TIMBER, COCOA, AND CROP-RAIDING ELEPHANTS: A PRELIMINARY STUDY FROM SOUTHERN GHANA

R.FW. Barnes[1], S. Azika[2] and B. Asamoah-Boateng[2]

[1] Department of Bioiogy 0116, University of California San Diego, La Jolla, CA 92093-0116, U.S.A.

[2] Wildlife Department, P0 Box 427, Cape Coast, Ghana

INTRODUCTION

Crop-raiding by elephants is a problem wherever cultivators live in close proximity to elephants. In southern Ghana elephants are usually found in forests surrounded by cultivation, and complaints of crop damage are common. Farmers living around the Kakum and Assin Attandanso forests complain that crop-raiding intensified after management of the forests was turned over to the Wildlife Department in 1989. In this paper we describe the losses suffered by farmers. We then present a hypothesis to explain why crop-raiding has increased. This hypothesis is based upon the effects that logging has on forest structure, the activities of cocoa farmers, and a simple conceptual model of a shrinking forest.

Measurements of crop damage were made in August and September 1992, and the rest of the field work was conducted in September and October 1993.

STUDY AREA

Kakum and Assin Attandanso forests (Figure 1) cover 212km^2 and 154km^2 respectively (Hawthorne & Musah, 1993). They lie in the moist evergreen zone of south-west Ghana (Hall & Swaine, 1981). They were demarcated with concrete pillars and established as forest reserves in 1925-26 and 1935-36 respectively to protect water catchments (Kpelle, 1993). Logging started in 1936 and was intensified during the 1 950s, and especially between 1973 and 1989 (Kpelle, 1993). In 1989 logging was suspended and the responsibility for management was transferred from the Forestry Department to the Wildlife Department. Kakum was designated a National Park (NP) and Assin Attandanso became a Wildlife Resource Reserve. (Figure 1).

Although once part of a larger forested area, today Kakum and Assin Attandanso form an isolated block surrounded by cultivation except for the adjacent Pra Suhien and Ajueso Forest Reserves. Elephants do not cross the road into the Pra Suhien Forest Reserve, and the Ajueso Forest Reserve is small, so the elephant population appears to be an isolated fragment (Dudley, Mensah-Ntiamoah & Kpelle, 1992). A rough estimate of 100 to 150 elephants was made by Dudley *et al.* (1992) who pointed out that their methods were crude.

DAMAGE TO CROPS

Cocoa is the main cash crop in the area. Farmers also grow subsistence crops interspersed with their cocoa plantations. Most elephant damage is caused in the wet season. An assessment was made of the losses suffered by farmers around Kakum NP who complained of depredations by elephants. In each case the dimensions

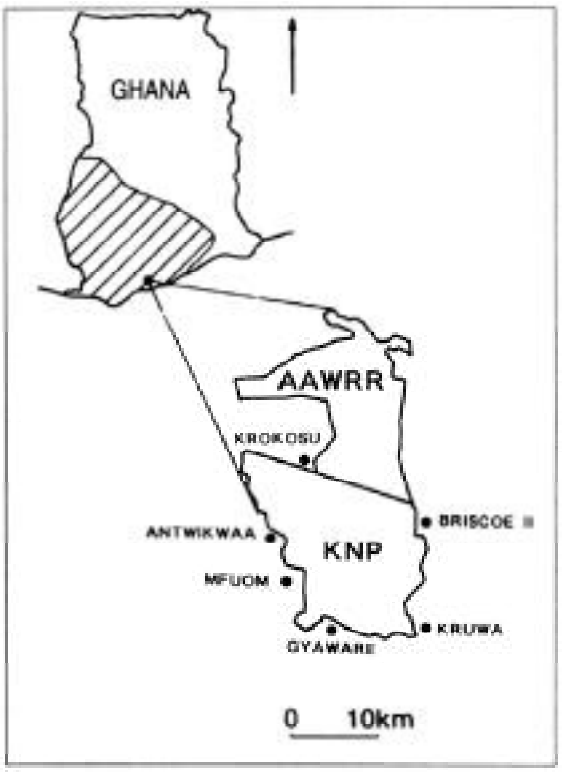

Figure 1. Map of Ghana, Kakum National Park (KNP), and Assin Attandanso Wildlife Reserve (AAWRR). The shaded area shows the forest zone.

of the field were measured with a tape measure. Then the dimensions of the patches damaged by elephants within the preceding 30 days were measured.

Altogether 140 fields were examined in six areas around Kakum (Tables 1 and 2). Maize and cassava were the crops that were most frequently reported to be damaged (Table 1). Yarns and maize were the crops which suffered the greatest percentage losses (Table 1). On average these farmers had lost 50% of their crops within the preceding 30 days (Table 1). These figures show that farmers who are afflicted suffer severely.

