

Elephant — Man Conflict in Karnataka

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"ELEPHANTS INVADE CITY" screamed the newspaper headlines on 29th January 1985. A herd of 9 elephants from the Bannerghatta forests had traversed nearly fifteen km. of cultivation during the night and finally entered the campus of an engineering college in the suburbs of Bangalore.

That elephants were audacious enough to approach a metropolis may have created headlines, but such an excursion into human habitation is not something new. It must be as old as the first human settlement in elephant habitation. The *Gaja-Shastra* (6th–5th century BC) and other ancient literature allude to crop raiding by elephants. Gazetteers give numerous instances of entire villages being abandoned due to the ravages of elephants and other animals. The conflict between elephant and man is a two way process. Elephants damage man's crops and kill people; man has reduced or altered the elephant's natural habitat, captured them for domestication and shot them for their valuable tusks or for sport. Needless to say, the elephant is the loser in the long run.

In South India elephants were traditionally captured solitarily in pits, as opposed to entire herds taken in stockades in the north. The Khedda method of capture was first successfully deployed in Mysore State by G.P. Sanderson in 1874, and 1977 elephants were captured within a century. Important sites of Khedda were the Kakankote forests along the Kabini river and the Chamarajanagar forests at the foothills of the Biligirirangans. This practice was discontinued after the Khedda in 1971.

This article, will first briefly describe the status and distribution of elephants in Karnataka, then examine aspects of elephant – human interaction, and finally make some recommendations for conservation.

The Elephant populations of Karnataka

Elephants are found in the Western Ghats and Eastern Ghats of Karnataka adjacent to the states of Tamilnadu and Kerala. The distribution of elephants has been described in some detail by Nair and Gadgil (1978), Nair *et al.* (1980), Gadgil (1985) and Sukumar (1985). However, for the sake of completeness a brief account is given here. Elephant distribution can be conveniently described under 5 regions.

1. Uttara Kannada

The Uttara Kannada (North Kanara) region is the northernmost limit of elephant distribution in peninsular India. The elephant habitat is primarily the deciduous vegetation between 700 and 1000 m altitude. In recent decades there has been considerable incursion into the natural habitat by cultivation, dam construction and mining. There are numerous enclaves of cultivation and consequently high pressure on the forests for fuelwood, leaves for manure and livestock grazing. Large areas of forest classified as "minor forest" to cater to the needs of the people are now in a highly degraded state. Under the giant Kalinadi hydroelectric project a series of reservoirs has submerged considerable areas of forest in river valleys. Manganese mining is carried out in the Haliyal division.

The elephants here have been reduced to a pathetic state due to persecution by man. Since the elephants resorted to crop raiding in the cultivated tracts, most of them have been shot during the past. Only a few scattered herds or lone bulls numbering perhaps less than 40 individuals still survive.

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2. *Crestline of Western Ghats*

To the south of Uttara Kannada the crestline of the Western Ghats rises to higher altitudes, exceeding 2000 m in places. In this high rainfall region there are evergreen and semi-evergreen forests on the hill slopes. This includes the Mudigere, Pushpagiri and Brahmagiri areas. Though the habitat integrity is maintained, this is a sub-optimal habitat for elephants.

The population here is difficult to estimate but elephants certainly occur at only low densities. A tentative estimate of 60 elephants has to be taken for the present.

3. *Malnad Plateau*

The Malnad region lies to the east of the crestline and is separated from it by a wide belt of coffee plantations and cultivation. The vegetation is mainly dry and moist deciduous forest at altitudes from 800 to 1400m. The Tunga and Bhadra rivers flow through this region. The elephant habitat includes the Bhadra and the Shettihally Wildlife Sanctuaries (total area 827 km²). The Tunga and Bhadra reservoirs and also cultivation have isolated some of the elephant herds. In recent years crop raiding and manslaughter by elephants occur commonly in the adjoining tracts of cultivation.

Apart from a few isolated herds, a viable breeding population ranges over the Bhadra sanctuary. Based on the Forest Department census figures, an estimate of 100–150 elephants can be given for the region.

4. *Mysore Plateau*

South of the Cauvery river, the forests of Tittimathi, Nagarhole and Kakankote stretching upto the Kabini river, and those of Bagur – Bandipur extending upto the Moyar river constitute the most important elephant region of Karnataka. Most of the area falls within the Nagarhole National park (572 km²) and the Bandipur Tiger Reserve (874 km²). The terrain is gently undulating and the vegetation largely moist and dry deciduous with scrub jungle on the eastern fringes. Extensive teak plantations occur in Nagarhole. Habitat continuity is maintained throughout the region, though the Kabini reservoir has reduced the corridor between Kakankote and Begur to a 6 km stretch along the river. Elephants can, how-

ever, easily cross over from one side to the other. A proposal to construct a luxury hotel in this stretch has been wisely shelved. This region is practically free from any large enclaves of cultivation though some tribal settlements are present.

