb the animals.

g) Reduction of poaching

The levels of poaching observed during 1980-1983 are certainly high and would further widen the already disparate sex ratio (Chapters 5 and 12). It may not be possible to completely eliminate poaching - the manpower required for this would be extremely high and, perhaps, not justifiable.

During 1982-83, the Karnataka Forest Department set up special anti-poaching squads to camp inside the

forests and regularly patrol the area. This did bring down the incidence of poaching in many areas.

At present some of the constraints faced in dealing with poachers are:

1) The Forest Departments do not have sufficient staff in some areas. In the Satyamangalam Division a forest beat with an area of 30-80 km^2 is patrolled by only two guards.

2) The poachers may be better equipped with modern arms. Forest guards in Tamilnadu are unarmed. Only a few guns may be available in an entire Forest Division.

3) Since involvement with forestry operations takes up most of their time and energy, the staff do not devote sufficient attention to protection. To be effective, protection has to be a full-time job.

4) Even if poachers are caught they often get acquitted or receive only a light sentence from the courts. The Forest Department should strengthen its capabilities for effective prosecution.

In Tamilnadu there is an urgent need to improve anti-poaching vigilance. The Forest Department may set up special squads based on the pattern in Karnataka. To sufficiently motivate, the guards they should be provided with camping equipment, arms, food provisions,

special pay allowances and rewards for capture of poachers. Further, all cases of poaching must be brought on record on and not hushed up . The lower staff should not have the fear of suspension if they report a poaching case. Hushing up only has the opposite effect of further encouraging the poachers. The department may also experiment with trained dogs to track down poachers. It would also be profitable to concentrate on nabbing and prosecuting the middleman (receivers of tusks). An intelligence network may be set up for this purpose.

II. RECOMMENDATIONS FOR THE PROTECTION OF HUMAN INTERESTS FROM ELEPHANTS

a) Prevention of crop damage

Either elephants should be prevented from entering cultivation by means of suitable barriers or else they should be discouraged from entering and chased away through psychological tactics.

1) Barriers to elephant entry :- The two factors that have to be evaluated regarding any proposed barrier is its effectiveness in keeping away elephants and the cost involved in relation to the economic returns.

High volgage electric fence :- Electrified fences that deliver a severe shock to the animal but do not cause any fatal injury have been in existence for nearly 50 years.

They have been used to keep a variety of mammals away including predators from waterfowl nests to elephants from plantations in Malaysia (Blair 1980). In Nov. 1982, an FAO consultant on electric fences, R.L. Piesse, visited India to advise on construction of such fences. I am indebted to him for the following technical information (Piesse 1982).

The fence essentially consists of one or more strands of high-tensile galvanized steel wires strung at appropriate heights (1 to 2 m for elephant) above the ground by hardwood posts. The posts are protected by vertical wires and insulators may be provided at places where the wires scome into contact with the posts. The heart of the fence is the Energiser which passes every second an electric pulse of 5000 volts at a duration of 3/10000 second. Due to the high voltage but short duration of the electric pulse, any animal coming into contact with the wire receives a severe jolt but is is no danger of dying or even any serious injury. The energiser may be powered by a 12 V car battery, from the 230 V mains or even by solar cells.

Each energiser can power upto 50 km of fencing but due to drop in voltage over long distances it may be necessary to incorporate more than one such unit. The costs of material and labour for the fence itself are between Rs.3000 to Rs.8000 per km. depending on the

number of strands used and the sophistication of design. Thus, for the 10 km perimeter of Hasanur village the total cost of electric fencing including energiser and a control box could work out to between Rs.40000 and Rs.90000. In addition, a qualified electrician has to be employed for operating and maintaining the fence. There will also be some maintenance cost.

Numerous experiments with elephants in Africa (Piesse pers. comm.) and Malaysia (Blair 1980) have shown that electric fencing is generally effective. During a period of 32 days in 1982, a total of 259 elephants made 184 contacts with an electric fence in Namibia Etosha, but not a single elephant got through. In Malaysia a few thousand kilometers of fencing have been erected around oil palm and rubber plantations. Early experiments during 1980 showed that only one bull elephant consistently broke through by rearing up on its hind legs, placing its forefeet on the upper wire and pressing it down. Another trick that a bull may try is use its tusks (a non-conductor) to break the wire or prise an insulator (newer designs do not use insulators). It must be emphasized that the electric fence is not strictly a physical barrier but more of psychological bluff.