Farmers living on the west side of the Park (in Mfuom, Antwikwaa, and Krokosu) complained most frequently about elephants in their fields (Table 2). But the small number of fields damaged on the east side suffered a greater percentage loss. For example, the eight fields at Briscoe II lost more than nine-tenths of their crops (Table 2).

Table 1. The extent of damage caused by elephants to different types of crops. Data are from farmers who complained of crop damage.

Crop	Area of crop (ha)	Percentage Damaged	Number of Fields
Cassava	14.6	42	31
Cocoyam	5.4	43	18
Pineapple	0.4	25	1
Maize	16.0	68	48
Plantain	9.2	43	27
Yam	2.1	76	14
Cocoa	4.0	25	1
Total	51.7		140
Average		50	

Note that although cocoa is cultivated all round the Park, only one cocoa field was reported damaged (Table 1). In this part of Ghana elephants very rarely touch cocoa, whereas further north they eat the pods (Dudley et al., 1992).

We have no data yet on the percentage of farmers who suffer crop damage. But it is clear that those close to the edge of the forest are at greatest risk (Dudley *et al.*, 1992), and the probability of crop damage declines with distance from the forest edge. Thus farmers living a kilometre or more from the forest are less likely to complain of elephant depredations.

Table 2. Crop damage measured in different areas around the Kakum National Park. The data are from farmers who complained of crop damage.

Location	Area of Farms Measured (ha)	Percentage Area	Number of Fields Damaged
Mfuom	22.5	55	39
Antwikwaa	8.8	12	24
Krokosu	9.2	64	44
Briscoe II	1.1	91	8
Kruwa	1.3	66	6
Gyaware	8.7	44	19
Total	51.6		140
Average		48	

LOGGING

Logging has resulted in marked changes in forest structure. Two physiognomic changes are of particular importance: the reduction in fruiting trees and the increase in secondary growth (Dudley *et al.*, 1992). Fruit is an important part of the diet of forest elephants (Merz, 1981; Short, 1981; White, Tutin & Fernandez, 1993; White, 1994). At present we have no data on the reduction of fruiting trees caused by logging. Nor do we have measurements of the enhanced availability of browse. However, the marked differences in the undergrowth between the unlogged and logged compartments has led us to suspect that the greater abundance of secondary growth, which is the preferred feeding habitat of elephants (Merz, 1981, 1986; Barnes *et al.*, 1991; Dudley *et al.*, 1992), far outweighs the loss of fruit resources. Nothing is known about the response of forest-dwelling elephant populations to changes in food abundance. However, if forest elephants respond in the same way as savanna elephants to variations in food supply (Laws, Parker & Johnstone, 1975), then the improvement in habitat has resulted in higher pregnancy rates and improved survival rates. The long gestation period plus the prolonged juvenile growth (family groups with infants rarely raid crops [Sukumar, 1991; Dudley *et al.*, 1992]) means that there would be a time lag between the improvement in the food supply and consequent increase in crop-raiding.

When it became known that the forest would be turned over to the Wildlife Department in 1989, there was a

flurry of logging activity, especially in Assin Attandanso. The loggers concentrated on the timber near the periphery because it was more accessible. Also, logging intensified in forest patches outside the reserves. Thus the greatest change in forest structure was probably around the edges of the forest. The greater abundance of food attracted elephants to the edge where they were more likely to smell nearby crops.

COCOA

Forty-seven farmers living around the Kakum and Assin Attandanso forests were interviewed (note that this was a non-random sample). Of the 31 who gave their place of origin, none had been born in the place they now lived. Five came from villages within the general vicinity, 12 came from other parts of Central Region, and 14 came from outside the region. Those who had moved into the area said they had come with the specific intent of growing cocoa.

The trend in world cocoa prices is shown in Figure 2. Prices (in constant 1980 dollars) rose in the 1950s, fell back, and then rose steeply in the 1970s to peak in 1977. They then fell sharply, rallied in 1983, but then continued their decline. We suggest that the higher prices in the 1970s drew immigrants into the area. They cleared forest around the park to establish cocoa plantations. One farmer told us that 20 years ago the forest extended 3km to the west of its present boundary at Antwikwaa. If we assume that the forest extended 3km on all sides from its present boundary, then in the early 1970s it could have covered 1.9 times the area it covers today, or about 700km^2. This fringe has been replaced by cocoa plantations, subsistence farms, and "farm bush" or secondary growth on abandoned fields.