Elephant density here is the highest in Karnataka. Between 1100 and 1400 elephants are present in the entire region within the boundaries of Karnataka alone. This region adjoins the Wynad belt of Kerala and the Nilgiri area of Tamilnadu.

5. *Eastern Ghats*

The elephant habitat in the Eastern Ghats of Karnataka is contiguous with the Bandipur region only through the Talamalai range of Tamilnadu. This is an extensive, hilly and dry region with altitudes from 600 to 1800m. South of Bangalore the elephant habitat begins in the Bannerghatta National Park and extends south through the Anekal, Kanakapura and Satnur ranges upto the Cauvery river. To the south of the Cauvery are the Hanur, Madeshwaramalai and Ramapuram ranges. The forests of the Biligirirangan hills to the east have been virtually cut off by cultivation (especially the Tibetan refugee settlement opened in the 1970's) from the Ramapuram range on the Karnataka side. However, the continuity is maintained through the Satyamangalam range of Tamilnadu.

Floristically, the region encompasses the entire spectrum of vegetation types from scrub through deciduous to evergreen forest. While the scrub and dry deciduous vegetation predominates, a significant stretch of evergreen shola-grassland is seen in the Biligirirangans. The numerous enclaves of cultivation witness regular conflict between elephant and man. There are, as yet, no other developmental activities such as large dams or mining. Two major chunks of forest are vital for elephant conservation. These are the Biligirirangan hills and the virtually uninterrupted stretch of forest for nearly 100 km along the banks of the Cauvery.

Between 800 and 1000 elephants are estimated to be present in this region.

A summary of the population status of elephants in Karnataka is given in the following table.

Table 1.

1. Uttara Kannada	40
2. Crestline of Western Ghats	60
3. Malnad Plateau	100- 150
4. Mysore Plateau	1100-1400
5. Eastern Ghats	800-1000
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Total	2100-2650
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These estimates may have to be revised in future as more reliable information becomes available. Numbers would also fluctuate due to seasonal movement into and from the adjacent forest areas of Kerala and Tamilnadu.

The Interaction between Elephant and Man

The following account on elephant-man interaction is based on a study carried out during 1981-83 in the Biligirirangan hills of Karnataka and the adjacent Satyamangalam Division of Tamilnadu (Sukumar 1985).

Crop raiding by Elephants

Elephants feed on cereal and millet crops such as paddy (*Oryza sativa*), sorghum (*Sorghum vulgare*), ragi (*Eleusine coracana*), maize (*Zea mays*) and samai (*Panicum miliare*). Other crops susceptible to damage include many legumes, sugar-cane, banana, coconut, jackfruit and mango. Elephants venture into cultivation almost invariably during night time; there are only stray instances of them raiding during the day. They have specific preferences for the fields and the stage of crop selected for feeding. With the cereals or millets they begin to feed intensively only after the plants begin flowering and continue to do so until the harvest or even later on the plants heaped for drying. Within the damaged area only about 60% of the plants are consumed, the rest being merely trampled. Coconut trees may be pushed over and only a very small portion, the central rachis, pulled out. Banana stems are crushed and the central pith consumed.

In the Eastern Ghats there are two crop seasons. Between May and August during the SW monsoon,

sorghum or maize is cultivated. The staple crop ragi is grown by most of the farmers during the major crop season between August and December. Raiding is generally at a low frequency during the dry months (January - April) when the fields are fallow. At this time the plantation crops are usually the targets of elephants. With the cultivation of sorghum and maize after the onset of rains in May, the raiding intensity increases. However, the peak raiding is during the ragi cultivation season. In the months of October - December some villages are visited practically every night by elephants. Table 3 shows the monthly frequency of raiding by elephant bulls and herds in the study villages.

Adult male elephants are more habitual raiders than the female-led herds. Certain males showed a strategy of seasonal movement that aimed at spending considerable time in the vicinity of cultivation. For instance, one bull (which was well identified since its right tusk was broken) entered cultivation on about 120 nights in a year. The bulk of the damage was caused by a few such notorious bull elephants. The maximum quantity of crops consumed by a bull during a single night was 75 kg dry weight (300 kg fresh) of ragi plants. This amount is adequate food for a bull for 24 hours. An interesting observation made was that male elephants showed a distinct tendency to form groups of 2, 3 or 4 individuals before raiding the fields at nights, though they were predominantly solitary while foraging in the forest during the day.

For the entire year it was estimated that cultivated crops comprised 9% of the diet of adult male elephants but only 2% for female herds. The family herds as a whole were less habitual and more opportunistic raiders in the course of their seasonal movement from one area to another. Herds usually confined their raids to fields close to the forest boundary, though there were exceptions. They were not as audacious as bulls which frequently traversed an entire tract of cultivation, a distance involving 3 to 6 km.

