THE SUMATRAN ELEPHANT *(Elephas maximus sumatranus)*: ITS POPULATION STRUCTURE AND IMPACT ON WOODY VEGETATION IN THE WAY KAMBAS NATIONAL PARK, SUMATRA, INDONESIA

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ABSTRACT

The subspecies Elephas maximus sumatranus, endemic to Sumatra, occurs in discrete populations across much of the island. Its range in Sumatra has declined as a result of deforestation and increase in human population growth. A study of the population of elephants in Way Kambas National Park (1,300 km²) was carried out between 1984 and 1986 to determine the population structure, composition, sex ratio, number, density, biomass and impact on woody vegetation. Group size of the family units ranged from 4-8 animals while, larger aggregations up to 45 animals were not uncommon. The most frequently observed category was that of the adult bull elephant which accounted for 34% of all observations. In addition, there were also bull groups whose size ranged from 2-9 (average 4.4). Mean group size tends to be smaller during the dry season and larger during the rainy season. Population structure is biased in favour of the adults and subadults. Sex ratio appears to be 1:5 in favour of the females. The proportion of tuskers among the adult bulls is about 28% - much higher than what is seen in Sri Lanka where it is less than 10%. Logging in the past has created secondary vegetation capable of supporting elephants at higher densities than primary rain forest habitats. Much of the elephant damage to the vegetation consisted of main-stem breaking. The incidence of bark peeling was low given the abundance of alternative food available. It is estimated that between 250 and 350 elephants may occur in Way Kambas, giving a crude density of between 0.19 and 0.27 per km2. The biomass may range between 344 kg/km2 and 488 kg/km2. Elephants appear to prefer woody vegetation with a stem girth between 1-32 cm dbh. Trees above 32 cm dbh appear to have some immunity from elephant damage. It is doubtful if elephants and economic timber production can be compatible. Way Kambas needs to be better managed to improve the grazing/browsing opportunities for the elephants.

INTRODUCTION

Of the three extant subspecies of the Asian elephant (*Elephas maximus* L.), the subspecies *Elephas maximus sumatranus*, is endemic to the island of Sumatra in the Indonesian archipelago. It is primarily an inhabitant of the moist tropical rainforest, where browse is scattered and herbaceous growth occurs only in cleared areas and along the river banks, where the canopy is broken.

Prior to about 1900, when agricultural settlement in Sumatra first led to substantial degree of deforestation, most of the island was covered with primary forest. In such circumstances, the somewhat smaller body size of the Sumatran subspecies would have been an advantage. Presumably, up to that time, although its population density would have been low, the effective use of the closed canopy habitat might have favoured the Sumatran elephant to be distributed widely across its habitat, in small social units. Less than a century later, it has almost disappeared from two provinces: North and West Sumatra (Fig. 1). The conversion of primary forest to agricultural holdings, some of which have proved ephemeral and been abandoned, is a particularly serious cause of conservation problems in Sumatra, and the elephant has been among the species of large mammals most seriously affected by it. It is estimated that between 65 and 80% of the forests in the lowlands of Sumatra (Fig. 2) have already been lost (Whitten *et al.* 1984). The mountain areas to date have been less seriously affected, but the disruption of continuous cover is already substantial in some cases, and perhaps 15% of their total area may tentatively be estimated as already removed (Santiapillai & Ashby, 1988). The altitude range of the mountains of Sumatra is such that most of their area is rich habitat in their undisturbed state. Unless much firmer conservation and management policies are adopted in forest areas than have been followed hitherto, and badly planned changes of land use curtailed, the Sumatran subspecies of the Asian elephant will be at severe risk in the wild within a few decades excepting perhaps in some of the large protected areas. It is already listed as endangered (IUCN, 1990) and has been protected since 1931. Legal protection alone however cannot save the Sumatran elephant if its habitat is lost. Such protection similarly failed to save the tiger from Java and Bali.

STUDY AREA

Way Kambas National Park with an area of 1,300 km^2, lies at the extreme southern end of the eastern coastal plain of Sumatra, in Lampung province. It was first established as a complex of Protection forests in 1924 and upgraded to the status of a Game reserve in 1937. It was declared a National Park in 1990. Natural boundaries exist on all sides except along a distance of 28 km in the south-east (Fig. 3). The eastern part of the park where the freshwater swamp forests are, is flat but towards the west, on the drier ground, the terrain is gently undulating. The altitude ranges from sea level to 16 m. The commonest soil type found in the park is the red-yellow podsol which is characteristic of the well drained areas. The Krakatau eruption in 1883, deposited a layer of fertile volcanic ash over the southern part of the park.

Drainage consists of a network of rivers and streams, of which the Way Kambas and Way Wako rivers, together with their tributaries drain approximately 68% of the reserve toward the coast (Wind *et al.* 1979). Seasonal inundation of brackish water may occur up to 2 km inland during abnormally dry periods owing to the low-lying nature of the land. The park receives on an average about 2000 mm of rain per year, much of it falling in December and January (Wind *et al.* 1979). There is a single, pronounced dry season that may last from July to October.