In India, about 20 electric fences are currently in operation.

Trench

To effectively prevent elephants from crossing it, a trench has to be atleast 7 feet (2.1 m) deep, 7 feet across at the top and 5 feet across at the base. If the dimensions are even a few inches shorter, an elephant may be able to get through. Elephants may also dig the soil with their forefeet, fill by the trench and then cross over. Of the few trenches in the study area I recorded instances of adult bulls crossing in every one of them. Trenches are especially liable to fail in wet conditions when the soil is loose. In Malaysia trenching has been given up as a failure.

The cost of digging a trench to the above specifications is Rs. 25000 to Rs.40000 per running km. An improved trench with stone lining to prevent it from collapsing would cost over Rs.100,000 per km.

Other barriers

Numerous other barriers have been suggested including a sausage barrier of boulders held together by a wire netting, a rubble wall in conjunction with a trench, a wall consisting of a series of stone slabs, a fence of iron pipes, a spike barrier with galvanized nails and so on. The main constraint is the prohibitive cost going anywhere from Rs. 300000 to Rs.600,000 per km.

questioned many of the farmers replied that it was not worthwhile to cultivate sorghum or maize because of the elephant problem. They were content with raising a single crop of ragi during the year Any investment made on elephant barriers could also substantially boost the productivity of the cultivable land. The value of this increased production would exceed the total value of damage to existing crop production by elephants.

Any scheme to prevent crop damage should be combined with an integrated programme of improving production, growing fuel wood and fodder trees, etc. There is an urgent need to initiate such a programme in the study area. As a beginning the energised electric fences should be tried out in some villages and if proved effective under local conditions extended to all the enclaves of cultivation and also along the outer forest-cultivation boundary. For the present any of the costlier methods such as trenching may be confined to smaller enclaves. Trenching on a large-scale is not justifiable due to its enormous cost and high risk of failure. There is a need to experiment with various methods before adopting the most suitable one.

Methods to discourage elephants from fields

1) Experiments may be initiated with chemicals which repel elephants. Blair (1980) reported that samples of

Cost effectiveness of barriers

Clearly the high voltage electric fence is the cheapest method. Taking Hasanur as an example the upper limit to the capital cost of fencing would be less than Rs.100,000 with a recurring annual expenditure of Rs.10000 for maintenance and wages for an electrician. Against this the damage to crops amounted to Rs.57000 in 1981. The capital investment could be recovered within 2 years. Each year the value of crops saved would be atleast 5 times the recurring costs of maintaining the fence. In other large villages such as Talamalai or Chikkahalli the cost effectiveness would be lower. But the damage intensity of 1981 could very well change during other years. An annual return of 20 percent of the capital investment would be a worthwhile proposition.

Many other factors have to be considered in evaluating cost effectiveness. Farmers spend money in devices to chase away elephants. The wage potential due to loss of manhours of labour in a village would be atleast 40 percent of the value of the crop produce lost. Another very important point to be realised is that farmers do not cultivate a good proportion of the land due to fear of depredation by elephants. Such lands are usually close to the forest boundary. During the first wet season (May-Aug) only a negligible fraction of the cultivable land area (less than 5 percent) was used. When

the German chemical Hate 4C were being shipped to Malaysia for research on its effectiveness against elephants but no further information is available. However, such chemicals cannot be used over large areas effectively.

2) Seidensticker (1984) recommended the creation of wide buffer zones which lack any cover or suitable food resources between cultivation and natural habitat to discourage elephants from using these areas and, hence, avoiding contact with cultivation. This principle CANNOT be applied to most elephant regions. Any such buffer zone can only be created in the existing natural habitat, which has already reduced so much that further loss of habitat cannot be accepted. Further, elephants especially adult bulls would certainly use the cover of night to cross these buffer zones and enter cultivation. Elephants which are habitual crop raiders cannot be kept away by any such simple bluffs.

3) Some changes in the crop pattern could also be examined. It is very difficult to change the traditional pattern of cultivation in rural areas. Farmers grow ragi because it is their staple food crop more than anything else. Attractive schemes should be designed in consultation with agricultural universities to make them grow crops not consumed by elephants. They should be provided with the staple food grains at subsidised rates.