Economic loss: In 10 study villages the total loss of crops during one year (March 1981 - February 1982) was as follows :

Table 20

Crop	Loss due to bulls	Loss due to herds	Total
Ragi	512 q	271 q	683 quintals
Sorghum	44 q	42 q	86 quintals
Maize	2 q	2 q	4 quintals
Paddy	30 q	5 q	35 quintals
Coconut	39 trees	30 trees	65 trees
Banana	137 plants	65 plants	202 plants

In addition, there was also some loss of samai, horsegram, sugarcane, jackfruit and mango. Niger (*Guizotia abyssinica*) plants planted along with ragi are also trampled but not consumed.

The economic value of the loss was estimated to be Rs. 1,89,600.

a) The total land area under cultivation in these villages was 3,200 hectares. This meant a loss of Rs. 56/-per hectare of cultivated land.

b) The number of people living in the villages was around 12,000 (comprising 2,200 households). A per capita loss of Rs. 15-80 was incurred.

c) If only the land owners are considered, there were around 900 families owning land. An average loss of Rs. 210 was incurred by a family. The maximum loss suffered by a farmer was much higher, about Rs. 5,000 in the village of Punjur.

d) The loss averaged 10% of the potential crop yield during the ragi season and 20% during the sorghum season.

e) The damage caused by one adult male elephant averaged Rs. 6,700 while that by an elephant in a herd was only Rs. 300.

f) On the basis of the above estimate it is worthwhile to consider the total loss suffered in the state of Karnataka due to elephants. Let the total elephant population be assumed as 2,500, of which 7% are adult bulls and the rest comprise family herds. Thus 175 bulls damage Rs. 11,72,500 and the other 2,325 elephants in herds damage Rs. 6,97,500 worth of crops. The total loss in the state would amount to Rs. 18,70,000.

The above estimate is, of course, a simplification. It is conceivable that elephants in more fragmented habitats (e.g. Anekal-Kankapura Range) could cause

a greater per capita damage, while those in relatively well forested areas (e.g. Bandipur) could cause much less damage. In the study area most of the damage was caused to millet crops for which the loss per unit effort is much lower than for a tree crop. For instance, the maximum loss to ragi during one night's raid by an adult bull was not more than 4 quintals of grain worth Rs. 600. On the other hand if 15 mature coconut trees were pushed over in one night, this would mean a loss of Rs. 5000-7000 in income to the farmer over the following years until these are replaced. If tree crops such as coconut or arecanut are the main targets in certain areas then the per capita damage by an elephant would be higher.

In addition to the direct losses the farmers also invest money in devices such as fire crackers and flashlights to scare away elephants. A considerable amount of time is also wasted by the farmers in keeping watch over their fields. A minimum of 90,000 "manhours" were lost in the study villages during one year.

Methods to keep away elephants

a) *Fire crackers*: Only a few farmers use fire crackers to scare elephants. But 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) describe 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 (Kankapura Range) a tape recorded 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 withdrawn 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 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 Biligirirangans many decades back but this was later discontinued. This design has been revived in recent years. In Karnataka an experimental high voltage fence was demonstrated in the Banerghatta National Park. The fence design is discussed in more detail in the section on conservation.

Most farmers do not attempt anything more than merely shouting and shining flash lights. 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

Elephant 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 (Plate 27). In the Hanur Range, the Molugankattai reservoir close to Prakasapalayam village on the forest boundary enables cultivation of irrigated sugarcane, paddy and sorghum. Herds which come to the reservoir raid the nearby fields. 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 nearby 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 manoeuvrability. 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 to chance alone.

The frequency of raiding in larger villages would be higher than in smaller ones.

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 the 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 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.

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). 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.

Manslaughter by Elephants

In the forests of South India the elephant is to be feared far more than a carnivore such as the tiger or the leopard. In Karnataka between 10 and 20 people are killed by elephants every year. What are the circumstances in which people are killed? Are some elephants more dangerous than others? Details of more than 150 cases of manslaughter obtained from South India provided insight into the matter. Of these, 30 cases pertaining to Karnataka were recorded.

A majority of the people killed were adult men. In 29 cases where the identity was known, 18 (62%) men, 8 (28%) women and 3 (10%) children were the victims. They largely hailed from villages in or near elephant habitat and included farmers, graziers, firewood gatherers and labourers. Occasionally people passing through the area get killed; these were sometimes nomads or mentally deranged people.

Encounters between elephants and people take place in the forest or within cultivation. Out of 26 cases where the place was known, there were exactly 13 (50%) encounters each in the forest and in cultivation. While killings in the elephants' habitat may be often unavoidable, the high incidence within human settlements is a consequence of the chronic problem of crop raiding. Inside the forest the encounters are usually due to elephants and people meeting unexpectedly at close quarters due to poor visibility. Often when people are engaged in gathering firewood or in other work they are not alert enough to notice an elephant until it is too late. Killings in the forest were by both male and female elephants, but within cultivation only male elephants were responsible in all the recorded cases.