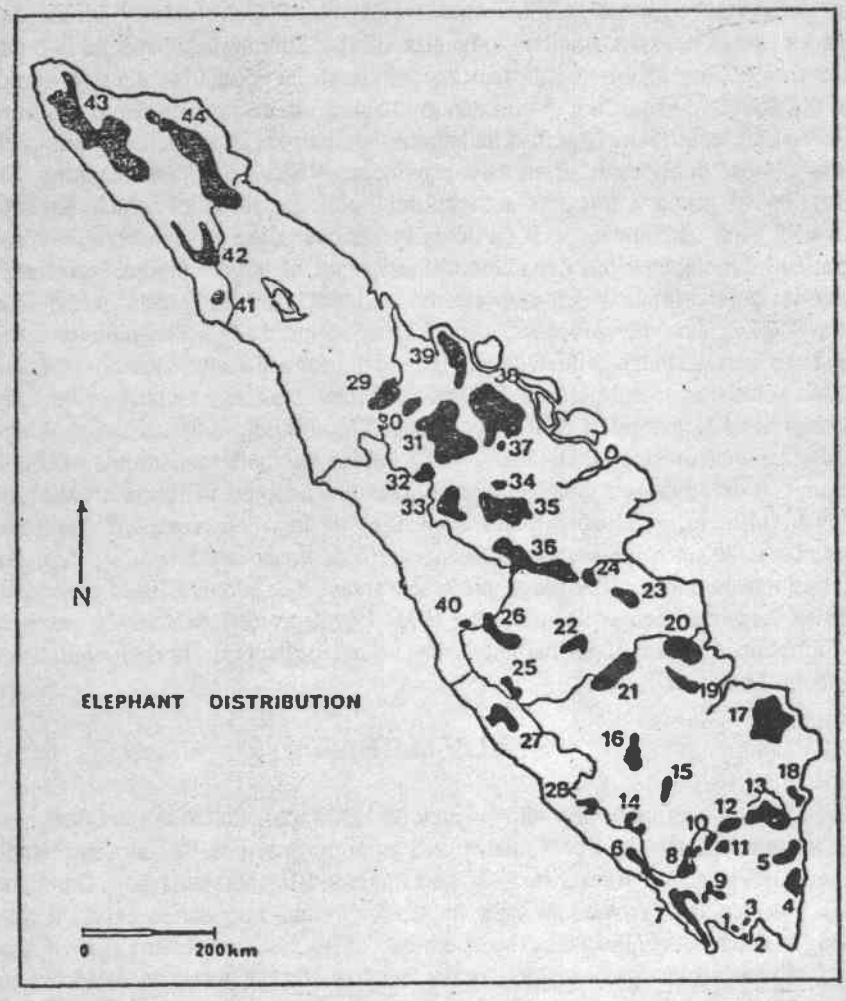


Fig. 1 The distribution of forty-four known populations of elephants in Sumatra. Number 4 represents the elephant population in the Way Kambas National Park, in Lampung province.

The original vegetation in the park was predominantly lowland dipterocarp forest. Today however, only about 5-10% of the park can be described as being "less disturbed" forest. Logging began in 1969 and by 1974, about 50,000 ha of the dipterocarp forest were selectively logged out (UNDP/FAO, 1977). Forest fires in 1972, 1974 and 1976 drastically altered the composition of the vegetation. The combined effect of logging and forest fires has led to the spread of grasslands composed predominantly of *Imperata cylindrica* locally known as alang-alang, which cover almost 70% of the park. Alang-alang is an aggressive weed, difficult to eradicate and thrives well in degraded areas. Despite the loss of up to 75% of the primary forest, Way Kambas still contains one of the largest areas of freshwater (non-peat) swamp forest of any reserve in Sumatra (McCarthy, 1991).

The mammalian fauna is diverse and consists of such threatened species as the Sumatran Tiger *(Panthera tigris sumatrae)*, Clouded Leopard *(Neofelis nebulosa)*, Malayan Sun Bear *(Helarctos malayanus)*, Red Dog *(Cuon alpinus)*, Asiatic Golden Cat *(Felis temmincki)*, Marbled Cat *(Felis marmorata)*, Oriental Small-clawed Otter *(Aonyx cinerea)*, Eurasian Otter *(Lutra lutra)*, Hairy-nosed Otter *(Lutra sumatrana)* and Malayan Tapir *(Tapirus indicus)*. There are six species of primates including the siamang *(Hylobates syndactylus)*. There is also recent evidence for the continued survival of a small population of Sumatran Rhino *(Dicerorhinus sumatrensis)* (Mr Widodo S. Ramono, pers. comm.). There are some 270 species of birds including white-winged wood duck *(Cairina scutulata)* and milky stork *(Mycteria cinerea)*. Reptiles include the estuarine crocodile *(Crocodylus porosus)* and the false gharial *(Tomistoma schlegelli)*.