Oil seeds such as niger and gingelly are potential candidates for replacing millet crops.

b) Compensation and crop insurance

In Karnataka farmers are eligible to get compensation for damage to their crops due to elephants. The problem with a compensation scheme is to get a realistic assessment of damage. Most farmers tend to wildly exaggerate the quantum of damage. At present the Forest Department staff have to inspect damaged fields and they are already burdened with their regular duties. On the whole only some farmers finally get any compensation.

Crop insurance schemes could also be extended to cover damage by elephants and other wildlife. However, compensation and insurance can only be temporary substitues for actual prevention of crop damage.

c) Translocation of villages

The haphazard land-use pattern has resulted in patches of isolated forest which the elephants cannot utilize. Such areas are excellent places to which some of the acutely affected villages can be translocated. In Tamilnadu three such forest patches are the Akkurjorai RF (Talamalai range), Barabetta RF (Satyamangalam range) and Velamundi RF (Bhavanisagar range).

When translocation is done on a large scale from the

submergible area of hydro-electric reservoirs, there is no reason why it cannot be done for protecting agriculture from elephants. Translocation involves considerable expense which has to be justified. In the initial period the released cultivable land can be used by the Forest Department for raising plantations to recover a portion of costs before allowing the land to revert back to wilderness. This would also increase habitat area for elephants.

Culling of rogue elephants and compensation to victims

Elephants known to regularly kill people or consistently raid crops will have to be selectively removed. These may be either shot or captured by tranquilising. This would create a favourable impression among villagers towards conservation. Today most villagers feel that the government regards wildlife more important than people.

For cases of manslaughter by elephants adequate compensation to the affected family should be made by the government. At present the District Collectors in Tamilnadu can sanction upto Rs.2000, while in Karnataka the Forest Department can sanction Rs.5000. These amounts are inadequate. For cases of manslaughter within cultivated land the compensation should be atleast Rs.25000.

When the killing occurs inside the forest the compensation may be much lower; the reason being that the person goes into the elephant's habitat at his own risk. Tribals engaged in collection of minor forest produce or forestry operations have to be insured against accidental death. This is being already done in the Satyamangalam Division.

III. SPECIAL CONSERVATION AREAS IN THE NILGIRIS-EASTERN GHATS

The already existing Sanctuaries and National Parks in the region are the following:

1) Nagarhole National Park - Karnataka
   (Total area = 572 km^2 , core area - 184 km^2)

2) Bandipur National Park - Karnataka
   (Total area = 874 km^2, core area = 335 km^2)

3) Biligirirangaswamy Temple Wildlife Sanctuary - Karnataka
   (Total area = 324 km^2 , core area = 85 km^2)

4) Mudumalai Wildlife Sanctuary - Tamilnadu
   (area = 321 km^2)

5) Nilgiri Tahr Sanctuary - Tamilnadu
   (area = 78 km^2)

6) Wynad Wildlife Sanctuary - Kerala
   (area = 344 km^2)

7) Silent Valley National Park - Kerala
   (area = 90 km^2)

The following recommendations are made for setting up further areas as sanctuaries:

CAUVERY WILDLIFE SANCTUARY (Karnataka and Tamilnadu)

Along the banks of the Cauvery river there is a virtually uninterrupted stretch of forest from Sivasamudram (near Kollegal) for 100 km until its entry into the Stanley Reservoir (at Mettur). The waters are swift flowing, often through rivines and hilly terrain. Elephants have access to its waters only at certain places. The vegetation is dry deciduous of the Hardwickia-Albizzia-Anogeissus type. This perennial river is the largest stretch available in elephant habitat anywhere in South India. During times of drought in the low rainfall Eastern Ghats region, the waters of the Cauvery are the only recourse for elephants. It is essential to protect this entire stretch by setting up a sanctuary. This would involve areas falling under both Karnataka and Tamilnadu states.

In Karnataka the forest ranges involved are Satnur and Kanakapura Ranges (Bangalore Division) along the northern bank of the Cauvery; Hanur, Ramapuram and Madeshwaramalai Ranges (Kollegal Division) along the southern bank. Along both the banks, suitably defined belts about 3 to 6 km in width should constitute this sanctuary. Some of the reserve forests (RF) involved are:

Northern bank - Dhanaguru RF, Basavanbetta RF, Chilandvadi RF, Muguru RF.