It is often impossible to determine the sex of the offending elephant with certainty as this knowledge may perish with the victim. In 16 cases where this was known it was seen that male elephants were responsible for 14 (87.5%) of the killings while the remaining 2 cases were due to a female herd. Even among males only a few "rogues" were responsible for most of the killings; these often had a long history of crop raiding and attacking people guarding their fields at night. Many such instances could have been avoided if the farmers had taken the precaution of staying in a safe place such as a tree top. The victims were those who were foolish enough to

stay on the ground in flimsy thatched structures. Farmers using dogs while watching their fields were at risk in another manner. Elephants seem to react to the barking of dogs by chasing them. The natural tendency of the dog would be to run to its master bringing behind it an enraged elephant which might redirect its aggression on the human. The following cases illustrate the circumstances in which people are killed by elephants.

a) *1971*: Nanjundiah, an employee of the potato farm at BRT Betta had gone along with a group of people to the Doddasampige tree (considered sacred) inside the forest. He apparently wanted to photograph an elephant and clapped his hands to attract its attention before taking the picture. He fell a victim to the elephant.

b) *April 1980*: Two children along with their parents were sleeping outside their hut in the village of Erambadi (Ramapuram Range). When an elephant came for raiding crops their dog barked and attracted its attention. The elephant charged and killed the children.

c) *29 July 1981*: Bommaiah of Ballapatna village (Channapatna taluk) was guarding his field at night when he was killed by a crop raiding elephant.

d) *31 July 1981*: Puttabasamma of Bokkapuram village (Chamarajanagar taluk) was cleaning the area outside her hut early in the morning when a large tusker killed her. The elephant later went on a rampage in sugarcane and sorghum fields, drank a barrel of palm toddy and evening entered Talavadi village where it damaged a number of houses. (Plate 26)

e) *October 1981*: Mahadevan of Jothigaudanapur village was grazing cattle along with some other people inside the forest (Chamarajanagar Range) when he was attacked around noon by a bull with short tusks.

f) *26 May 1982*: Two elephants (1 tusker, 1 tuskless) from the Banerghatta forest came at 14.00 hr into the crop fields at Singena Agrahara near Bangalore. A large group of people gathered and in the ensuing panic two persons, Reddy and Basappa, were killed by the sub-adult tusker. Rajagopal was lifted with the trunk and flung. He suffered injuries in the thoracic region and lost consciousness but

later recovered in the hospital where he was questioned.

g) *October 1982*: Kunmadappan of Kalkeredoddi (Kollegal Range) was guarding the ragi field from a hut. An elephant pulled down the structure, chased and killed him.

An elephant kills either by hitting out with its trunk or grasping the person with the trunk and flinging. Sometimes people are trampled, especially if they happen to fall down when running away from the elephant. A bull may also gore the victim with its tusks. Contrary to popular tales about people being smashed beyond recognition, in most of the cases there was no disfigurement of the body. Often there were no serious external injuries and the victims died due to internal haemorrhage.

Habitat modification by man

Man has reduced the elephant's habitat and modified the remaining portion by exploiting it for his needs of timber, fuel and fodder. Since many articles on the human impact on the environment in Karnataka have already documented these aspects only the implications of this change for elephants will be briefly dwelt upon.

Reduction of habitat

The discontinuous distribution of elephants in the Western Ghats of Karnataka is due to the incursion of hydroelectric and irrigation reservoirs, mining, agriculture and plantations into the hill forests. In the Uttara Kannada a series of reservoirs on the Kali river and its tributaries and in the Malnad region the Tunga and Bhadra projects have submerged river valleys which are prime elephant habitats. Coffee plantations in the Malnad have also occupied considerable area and isolated the elephant population in the Bhadra sanctuary. Enclaves of cultivation are common in the Eastern Ghats. During the 1970s the settlement of Tibetan refugees in the Kollegal Range has made a large dent on the habitat. In fact, the most serious problem faced by elephants today is the drastic reduction in space. This may compress the elephants into areas too small to sustain them on a long-term basis.

The spread of human settlements has deprived the elephant of its most favoured habitats since the human need for perennial water and fertile soil also clashes with the elephant's requirements. Apart from

providing water, the river valleys are also sites of high productivity of plants favoured by elephants. With the occupation of such sites the elephants are pushed into sub-optimal habitats.

Exploitation of the habitat

Selective logging in forests is not necessarily detrimental to the elephant. In certain moist vegetation types this may actually promote the growth of food plants such as bamboos, grass and *Kydia calycina* and increase the carrying capacity. This does not mean that logging should be permitted over large areas. The current Working Plan for Chamarajanagar Division prescribes an annual selection working of 493 hectares over a 30-year period (1973 to 2003-04). If this is carried out a total area of 14,800 hectares or 44% of the total area of 3 forest ranges (BRT, Chamarajanagar and Punjur) would be involved. But since felling compartments are located only within the good mixed deciduous forests of the hills, this entire vegetation type would be affected.