How would the changes in forest area since 1970 affect the interface between elephants and farmers? Figure 3 shows the results of a simple model in which it is assumed that in 1970 there were 50 elephants dwelling in a circular forest with an area of 700km^2. Between 1970 and 1993 the radius of the forest decreased by 3km, so the area of forest was halved. Even if elephant numbers did not change, the contraction of the forest would have caused the elephant density within the forest

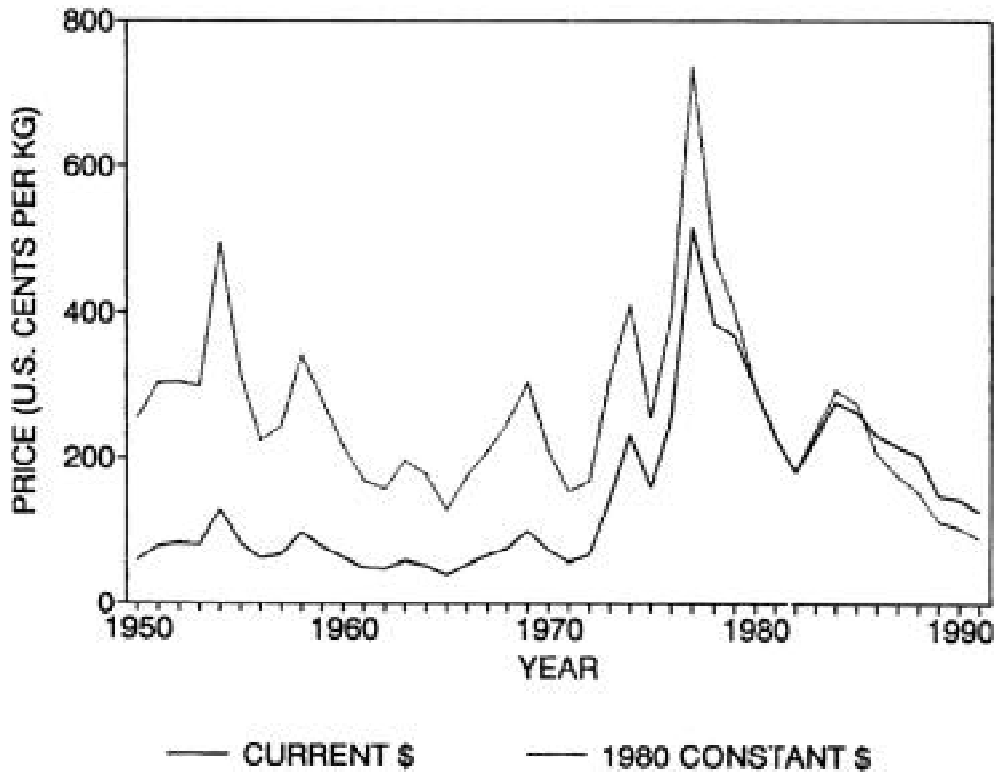

Figure 2 The trends in prices of Ghanain cocoa beans atthe London commodIty exchange between 1950 and 1991. Data from World Bank (1994)

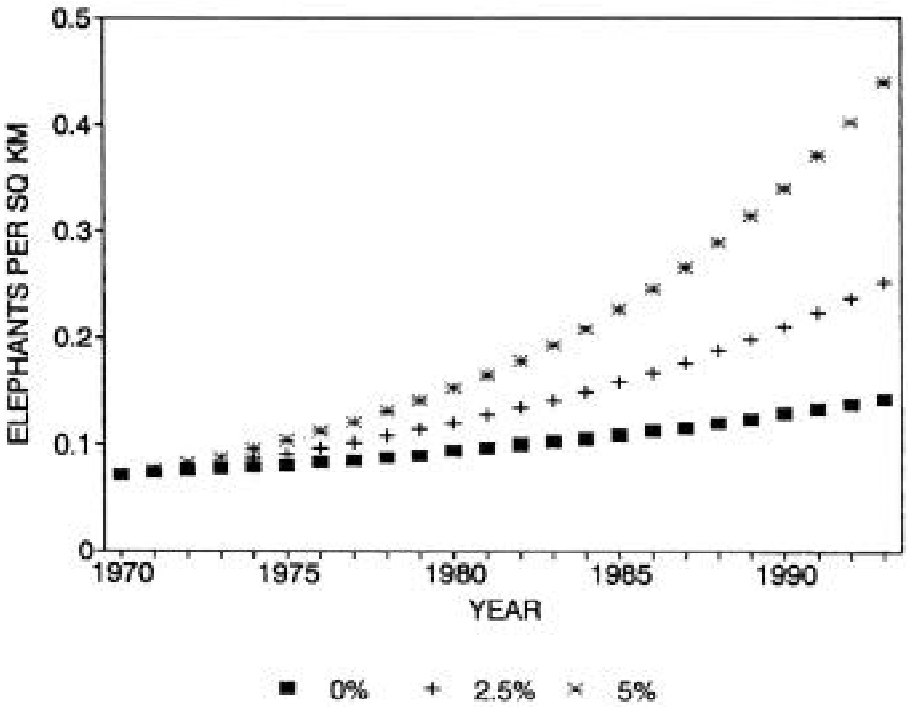

Figure 3. Modelled trends in elephant densities as their forest habitat decreased in size, assuming that the elephant numbers remained constant or in creased at an annual rate of 2.5% or 5%.