METHODS

The dense and tangled nature of the vegetation in the park makes the observation of even the largest terrestrial mammal such as the elephant difficult. Observations of elephants were carried out between June 1984 and January 1986, during which time a total of 85 days was spent in the park, spread over 14 visits. Classification of the groups was often difficult and in most instances, only a total count of the elephants could be taken. Much of the data on elephants was obtained on foot, in areas south of the Way Kam bas river, along the network of trails. The riparian vegetation and grasslands along the Way Kambas river were regularly surveyed from a boat and at every sighting of elephants, the location, time, number, composition and activity were recorded. The term "group" refers to any aggregation of two or more animals (Kurt, 1974). Five categories (adult male, adult female, subadult, juvenile and calf) were used in the study of population structure.

The effect of elephants on the woody-vegetation in the park was determined from a study of six categories of elephant-induced damage signs such as (i) branch breaking, (ii) main stem breaking, (iii) stem twisting, (iv) bark peeling, (v) pushing over, and (vi) tusk marking (Wing & Buss, 1970; Vancuylenberg, 1974; Ishwaran, 1983, 1984). These damage signs were scored along five trails randomly selected (each 0.5 km long) on either

side up to 2 m, on trees that were over 1.5 m height. Broken branches with leaves that could be attributed with certainty to elephants were collected for identifcation.

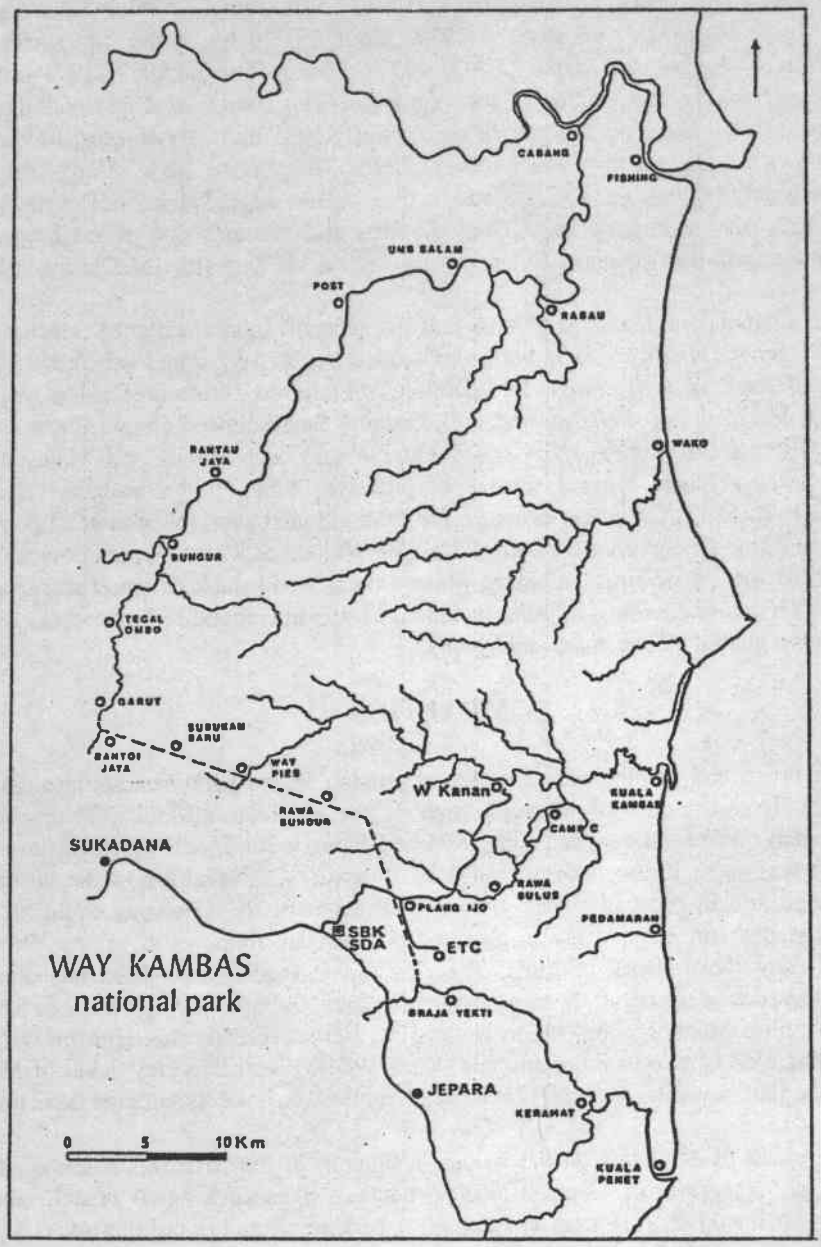


Fig. 2. Map of the Way Kambas National Park, situated in the southern province of Lampung in Sumatra, Indonesia.