Southern bank - Chikkayalur RF, Kaudhalli RF, Madeshwaraimalai RF.

The total area on the Karnataka side may be about 350-450 km^2. The forest department of Karnataka has already accepted in principle the creation of this sanctuary.

In Tamilnadu the areas involved are the Hosur and Dharmapuri Forest Divisions. Here again, a belt of forest of about 4 to 5 kms. wide along the Cauvery (northern and eastern bank) and the Chinnar river may be declared a sanctuary. The reserve forests include Kestur and Kestur Extn RF, Bilikal RF, Mallahalli RF, Natrapalayam RF, Biligundlu RF, Wodapatti RF, Guthirayan RF, Pennagaran RF, Baiyanurmalai RF and Badanavadi RF. The total area would be about 250 km^2.

EXTENSION TO BRT SANCTUARY (Karnataka)

The Doddasampige Reserve Forest in the Kollegal Range lies on the eastern side of the Biligirirangans and is contiguous with the Chamarajanagar Division (which has been declared as the Biligirirangaswamy Temple Wildlife Sanctuary). It would be logical to include the Doddasampige RF along with the BRT Sanctuary.

SATYAMANGALAM DIVISION - Smaller range sizes

The present areas of Talamalai Range (546 km^2) and Satyamangalam Range (816 km^2) are too large to be effectively controlled. Similarly, the areas of certain beats going upto 80 km^2 cannot be looked after by just a guard

and a watcher. Atleast 5 ranges should be constituted in the Satyamangalam Division. Some of the suggested boundaries are:

1. Bhavanisagar Range : All the reserve forests in the plains can go into this range. This would include the Moyar valley (northern portion of river), the plains around Bennari, the southern slopes of the ghats and the Nilgiri Eastern Slopes which is currently under the Erode Division.

2. Talamalai Range : The reserve forests in the hills enclosed within Talamalai - Dimbam - Karapallam - Talavadi. This would also include the portion to the south of the Talamalai-Dimbam road upto the edge of the hills.

3. Talavadi Range : This would include the forests to the west of the Talavadi-Talamalai road (Zones 8 and 9) upto the Karnataka border.

4. Hasanur Range : This would include the reserve forest to the east of the Karapallam-Dimbam highway upto the Germalam-Kadambur road.

5. Satyamangalam Range : The remaining portion of the present Satyamangalam Range east of the Germalam-Kadambur road upto the boundary of the Andhiyur and Bargur Ranges.

The forest department may also declare the Moyar valley of the present Talamalai Range as a Blackbuck sanctuary. About 60 km^2 area may constitute this sanctuary.

THE NILGIRI BIOSPHERE RESERVE

Conservation until now has primarily meant the protection of large, spectacular animals such as the tiger, elephant or rhino within Sanctuaries and National Parks. Where sufficiently large areas have been set aside this approach also protected an ecosystem to a certain extent. But there has also been a distinct bias towards setting up protected areas in deciduous vegetation. It is now realized that the aim should be the conservation of the overall biological diversity of different geographical regions. These concepts are being extended to the Indian context (Gadgil 1982, Anon 1983). There are plans to set up many Biosphere Reserves in the country.

In 1980, the Department of Environment, Govt. of India commissioned the preparation of a project document for the Nilgiri Biosphere Reserve, the first proposed Biosphere reserve in the country. Again during 1984-85 the Department of Environment appointed a committee to demarcate in detail the various zones of the Nilgiri Biosphere Reserve. The committee included Prof. Madhav Gadgil (Indian Institute of Science - Convenor), Shri S.R.Bhagwat, I.F.S. (Principal CCF, Karnataka), Shri G. Mukundan, IFS (CCF Wildlife, Kerala), and Shri John Joseph, I.F.S. (Addl. CCF Planning, Tamilnadu).

The field survey and preparation of maps was

carried out by a team including the present investigator, Dr.P.V.Nair (Kerala Forest Research Institute and Shri K. Ullas Karanth (Hon. Wildlife Warden, Mysore). The final report of the committee is under active consideration of the Central and State Governments and the Biosphere Reserve is expected to be established shortly.