Clear felling causes adverse changes in soil properties and further allows weeds such as *Lantana* and *Chromolaena* (*Eupatorium*), useless as food, to establish and suppress the native plant growth. In many regions the bamboos have been clearly over exploited and these may be taken over by weeds (Prasad and Gadgil, 1981). The tall grasses are also exploited for the paper industry. In the Chamarajanagar Division about 2000 tons were removed annually for some years until 1982. However, studies on the productivity indicated that less than 5% of grass production was removed. This does not affect the elephants adversely, though the long-term consequences of this practice on the ecosystem will have to be evaluated. Collection of minor forest products does not reduce the elephant's food supply, but it would be prudent to leave a certain proportion of tamarind and wood apple uncollected for them to consume seasonally.

Livestock grazing is now prohibited in most of the protected areas of Nagarhole, Bandipur and BRT sanctuaries. While there may be serious competition between cattle and wild mammals such as gaur or deer, the same is not true of interaction with elephants. The food preferences of cattle and elephants are sufficiently distinct. Thus, livestock grazing does not adversely affect the elephant.

The role of fire in the ecosystem needs further study. Most of the dry and moist deciduous forests with tall grasses are regularly burnt in the dry season. Fires are set by the villagers to promote the growth of fresh grass for livestock, improve visibility and facilitate collection of forest produce. Elephants prefer to graze in fire-burnt areas once the early rains stimulate the growth of green grass. But the consequences on the woody vegetation have also to be considered. Frequent fires may enable unpalatable trees such as *Anogeissus latifolia* to dominate the plant community. This would reduce browse availability for elephants.

The impact of plantations has been a mixed one. Certain monoculture plantations such as Silver Oak (*Grevillea robusta*) clearly have a depressing effect on elephants. In many plantations of teak and *Eucalyptus* the undergrowth is choked with useless weeds such as *Lantana* and *Chromolaena*. However, elephants may adapt themselves to teak and *Eucalyptus* plantations provided the understory vegetation has sufficient food plants. The bark of teak and *Eucalyptus* is also consumed to a certain extent by elephants. In the Nagarhole National Park, elephants exist at a high density even in the plantations. Monoculture plantations of *Eucalyptus* have a more adverse impact on elephant habitat if raised on a large scale. In the Working Plan for Chamarajanagar Division a total of 15,726 hectares or 47% of the area has been allotted for the Industrial Plantation Working Circle. If implemented it would drastically change the natural ecology of the region. The more positive side of artificial regeneration has been that raising of bamboo and *Acacia* spp. has actually increased the food supply areas.

It is often inevitable that elephant and man have to share the same habitat and resources. With proper planning, human land-use need not always be incompatible with the elephant's needs. It is possible to ensure the elephant's survival in secondary vegetation.

Elephant slaughter by man

The elephant in South India faces a more serious threat from poachers than in most other parts of Asia. For instance, in Sri Lanka over 90% of the male elephants are without tusks (makhnas) while in Northeast India nearly 50% are tuskless. In these

regions any pressure from poaching will not seriously affect the male segment of the population. On the other hand, in the southern states, including Karnataka, over 90% of the male elephants are tuskers. These suffer an increased mortality from poaching leading to a depletion in their gene pool and a very disparate sex ratio.

Apart from poaching, both male and female elephants are killed by man in defence of his crops. To get an idea of the causes of death, natural and unnatural, in elephants a sample of 208 deaths in Karnataka during 1975-83 is analysed in Table 4. This is only a partial record of deaths, and that, too, pertaining to only 5 Forest Divisions - Mysore, Bandipur, Chamarajanagar, Kollegal and Mandya.

About 20% female elephant deaths are due to gun shot or electrocution in crop fields, the rest succumbing to natural causes. It is the male elephant that suffers more at the hands of man. Of the total number dying, 66% were shot by poachers. While the tusks were recovered by the Forest Department from one out of every six elephants killed, the poachers were able to extract their booty from the rest. Some bulls are also killed while raiding crops. Less than a third of them die due to natural causes.

The total number of male elephants killed by poachers may vary from year to year. In 1982 about 40 bulls were shot according to the official record in the entire state. In 1983 also the figures were high but in 1984 the rate of poaching seemed to have declined. Although most of the cases discovered are taken into record, it is possible that some carcasses are not found or not reported. Forest areas plagued by poaching are mainly those in the Eastern Ghats including Chamarajanagar, Kollegal and Mandya Divisions. Poaching also occurs in Bandipur, Mysore and Hunsur Divisions. During August 1983 there was a spate of killings in the Tithimathi forests of Hunsur Division. Within two weeks at least 7 elephants were shot. Recently in July 1985, 3 tuskers were poached in the BR hills but the poachers have been apprehended. The Kollegal Division in particular has been affected seriously by poaching during the past decade. According to one estimate 90 elephants were shot between 1976 and 1983 in this division (Krishna Vattam 1983).