Table 1. Number of elephants recorded in Way Kambas National Park, Sumatra.

Date	Days	No:	Location	Composition					Total
				am	af	sa	ju	cl	
Jun. 84	(8)	1	Karangsari	1	1	-	-	-	2
		2	Camp D2						(30)
		3	Camp D2	1	2	-	-	-	3
Jul. 84	(8)	4	Karangsari						(23)
		5	Karangsari	1	-	-	-	-	1
		6	Post 1	1	-	-	-	-	1
Aug. 84	(10)	7	Pancasila						(32)
		8	Post 1						(12)
		9	Camp D2	1	-	-	-	-	1
		10	Negarabatin	1	-	-	-	-	1
		11	Post 1	2	-	-	-	-	2
		12	Post 1	1	-	-	-	-	1
Sep. 84	(10)	13	Wako						(45)
		14	Post 1	2	-	-	-	-	2
		15	Karangsari	-	4	-	-	1	5
		16	Pancasila						(16)
		17	Post1	1	-	-	-	-	1
		18	Camp D2	-	2	1	-	-	3
		19	Camp D2	1	19	11	-	4	35
		20	Camp D2	-	12	9	5	2	28
Nov. 84	(4)	21	Jepara						(20)
Jan. 85	(4)	22	Wak Kanan	1	-	-	-	-	1
Apr. 85	(7)	23	Camp D2						(32)
		24	Way Kanan	1	-	-	-	-	1
		25	Way Kanan	1	-	-	-	-	1
		26	Rasau East	7	12	16	3	2	40
May. 85	(6)	27	Post 1						(12)
		28	Post 1						(6)
Jun. 85	(3)	29	Way Kanan	1	-	-	-	-	1
Jul. 85	(6)	30	Post 1	1	1	-	-	-	2
		31	Post 1	1	-	-	-	-	1
		32	Post 1	-	3	-	1	-	4
Sep. 85	(8)	33	Boundary	1	-	-	-	-	1
		34	Pancasila						(9)
		35	Negarabatin	5	-	-	-	-	5
		36	Karangsari						(23)
		37	Karangsari						(30)
Oct. 85	(3)	38	Post 1	1	-	-	-	-	1
Dec. 85	(5)	39	Boundary	9	-	-	-	-	9
		40	Boundary	4	-	-	-	-	4
Jan. 86	(3)	41	Boundary	1	-	-	-	-	1
Total	85			47	56	37	9	9 = 158+(313) = 471	

am (adult males), af (adult females), sa (subadults), ju (juveniles), cl (calves)
Totals within brackets refer to unclassified animals.

Table 2. Composition of the groups (excluding bull groups) classified

Ad. males	Ad. female	Subadults	Juveniles	Calves	Total
1	1	-	-	-	2
1	2	-	-	-	3
-	4	-	-	1	5
-	2	1	-	-	3
1(1t)	19	11	-	4	35
-	12	9	5	2	28
7(1t)	12	16	3	2	40
1	1	-	-	-	2
-	3	-	1	-	4
11(2t)	56	37	9	9	122
% 9	45.9	30.3	7.3	7.3	100

t = tusker

RESULTS AND DISCUSSION

Group size

The basic population unit among elephants is the family unit, consisting of an integrated group of closely related animals of all classes, excluding adult males (Buss 1961, Laws & Parker 1968, Laws 1970, Douglas-Hamilton 1972, Moss & Poole 1983, Moss 1988). In Way Kambas National Park, of the total 471 animals recorded in 41 sightings, (Table 1) such family units comprised between 4-8 animals (Fig. 3) and accounted for 12.2% of the observations. White *et al.* (1993) in a study of the African forest elephant, *Loxodonta africana cyclotis* found the mean group size to be 3.3. Olivier (1978) gave a figure of 5-6 for the family unit of the Asian elephant in the rain forests of Malaysia. The majority of the observations (34.1%) were of solitary individuals (14), all of which were adult bulls. Family units are stable, but aggregate to form "kin" or bond groups, clans, subpopulations and populations (Douglas-Hamilton 1972, Moss & Poole 1983). In Way Kambas, the remaining sightings were for the most part larger groupings or clans of up to 45 individuals, formed by the temporary merger of a number of family units (Eisenberg, 1981). Such larger aggregations in general, split into smaller foraging groups, which move in a coordinated manner (Owen-Smith, 1988).

The other small population unit is the loose group of mature bulls, the bull herd, averaging 4.4 animals. There were five bull groups that ranged in size from 2 to 9. Bull groups are characterized by ever-changing composition (Croze, 1974). Bull groups accounted for 12.2% of the observations. Laws (1974) has postulated that group size is a measure

of the ecological health of elephant populations, since aggregation of family units and bull herds is the result of stressful conditions. This was borne out by Ishwaran (1981) who found the mean group size of an elephant population in an area interspersed with human settlements to be larger than that of a similar population living within a nearby national park. In Way Kambas, the higher group size of the bull group (9) is indicative of the scale of the human-elephant conflicts that exist along the periphery of the park. Similar high group size of bull elephants was observed in Sri Lanka in the Handapanagala area where elephants are in conflict with man (Hendavitharana *et al.* 1994).