The zones of the Biosphere Reserve are:

Core Zones : Human activity should either be absent or kept to a minimum out of necessity. For practical reasons the core zones have been restricted to a basic minimum for the present. The total area of the core zones comes to around 1240.3 km^2. Most of the vegetation types are represented in the core zones. These include:

1. Tropical wet evergreen forest and evergreen shola-grasslands-New Amarambalam (part), Nilambur Kovilakam, silent valley, Nilgiri peak-Kundah plateau (Nilgiri Tahr Sanctuary)

2. Semi-evergreen forest-Siruvani hills (Bolampatty range)

3. Moist and dry deciduous forest-Nagarhole sanctuary (part) Bandipur (part), Mudumalai (part), Nilgiri eastern slopes (Erode division) and Minchikuli valley (Satyamangalam division)

4. Tropical thorn forest : A small portion of the Nilgiri eastern slopes. This vegetation type has not been properly represented in the core zone due to the human activity in such areas. In future,

it may be possible to set apart a portion of the Moyar valley (Satyamangalam division) which has a true representation of this vegetation type as a core zone.

Manipulation (forestry zones) : The major portion (3238.7 km^2) of the reserve comes under this zone. Such areas should be managed according to sound forestry principles for obtaining a sustained yield of forest produce consistent with the needs of the ecosystem.

Manipulation (tourism) zones : Regular tourism should be largely restricted to these zones in Nagarhole, Bandipur and Mudumalai. The total area is 335 km^2.

Manipulation (agriculture) zones : The cultivated enclaves within the Biosphere reserve constitute these zones. Farmers will be encouraged to preserve the traditional genetic stock of cultivated plants and domestic animals for which they will be subsidised. Protection of crops from wild animals will receive priority here.

Buffer and Restoration zones : These are mainly at the interface of cultivation and forest which may be used for plantations and use by the villagers.

The total area under the various zones of the Nilgiri Biosphere Reserve of the 3 states is given below:

State	Area in NBR	Core	Manip. Forestry	Tourism	Resto-ration
	km^2	km^2	km^2	km^2	km^2
Tamilnadu	2537.6	274.0	2081.5	65.8	116.3
Kerala	1455.4	264.5	945.0	0.0	245.9
Karnataka	1527.4	701.8	212.2	269.2	344.2
	5520.4	1240.3	3238.7	335.0	706.4

A summary of area under the various zones in each Forest Division is given in Table 14.1

This project aims not only at the preservation of the wild flora and fauna, but also provides for the sound eco-development of human agricultural systems within the reserve. Schemes for the protection of agriculture from wildlife could then be taken up in earnest. Covering an area of 5520 km^2, the Nilgiri Biosphere Reserve would hold an estimated 2500-3200 elephants and provide a chance for the survival of this magnificent species.

Table 14.1 - Summary of area under various zones of the Nilgiri Biosphere Reserve

All areas are given in square kilometers

Forest Division	Area in NMB	Core	Manip. Forestry	Tourism	Resto-ration
TAMILNADU					
1) Mudumalai WLS	321.1	96.0	163.1	62.1	0
2) Satyamangalam	745.9	40.0	660.9	0	45.0
3) Erode	49.3	30.0	0	0	19.3
4) Nilgiris North	448.3	0	445.5	3.8	0
5) Nilgiris South (including Tahr Sanctuary)	276.8	78.0	198.8	0	0
6) Coimbatore	696.2	30.0	614.2	0	52.0
	2537.6	274.0	2081.5	65.8	116.3

Forest Division	Area in NBR	Core	Manip. Forestry	Tourism	Restoration
KERALA					
1) Wynad	344.4	0	344.4	0	0
2) Nilambur (including Silent valley and New Amaranbalam)	517.5	164.5	313.0	0	40.0
3) Nilambur vested	277.6	100.0	177.6	0	0
4) Kozhikode vested	110.0	0	110.0	0	0
5) Palghat	205.9	0	0	0	205.9
Total:	1455.4	264.5	945.0	0	245.9
KARNATAKA					
1) Hunsur (incl. Nagarhole NP)	354.4	60.1	182.0	46.4	65.9
2) Mysore	462.7	168.6	30.2	67.1	196.8
3) Bandipur NP	689.5	473.1	0	155.7	60.7
4) Chamarajanagar	20.8	0	0	0	20.8
	1527.4	701.8	212.2	269.2	344.2

Note : The boundaries of Bandipur NP have been extended to 874 km^2.