The ivory poaching organization has at least 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 final processing.

a) The people who kill the elephants are usually villagers, including tribals, living in or near the forest. They receive only a fraction of the market value of the tusks. They camp for long periods inside the jungle and are constantly on the move in search of tuskers and in order to avoid being captured.

b) The middleman patronises and encourages such villagers to poach. He is usually from a middle class background and lives in a small town with easy access to the forest. He is a crucial link in the poaching business.

c) The ivory dealer hails from a large city such as Mysore, Bangalore or towns in Kerala. He manages to palm off the poached ivory as legal ivory after processing it into art objects.

There has generally been a tendency for each state to blame poaching on a neighbouring state. While it is true that poachers enjoying relative immunity in their native state resort to poaching in other states, every state has its own share of poachers. In the Eastern Ghats at least two gangs were known to operate. One was a relatively small group from the village of Kolipalya - Irayanpur in the Punjur Range. This was patronized by middlemen from Tamilnadu. A bigger gang of 30 or more men from Gopinatham and adjoining villages in the Madeshwaramalai Range (Kollegal taluk) is known to still operate over a wide area of Karnataka and Tamilnadu.

What is the value of the tusks poached in the state? The average weight of a single tusk from a poached elephant was calculated to be 95 kg (Sukumar 1985). Assuming that 30 pairs of tusks are poached in a year in Karnataka, this would yield 570 kg of ivory. At the 1982 rate of Rs. 1,500 per kg, the total value of the poached ivory works out to Rs. 8,55,000. The quantity of poached ivory in fact makes a higher contribution to the trade than the quantity of legal ivory released by the Forest Department to the State Handicrafts Board.

What are the implications of the high mortality of male elephants for the population structure? At present the adult sex ratio is disparate in all the populations. In the BR hills the ratio was 1 adult male: 5 adult females during 1981–83. Computer simulations indicate that with the prevailing death rate of around 15% per annum this ratio would further widen to between 1:10 and 1:20 (Sukumar 1985). If the average mortality rate of males could be plugged at 8% per annum then the adult sex ratio would stabilize at 1 male:5 female. This calls for a regular monitoring of the population numbers, age structure, sex ratio, birth and death rates in the elephant population.

One disturbing feature in recent years is that poachers shoot even young males only 5 years of age. The tusks of a 5 year old would hardly weigh 1 kg each. This trend is undesirable since any drastic reduction in sub-adult males now would mean that, even if poaching were to be reduced, there would be fewer young males left to grow into adults in the future.

Conservation

There are two aspects to conservation planning—the conservation of the elephant population and the protection of human interests from elephants. The latter aspect is especially important if the former is to gain acceptance among the villagers who are victims of the elephant's depredation. Certain broad principles for reducing elephant-human conflict and promoting the long-term conservation of the elephant in Karnataka are discussed here.

a) *Maintenance of habitat integrity for the major elephant populations.*

The elephants of Nagarhole, Bandipur and the Eastern Ghats (BR hills–Kollegal) constitute a single population by virtue of habitat continuity through the adjoining forests of Tamilnadu. About 90% of Karnataka's elephants are found in these regions. Conservation efforts should concentrate in these major areas. The Nagarhole and Bandipur forests have already been declared as National Parks and further, have been included under the proposed Nilgiri Biosphere Reserve. In the Eastern Ghats the BRT sanctuary has been constituted in the Biligiri-

rangans. The Doddasampige Reserve Forest of Kollegal Range which is geographically a part of the Biligirirangans may be added to the BRT sanctuary. There is a need to declare a sanctuary along the Cauvery river. A suitably defined stretch (perhaps between 3 and 6 km wide) along both banks of the Cauvery may be demarcated. This would comprise portions of the Satnur, Kanakapura, Hanur, Ramapuram and Madeshwaramalai Ranges. The elephant population in the Bhadra – Shettihally sanctuaries of Malnad may also be viable given adequate protection, though this is an isolated population.

If one is to be realistic the scattered elephants of North Kanara will have to be written off. Similarly, the peripheral herds in the fragmented Bannerghatta–Anekal sector may have to be driven south towards the Cauvery or captured and a suitable barrier imposed to prevent them from entering this region. Much of the crop raiding occurring at present could thus be prevented.

For maintaining large viable elephant populations the integrity of the habitat must be assured. Fortunately there is no immediate danger of habitat shrinkage in the Nagarhole – Bandipur region. In the Eastern Ghats the numerous enclaves of cultivation and future development projects may lead to fragmentation of habitat if adequate safeguards are not taken. There is a proposal for a hydroelectric project across the Cauvery at Mokedatu. It is possible that the submergence of the river valleys could sever the forest continuity along the Cauvery.

b) *Maintenance of habitat quality*

Besides setting apart sufficient area for elephants, the quality of the habitat must be kept close to the optimum conditions needed by elephants. Elephants use different vegetation types seasonally to optimize their dietary intake. A diversity of vegetation types seems to be the best habitat for elephants. This should include the moist deciduous and dry deciduous forest, scrub thickets (with an abundance of leguminous plants such as *Acacia* and *Albizia*), riverain forest and patches of swampy grassland. The consequences of human exploitation of the habitat have been mentioned

earlier. These principles may be used as guidelines in habitat management.