The extent to which elephants aggregate in a particular area is relevant to their management as regards habitat utilization. Group size of elephants in Way Kambas National Park showed variation in time and space, ranging from 2 individuals to a maximum of 45 in the grasslands of Wako (Table 1). Western & Lindsay (1984) discuss the reasons for large group formation. Large aggregations formed in response to heavy human predation (Laws *et al.* 1975). The higher group sizes may indicate a high level of disturbance due to social factors in the park. In Uganda, higher group sizes were observed among elephants inhabiting areas where poaching was prevalent, while those areas that were most secure from poaching had the lowest group sizes (Eltringham, 1977).

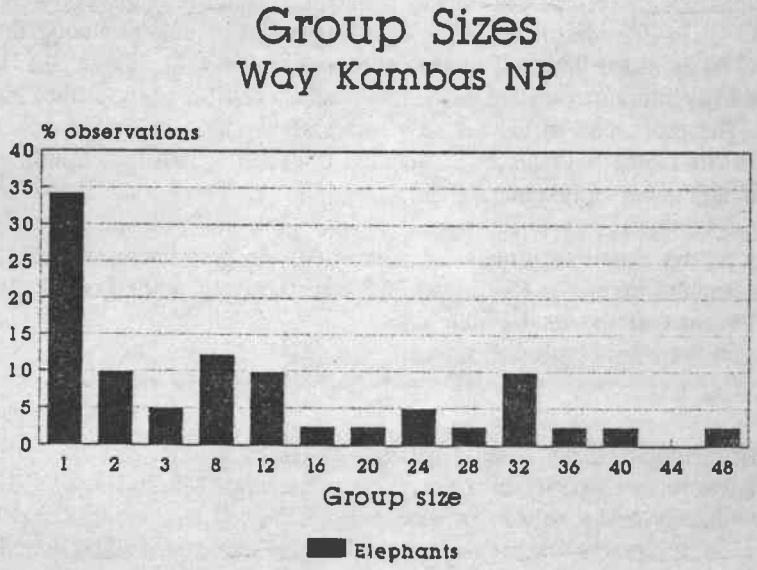


Fig. 3 Frequency of sightings for elephant groupings of various sizes.

Social factors such as territoriality, average group size, seasonality of breeding etc. have a profound influence on the population dynamics of many large mammals and are also important in their management (Caughley & Walker, 1983). Elephants being social animals, live in groups. The basis of their social organization is matriarchy. The groups

are led by the oldest reproducing cow. As in man, the grandmother is an integral part of the group and has important leadership and/or infant care function (Laws *et al.* 1975). The extensive generation overlap leads to the establishment of linear dominance hierarchy among the females, and the leadership often falls on the oldest female in the group. Such female leadership is also known in the water buffalo (Tulloch, 1967) and in the gaur (Schaller, 1967; Ulrich, 1968).

Population structure

The population structure of elephants in Way Kambas National Park appears to be biased towards adults and subadults. Of the 158 animals that were classified, 103 (or 65%) were adult males and females. This was similar to what was observed in the Ruhuna National Park, Sri Lanka (Santiapillai *et al.* 1984). Subadults in Way Kambas accounted for 23% (37 out of 158) of the classified total, while the proportions of the juveniles and calves were 6% (9 out of 158) each. The proportion of tuskers among the bull elephants in Way Kambas appears to be high, given that 13 out of the 47 bulls classified (or 28%) were tuskers. This is less than what was reported by Deraniyagala (1955) who found 98% of a sample of 29 bull elephants from Sumatra to be tuskers. The lower incidence of tuskers in Way Kambas could well be due to the fact that a number of tuskers were poached for their tusks or in defence of the crops. The proportion of tuskers among the bulls in captivity (72.2%) is much higher than that observed in the wild. (Table 3). These bulls were captured in operations to resolve the human-elephant conflict and to reduce the elephant depredations. The proportion of tuskers varies enormously in Asia. While, less than 10% of the bulls in Sri Lanka have tusks (Santiapillai & Jackson, 1990), in South India, over 90% of them are tuskers (Sukumar, 1989).

As far as the classified groups are concerned, the proportions of the adult bulls, adult cows, subadults were 9%, 45.9% and 30.3% respectively, while juveniles and calves made up 7.3% each of the total (Table 2).