APPENDIX - I : ELEPHANT CENSUS IN SOUTH INDIA

The Forest Departments of Karnataka, Tamilnadu and Kerala conducted a simultaneous census of elephants on 15 May 1979 (areas south of Palghat gap) and 29 May 1979 (areas north of Palghat gap) to avoid duplication due to elephant movement between adjacent areas. Another simultaneous census was conducted on 30 Apr 1983. The figures are given here just for the record but have to be viewed cautiously

A . KARNATAKA STATE

Forest Division/Circle	1979	1983
1. Bangalore Cir.	114	58
2. Mandya Div.	102	119
3. Kollegal Div.	-	426
4. Chamarajanagar Div.	96	691
5. Bandipur (Project Tiger)	1187	1024
6. Mysore Div.	90	136
7. Kodagu Cir.	212	900
8. Shimoga Cir.	165	184
9. North Kanara Cir.	11	41
	1977 +	3579

B - TAMILNADU STATE

Forest Division	1979	1983
1. Dharmapuri	92	85
2. Hosur	284	144
3. Erode	532	199
4. Satyamangalam	736	251
5. Mudumalai	446	401
6. Gudalur	48	85
7. Nilgiris North	66	240
8. Nilgiris South	15	6
9. Coimbatore	72	142
10. Anamalai	388	356
11. Madurai (Circle)	225	165
12. Tirunelveli	13	5
13. Kanyakumari	38	48
14. Kalakkad	20	8
15. Mundanthurai	19	44
	2994	2179

C - KERALA STATE

Forest Division	1979	1983
1. Kozhikode	237	102
2. Nilambur	211	203
3. Palghat	84	68
4. Nemmara	3	60
5. Wynad	100	35
6. Nilambur (Spl.)	85	97
7. Kozhikode (Spl.)	30	14
8. Palghat (Spl.)	140	44
9. Tellicherry (Spl.)	43	0
10. Parambikulam	52	114
11. Trichur	48	12
12. Malayattur	106	125
13. Chalakudy	160	125
14. Vazhachal		72
15. Periyar (Project Tiger)	903	932
16. Kottayam	232	156
17. Munnar	464	245
18. Achenkoil	11	27
19. Konni	57	55
20. Ranni	133	290
21. Punalur	3	7
22. Thenmala	276	105
23. Trivandrum	177	65
	3555	2865

APPENDIX - II : HUMAN SETTLEMENTS, AREA AND POPULATION

Settlements and sub-villages	Area (hectares)	Human population
KARNATAKA		
1. BRT Betta	c. 500	1052
2. Kinnare colony	8	
3. Kyatedevaragudi	2	s .
4. Coffee Estates	c. 900	
Honnametti CE		
Attikan CE		
Biligirirangan CE		
Bedguli CE		
Beduguli village		
5. Punjur	440	934
6. Kolipalya	950	1539
Mukanpalya		
Irayanpur		
Bejjalpalya		
Banavadi		
Mudahalli		
7. Budipadaga	c. 265	500 +
Kullur		
TAMILNADU		
8. Chikkahalli	778	2149
Iggalur		
Balepadugu		
9. Neydalapuram	660	986
Kodampalli		
10.Mudiyanur		

Settlements and sub-villages	Area (hectates)	Human population
10. Mudiyanur	225	
11. Talamalai	1013	
Sirgaudanahalli		2944
Doddapuram		
Kodipuram		
12. Ittarai	115	
13. Galidimbam	39	
14. Ramaranai	13	23
15. Bejjaluhatti	8	c. 100
16. Mavanattam	7	88
17. Hasanur	559	1715
Hongalvadi		
Arepalayam		
Binakanahalli		
18. Gaddesal	c. 50	361
19. Mavallam	109	c. 1200
20. Devarnattam	93	
21. Kotadai	264	
Hosatti		
22. Dimbam	2	s
23. Bennari	10	t
24. Gajalahatti	1	s

The names of settlements refer to the most prominent village or commonly used name for an enclave. Other important cluster villages are listed below.