Should the habitat be purposely manipulated to ensure a high carrying for elephants? For instance, should artificial water holes be promoted on a large scale in elephant habitat. It is a sound principle in wild life management not to build up artificially high populations. Otherwise during times of drought there would always be the risk of a crash in numbers. Instead, animal populations should be allowed to regulate themselves under natural conditions. This is especially true in regions where the elephant numbers are sufficiently high and a large area is available as in Nagarhole-Bandipur-Eastern Ghats. However, in areas holding smaller populations some manipulation may be justified so as to maintain a viable population size of animals.

c) *Reduction of poaching*

The Forest Department in Karnataka has already stepped up its anti-poaching vigilance. Special squads camp inside the forests and regularly perambulate the area. These efforts are certainly commendable. But difficulties in controlling poaching still remain. Often searching for a poacher inside a vast forest is like looking for the proverbial needle in a haystack. Since it is beyond my scope to go into the administrative aspects, I shall merely make a few general suggestions.

An information system may be set up in vulnerable areas to provide information about poachers. This approach has been already tried out successfully in certain cases of poaching in the Mysore Division. A major lacuna at present is in the Forest Department's capabilities for prosecution of the those apprehended. This needs to be strengthened. The poachers usually caught are the local villagers who are expendable to the organisation. Instead, by apprehending the middlemen who are the crucial links, poaching may be curbed more effectively. Finally, since the forest staff have to work under very difficult conditions in the field, a system of rewards for capture and special pay allowances would go a long way in motivating them.

d) *Protection of agriculture from elephants*

The main problem is to find a suitable barrier that would be economically feasible in relation to the potential crop yields that would otherwise be lost. Trenches have been conventionally used but the cost of digging a trench is around Rs. 25,000 per km. There would also be considerable recurring costs in maintaining the trench in effective condition. Such high costs may not be often justifiable when weighed against the quantity of crops that may be damaged.

A high voltage electric fence that delivers a severe shock but does not cause any fatal injury to the animal (or to people) is being used as a barrier to animal movement in many parts of the world. The fence consists of strands of galvanised steel wire strung at appropriate heights above the ground. The fence is activated by an "Energiser" which passes every second an electric pulse of high voltage (say 5000 V) but at a very short duration (1/3000 second). Thus an animal making contact with the wire receives a severe jolt but due to the current flowing in pulses there is no danger to its life. The energiser may be powered by a 12 V car battery, from the 230 V mains or even by solar cells. The cost of fencing and electrifying would be between Rs. 4,000 and Rs. 8,000 per km depending on the sophistication of design. Such fences have proved effective in keeping away elephants from rubber plantations in Malaysia (Blair, 1980) and in experimental situations in parts of Africa (Piesse, R. L. pers. comm.). It must be mentioned that the energised electric fence is also only a psychological bluff and not a physical barrier. An intelligent bull may use its tusks (a non-conductor) to break the wire and enter cultivation.

There is no easy way of protecting agriculture from elephants (save the gun). Experiments on different methods must be initiated before any single method is adopted on a large scale. Until then the compensation scheme operating now should be continued to provide some relief to the villagers.

e) *Compensation for victims of manslaughter*

For cases of manslaughter by elephants adequate compensation should be made by the government to the affected family. The Forest Department now grants Rs. 5,000. This amount is inadequate. If

Table 3: Frequency of crop raiding by Elephants in the study villages

VILLAGE	Mar 1981	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 1982	Feb
1. Punjur	0	0	0	II	I	0	II	VI	V	V	0	I
2. Kelipalya	0	0	0	I	I	I	II	VI	VI	III	0	0
3. Hasanur	0	0	I	II	II	0	II	VI	VI	VI	III	0
4. Chikkahalli	I	0	0	I	0	0	I	V	II	II	II	0
5. Neydalapuram	I	0	I	I	I	0	I	I	V	V	III	0
6. Talamalai	I	0	I	0	I	I	0	II	V	V	III	II
7. Bejjaluhatti	0	0	0	0	0	0	0	0	0	0	0	0
8. Mavanattam	0	0	0	0	0	0	0	0	I	II	0	0
9. Gaddesal	0	0	0	III	III	II	0	0	0	0	0	0
10. Mavallam	0	0	0	0	0	0	0	0	0	I	I	0

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.

manslaughter occurs within cultivation the compensation should be at least Rs. 15,000 (equal to the value of the Janatha Accident Insurance Scheme). When the incident occurs in the forest the amount may be lower since the person ventured into the elephant's habitat at his own risk. Tribals engaged in collection of minor forest produce or other work must be insured against accidental death.