Sex-ratio

In most mammals, there is parity between the sexes at birth. But the "natural" adult sex-ratio is unlikely to be parity in a polygynous mammal (Mitchell *et al.* 1977). Adult bull elephants usually lead a solitary or semi-solitary life and rejoin matriarchal units only during the period of reproduction. Therefore, the "natural" sex-ratio will be biased in favour of the adult females (Kurt, 1969; Eisenberg & Lockhart, 1972; Santiapillai *et al.* 1984). In Way Kambas, the adult sex-ratio was 1:5 biased in favour of the females (Table 2). This reflects the selective mortality of the bulls, especially the tuskers as a result of escalating human elephant conflicts.

The elephant is a polygynous species, where one bull can successfully mate with a number of cows in oestrus. Thus, there is always some "surplus" bulls available for mating with cows. Furthermore, as Sukumar (1989) points out, a certain proportion of adult females

would also be either pregnant or in lactational anoestrus, and therefore not available for conception, in which case, the operational sex ratio would not be as disparate as the observed sex ratio in the population. Despite the low proportion of adult males, as long as the female mortality remains very low, the populations will increase or remain stable even in the face of a decrease in fertility due to higher male mortality (Sukumar, 1989). From Table 2, it appears that the inter-calving interval is about 6 years, which is somewhat longer than the average of 4 years. In view of the wide range of adjustment possible in mean calving interval (3 to 9 years), and in the attainment of maturity (9 to 20 years), reproduction might be the actual regulatory process (Laws, 1981).

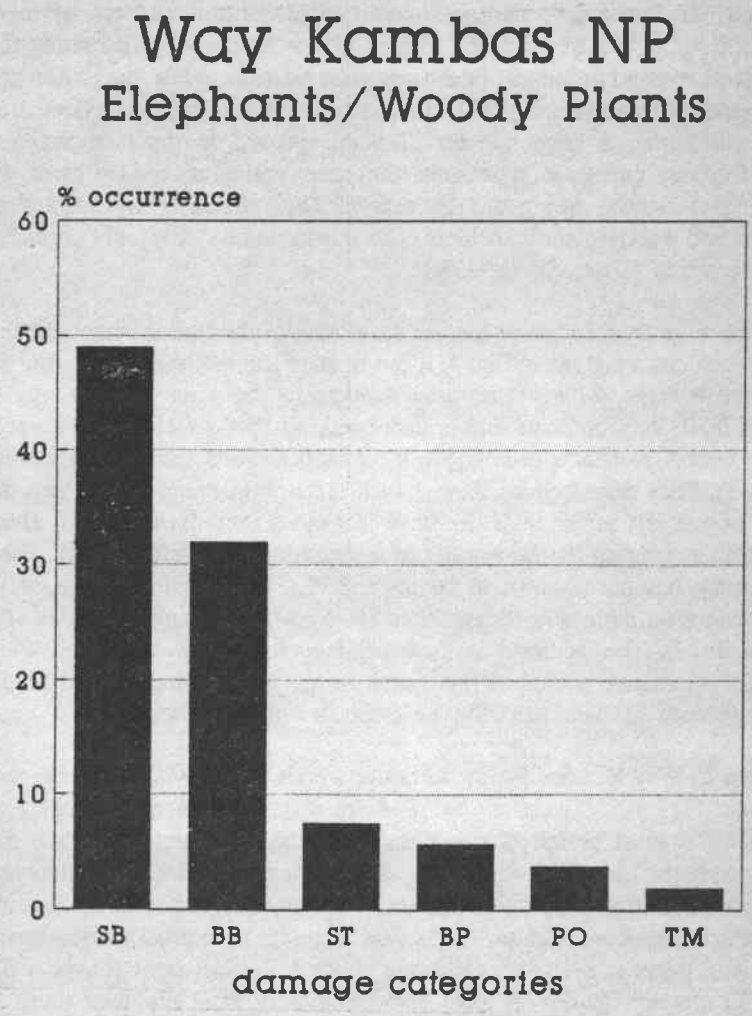


Fig. 4 - Impact of elephants on woody vegetation in Way Kambas National Park, Sumatra. (SB = main stem breaking; BB = Branch breaking; ST = Stem Twisting; BP = Bark Peeling; PO = Push Over; TM = Tusk Marking)

Impact on woody-vegetation

Way Kambas National Park was subject to intensive logging for almost three decades. Much of the original lowland dipterocarp forest has disappeared and what is left today are large areas of secondary scrub and extensive grasslands dominated by *Imperata cylindrica*. The much valued hardwood timber species have been largely extracted and now, a large proportion of the woody vegetation is made up of trees with less than 20 cm diameter at breast height (dbh). But for the elephants and other herbivores, there are sufficient resources in the park, since secondary deciduous forests provide the greatest potential carrying capacity as standard foods can become superabundant and are of high quality (Olivier, 1980). Logging has also created a much higher diversity by increasing the "edge" habitats. Elephants respond to "edges" or the transition zones between forests and grasslands, in a positive manner (Seidensticker, 1984). Elephants being generalized feeders, are catholic in their diet, consuming a large number of plant species. In most environments food abundance and quality change with seasons. Elephants prefer to feed on grass when it is green, switching to browse during the dry season. Thus elephants are adapted as mixed grazer-browsers and woody plant branchlets offer a suitable mix of rapidly digestible leaves and indigestible stems (Owen-Smith, 1988).