The population figures for all villages except Hasanur and Gaddesal have been taken from the Census of India - 1971
Handbooks, Series 14 (Mysore District, Karnataka) and series 19 (Coimbatore District, Tamilnadu) and also from Joseph (1969).

The population during 1980-83 would be higher by atleast 10 percent on the whole. For Hasanur and Gaddesal the population figures pertain to a census conducted in 1981.

The exact population size was not available but could be atleast 1500 resident. During the coffee harvest season additional labourers come cor work.

s - No cultivation but only a small settlement of less than 50 peopel.

t - Resident population small but a large tourist influx to the temple daily.

APPENDIX - III : PLANTS EATEN BY ELEPHANTS IN THE STUDY AREA

A. WILD PLANT SPECIES

Species (a)	Part consumed (b)	Importance rank (c)
RANUNCULACEAE		
1. Clematis gouriana Roxb.ex DC	E	I
CAPPARIDACEAE		
2. Capparis grandis L.f.	L	I
3. Capparis sepiaria L.	L	II
4. Capparis zeylanica L.	L	I
MALVACEAE		
5. Kydia calycina Roxb.	B,L	III
STERCULIACEAE		
6. Helicteres isora L.	B,L	III
TILIACEAE		
7. Grewia tiliaefolia Vahl	B,L	III
8. Grewia aspera Roxb.	L	II
9. Grewia hirsuta Vahl	L	II
MALPIGHIACEAE		
10. Hiptage madablota Gaertn.	L	I
RUTACEAE		
11. Atalantia monophylla Corr.	L	I
12. Feronia elephantum Corr.	F	I

(a)	(b)	(c)
29. Hardwickia binata Roxb.	L	III
30. Dichrostachys cinerea W. and A.	L	III
31. Mimosa rubicaulis Lamk.	L	II
32. Acacia leucophloea Willd.	B,L	III
33. Acacia latronum Willd.	B,L	II
34. Acacia suma Buch.-Ham.	B,L	III
35. Acacia sundra DC.	L	III
36. Acacia ferruginea DC.	L	II
37. Acacia caesia (L.) Willd.	L	II
38. Acacia torta Craib.	B,L	III
39. Acacia pennata (L.) Willd.	B,L	III
40. Acacia sinuata (Lour.) Meir (= A. concinna DC)	L	I
41. Albizzia odoratissima Benth.	B,L	II
42. Albizzia lebbeck Benth.	B,L	I
43. Albizzia amara Boivin.	L	III
MYRTACEAE		
44. Syzigium jambolanum DC (= S. cumini Skeels)	B	I
45. Eucalyptus spp. (planted)	B	II
LECYTHIDACEAE		
46. Careya arborea Roxb.	L,F	I

(a)	(B)	(c)
BURSERACEAE		
13. Commiphora caudata Engl.	L	II
MELIACEAE		
14. Melia composita Willd.	L	I
RHAMNACEAE		
15. Zizyphus jujuba Lamk.	B,L	I
16. Zizyphus xylopyrus Willd.	B,L	III
17. Zizyphus oenoplia Mill.	L	I
VITACEAE		
18. Unidentified climber	E	I
SAPINDACEAE		
19. Sapindus emarginatus Vahl	L	I
ANACARDIACEAE		
20. Buchanania lanzan Spreng.	L	I
21. Mangifera indica L.	L	I
22. Anacardium occidentale L.	L	I
23. Semecarpus anacardium L.f.	L	I
LEGUMINOSEAE		
24. Atylosia albicans Benth.	E	II
25. Pterocarpus marsupium Roxb.	L	I
26. Cassia fistula L.	L	I
27. Bauhinia sp. L.	B,L	II
28. Tamarindus indica L.	L,F	II