Table 4: Causes of death in Elephants in Karnataka during 1975-83

Causes of death	Number of elephants	sex specific percentage
<i>Female Elephants</i>		
Natural death	53	80.3%
Crop defence	13	19.7%
	<u>66</u>	<u>100.0</u>
<i>Male Elephants</i>		
Natural death	44	31.0%
Crop defence	4	2.8%
Attempted poaching	16	11.3%
Poaching	78	54.9%
	<u>142</u>	<u>100.0</u>

Please note that the above figures represent only a partial record of deaths in 5 Forest Divisions.

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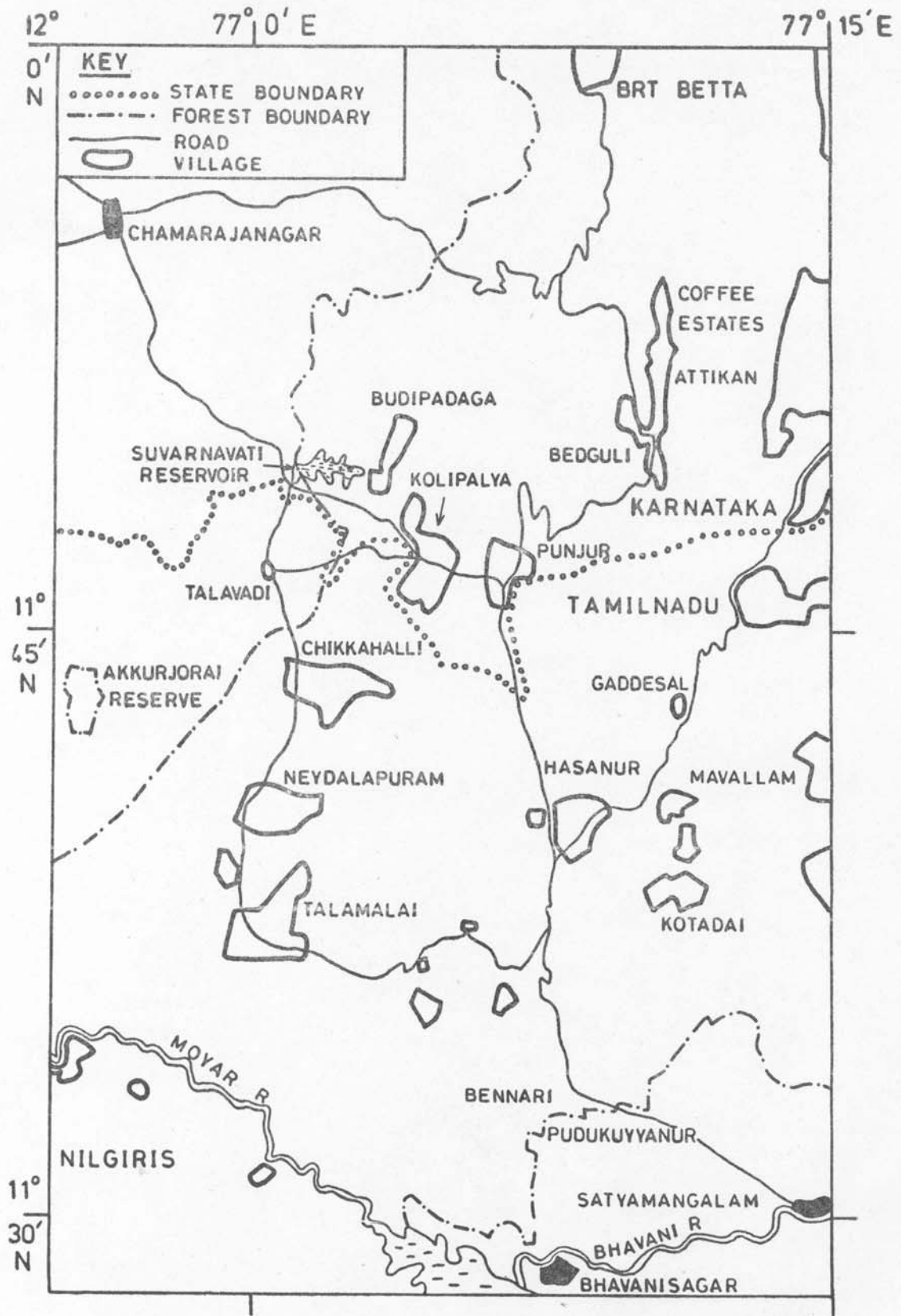


Fig. 1. Map of the Study Area

ELEPHANT VERSUS MAN



SUKUMAR

A herd of elephants in a pond in the Biligirirangan Hills



SUKUMAR

House at Talavadi damaged by a drunken bull elephant



SUKUMAR

Coconut trees raided by elephants in Hunsanhalli village