The percentage frequencies of the six categories of damage inflected on the woody vegetation by elephants are given in Fig. 4. It can be seen that main-stem breaking accounted for much of the damage. 81% of the total damage to the woody plants was due to a combination of main stem breaking and branch breaking by the elephants. When browsing during the dry season, elephants usually break off branches and feed on the terminal twigs (Ishwaran, 1983). They also feed on bark, which are rich in minerals and sap. In Africa, bark stripping occurs just before trees flower or leaf out (Owen-Smith, 1988). The elephant is a wasteful feeder, judging by the amount of vegetation that is left uneaten. The animal's foraging efficiency has been shown to be high (80%) when feeding on grass, low (20-25%) when feeding on bark, and intermediate (50%) when feeding on leaves, stems and twigs (McKay, 1973). The incidence of bark peeling observed was low (5.7%). Perhaps, an abundance of alternative source of food, such as regenerating trees could be the reason for the low incidence of bark stripping by elephants in Way Kambas.

Elephants in Way Kambas appear to prefer woody plants with a stem girth between 1 to 32 cm dbh (Fig. 5). Size classes below 8 cm dbh were the most prone to elephant damage (81%). The most preferred size class of woody vegetation was between 2 and 4 cm dbh (or saplings). Small woody plants are commonly eaten whole. Elephants prefer feeding on most quick growing pioneer species, while rejecting most of the dominant trees of the Dipterocarpaceae (Owen-Smith, 1988). Forest studies have shown that when abundant young woody vegetation is available, elephants prefer it to older trees (Laws *et al.*, 1975). Trees above 32 cm dbh appear to have some immunity from elephant damage. These observations in Way Kambas National Park where the vegetation is secondary, are in agreement with those of Wing & Buss (1970), Laws *et al.* (1975) and Ishwaran (1983).

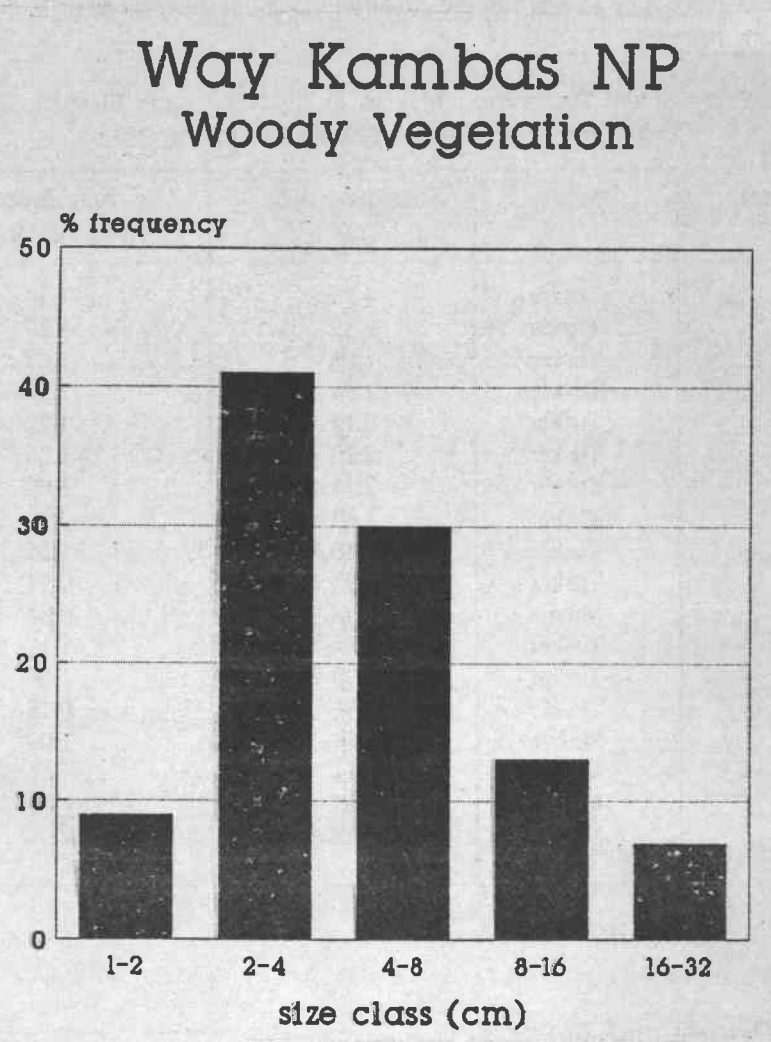


Fig. 5 - Size of woody vegetation preferred by elephants in Way Kambas National Park, Sumatra.