(a)	(b)	(c)
RUBIACEAE		
47. Xeromphis spinosa (Thunb.) Key (= Randia dumetorum Lam.)	L	I
48. Gardenia latifolia Air.	L	I
SAPOTACEAE		
49. Madhuca indica J.F. Gmel. (= Bassia latifolia Roxb.)	L,F	I
OLEACEAE		
50. Ligustrum roxburghii C.B.Clarke	L	I
APOCYANACEAE		
51. Carissa carandas L.	L	I
ASCLEPIADACEAE		
52. Sarcostemma sp. R.Br.	E	I
CONVOLVULACEAE		
53. Lettsomia elliptica Wt.	L	I
VERBENACEAE		
54. Lantana camara L.	L	I
55. Tectona grandis L.f.	B	II
EUPHORBIACEAE		
56. Emblica officinalis Gaerth. (= Phyllanthus emblica L.)	L	II
MORACEAE		
57. Ficus bengalensis L.	L	I
58. Ficus glomerata Roxb.	L	I

(a)	(b)	(c)
DIOSCOREACEAE		
59. Dioscorea tomentosa Heyne	E	I
LILIACEAE		
60. Asparagus racemosus Willd.	E	I
61. Sanseviera roxburghiana Schult.f	L,U	I
PALMAE		
62. Phoenix humilis Royla	L,U	III
CYPERACEAE		
63. Cyperus eleusinoides Kuk.	E	II
64. Cyperus iria L.	E	I
65. Cyperus dubius Rottb. (= Mariscus dubius Kuk.)	E	I
66. Cyperus rotundus		
GRAMINEAE (POACEAE)		
Bamboos		
67. Dendrocalamus strictus Nees	L,C	III
68. Bambusa arundinacea Willd.	L,C	III
Tall grasses		
69. Themeda cymbaria Hack	In most tall grasses the consumption of the top portion (wet season) and basal portion (dry season) alternates seasonally. Importance rank for Nos.69,70 and 71 is III; for all others it is II.	
70. Themeda triandra Forsk		
71. Cymbopogon flexuosus Wats.		
72. Cymbopogon caesius (Nees) Stapf.		
73. Imperata cylindrica Beauv.		

(a)	(b)	(c)
74. Heteropogon contortus Beauv.		
75. Arundinella setosa Trin.		
76. Panicum trypheron Schult.		
77. Arthraxon lanceolatus (Roxb.)Hochst		
78. Enneapogon elegans (Nees ex. Stend.)Stapf		
79. Bothriochola pertusa (L.)A.Camus		
80. Capilipedium huegelii (Hack.) Stapf.		

Short grasses

About 32 species of short grasses were collected in the study area. These included the genera Digitaria, Brachiaria, Aristida, Oplismenus, Eragrostis, Setaria and Sporobolus

Collectively the importance rank for short grasses is II, though for individual species it is I.

L - Leaves (usually along with twigs), B - Bark,

F - Fruits, E - Entire plant, usually referring to a creeper or herb.

U - Underground/stem or rootstock, C - Culm

Importance Rank:

I - Low, II - Medium, III - High proportion of the diet. This rank is not based on any preference index for the plant, but merely on how commonly the plant is consumed. Thus a highly preferred plant present at a low density in the study area may only make a low contribution to its diet.

B - CULTIVATED PLANT SPECIES

Plant species	Common name	Part consumed
CEREALS AND MILLETS		
1. *Oryza sativa* L.	Paddy, rice	In.
2. *Eleusine coranaca* Gaertn.	Ragi, finger millet	In.
3. *Sorghum vulgare* Pers.	Cholam, sorghum, jowar	In.
4. *Zea mays* L.	Maize, makka cholam	In.
5. *Panicum miliare* L.	Samai, little millet	In.
6. *Pennisetum typhoides* Stapf et Hubb.	Kambu, bulrush millet	In.
7. *Setaria italica* Beauv.	Tenai, Italian millet	In.
LEGUMES		
8. *Dolichos biflorus* Roxb.	Kollu, horse gram	E
9. *Glycine max* Merr.	Soybean	E
OTHERS		
10. *Saccharum officinarum* L.	Sugarcane	E
11. *Cucurbita pepo* DC	Pumpkin	F
12. *Musa paradisiaca* L.	Banana	P,F
13. *Artocarpus integrifolia* L.	Jack fruit	F
14. *Mangifera indica* L.	Mango	L,F
15. *Cocos nucifera* L.	Coconut	L

In. - In most cereals and millets the portion of the plant bearing the inflorescence is commonly consumed.

E - Entire, F - Fruits, P - Pith, L - Leaves

Ragi is by far the most commonly eaten crop.

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