There is currently evidence to show that the tree species eaten by elephants are also fast growing and short-lived (Laws *et al.* 1975). Such fast growing species are characteristic of the secondary forests and production forests in Sumatra. Moreover, elephants not only selectively damage the smaller size classes of woody vegetation, they are also species selective and therefore in the long term, can alter the composition of the forest. If this is so, then elephants and economic timber production may not be compatible

(Laws *et al.* 1975). These observations therefore have serious implications for the management of production forests situated either within an elephant range or in the vicinity of an elephant reserve.

Table 3. Record of the Tuskers and Maknas in captivity at the Elephant Training Centre, near Way Kambas National Park, Sumatra.

Age (yrs)	Status	Shoulder height (m)	circumference of right fore foot (m)
18	Tusker	1.99	1.14
15	Tusker	2.32	1.34
15	Tusker	1.96	1.07
8	Tusker	1.94	1.06
15	Tusker	2.13	1.22
16	Tusker	2.29	1.25
12	Tusker	2.11	1.09
6	Tusker	1.63	0.89
12	Tusker	2.16	1.25
8	Tusker	1.98	0.99
3	Makna	1.48	0.84
6	Tusker	1.84	1.13
5	Tusker	1.73	1.09
2	Tusker	1.31	0.78
7	Makna	1.89	1.09
6	Makna	1.71	-
4	Makna	1.65	-
5	Makna	1.58	-

% of tusker = 13/18 x 100 = 72.2%

Number, Density and Biomass

The number of animals and their occupance are of fundamental importance to wildlife management (Jachman & Bell, 1979). However, in the dense and tangled vegetation of the humid tropics, it is not often easy to arrive at accurate estimates of population size of even elephants. Any assessment of elephant number will therefore be prone to underestimate the actual total. This was very clearly demonstrated in 1982 during the elephant drive code-named, *"Operation Ganesha"* in South Sumatra province when a total of 232 animals were flushed out of a patch of forest in Air Sugihan transmigration settlement which was long thought to have had only about 80 elephants (Blouch & Haryanto 1984).

An alternative approach would be as recommended by Laws *et al.* (1975) to estimate the area available to the elephants and then apply hypothetical elephant densities to this area and thereby estimate the total number of elephants. In suitable South east Asian habitats, crude density of elephants can range from 0.1 to 1.0/km² (Eisenberg, 1981; Eisenberg & Seidensticker, 1976). In general, elephants are known to live at a higher density in secondary forests than in primary forests. Based on the number of separate groups of elephants actually recorded in the park in 1984 (minimum number of about 140 from three separate groups of 65 animals from Camp D2; 45 animals from Wako and 30 animals along the southern boundary) and the subsequent number of elephants translocated into the park from outside in two elephant drives (72 and 40 elephants totalling 112 animals), the minimum estimate of the total population of elephants in Way Kambas National Park by the end of 1987 was 252, giving a minimum crude density of 0.19 per km². The actual number could be anything between a minimum of 250 and a maximum of 350 animals. Despite its limitations, this is a more realistic estimate of elephant number than what was previously estimated; 30 by Wind (1978) and 40 by Olivier (1981) for the entire park.

In calculating the biomass of elephants in Way Kambas, an average value of 1,810 kg was used as the elephant's weight (adjusted with respect to percentage of age and sex classes) as recommended by Eisenberg & Lockhart (1972). This would mean a biomass of 344 kg/km2 at the minimum crude density of 0.19 per km². The biomass could be as high as 488 kg/km² at a maximum crude density of 0.27 per km², which is typical for most of the secondary forest habitats in the Indomalayan region. Even though elephants are not numerically the most dominant species in Way Kambas, they still remain ecologically the most important in terms of biomass and cycling of plant material.

CONCLUSION

The elephants in Way Kamabs National Park represent an important lowland population, whose prospects for long term survival appear to be good provided efforts are made to minimize the human-elephant conflicts. The agency responsible for the conservation and management of elephants in Indonesia, the Directorate General of Forest Protection and Nature Conservation (PHPA) have taken a number of measures that range from translocation of problem elephants, establishment of electric fences, to capture and domestication of chronic crop raiders so that they could be gainfully employed in forestry, agriculture and nature tourism.

Some of the common management problems associated with elephants in the park are the inevitable consequences of their large body size and intemperate appetite. Land adjoining the park was once part of the elephant's range and today it is being intensively cultivated, which attracts the elephants even though there is plenty of food within the park (Santiapillai & Widodo, 1993). Sumatra is rapidly approaching a stage when all the remnant of natural environment will be contained in a patchwork of parks and reserves. Containing elephants within protected areas surrounded by dense human settlements will inevitably lead to an escalation of conflicts between man and elephant. Therefore elephant habitats

within the protected areas must be properly managed to improve the grazing/browsing opportunities for the elephants, given that the elephant's digestive physiology is adapted to a bulky, high fibre diet (Janis, 1976; Olivier, 1978).

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