to double (Figure 3). If numbers increased at an average rate of say 2.5% per annum, because of the improved food supply caused by logging, then the density increased to 3.5 times its initial level. If numbers increased at an average rate of 5% per annum, then the final density would have been six times its initial level.

Rather than the density of elephants being the critical factor determining crop-raiding, it might be the number of elephants close to the periphery where they may smell crops. Let us assume that elephants within one kilometre of the forest edge are more likely to be tempted into the fields. As a circle shrinks, its radius diminishes and a greater proportion of the circle's area lies within one kilometre of the periphery. In 1970 the ring of forest within one kilometre of the boundary covered 91km^2. If the 50 elephants were evenly distributed through the forest, then six or seven elephants would have been found within this ring. In 1993, when the forest was half the size, the area of the outer ring was 63km^2. Assuming there were still 50 elephants, then nine would have been found within one kilometre of the boundary. Thus the shrinkage of the forest would result in more elephants being within easy reach of the forest boundary and the nearby fields. If elephant numbers had increased by 2.5% or 5%, then the number of elephants in the outer ring would be 16 or 28 respectively.

The perimeter of the forest has also decreased. In 1973 our circular forest would have had a perimeter of 94km, compared with 66km in 1993. If the average farm size had not changed, then for every 94 farms adjacent to the forest in 1970 there would be 66 today. Thus today there would be fewer farms at the interface between forest and cultivation. But those at the interface today could expect to suffer a greater intensity of elephant damage than in 1970 because of the higher elephant density in the forest.

DISCUSSION

As cocoa prices rose in the 1970s, people moved to the Kakum and Assin Attandanso area. Gradually they cleared the forest up to the boundary pillars. At the same time timber companies were unintentionally improving the structure of the forest in favour of elephants. Dudley *et al.* (1992) pointed out the link between world timber markets and changes in the quality of forest elephant habitats. The better food supply per unit area may well have balanced the decline in forest area, in which case elephants prospered. There would have been a lag between the changes caused to the vegetation by logging and the consequent increase in crop-raiding.

Even without any change in elephant numbers, the contraction of the forest resulted in more elephants within easy reach of the forest edge and adjacent fields. Logging exacerbated this by attracting them towards the periphery. Thus we suggest that cocoa farming and logging have stimulated crop-raiding because they both (a) caused an increase in elephant density and (b) resulted in a greater number of elephants close to the edge of the park.

The apparent increase in crop-raiding after the Wildlife Department assumed responsibility for the forest is probably explained by the concentration of logging activity at the periphery just before logging ceased in 1989. This must have attracted elephants to the edges of the forest in the years after 1989.

We have presented a hypothesis in this paper to explain the increase in crop-raiding around Kakum and Assin Attandanso forests. Most parts of the hypothesis can be tested. For example, when new aerial photographs become available, they can be compared with those taken in the 1970s to show the rate at which the forest has contracted, changes in the distribution of cocoa plantations and other forms of cultivation, and the effect of logging (by measuring changes in the density and distribution of emergent trees). Changes in the structure of the forest could also be investigated by field surveys combined with examination of compartment records kept by the timber companies. The preference of elephants for heavily logged areas could be demonstrated by studies of elephant distribution. A properly conducted sample survey of cocoa farmers could show the relationship between cocoa prices and immigration to the area. However, it will not be possible to assess the trend in elephant numbers because there are no data on elephant abundance in the past.

If our hypothesis is not falsified, then we will argue that the forest is a system of which the elephants are but one component. Economic forces, such as world demand for cocoa or timber, can exert an effect on the forest and the people living around it. Meddling with one component of the system, such as removing the larger trees, may result in unintended consequences elsewhere, such as damaged crops outside. Time lags can obscure the causes of the problem. For example, we would suggest that although the timber companies have long gone, it is only today that the farmers are suffering the consequences of their activities.

ACKNOWLEDGEMENTS

This work was conducted as part of the Wildlife Department/Conservation International initiative to develop the tourist potential of the Kakum National Park. Funding was supplied by U.S.A.I.D. via Conservation International. We thank Malcolm Stark for logistical support. John Oates and Malcolm Stark criticised earlier drafts of the manuscript.

REFERENCES

Barnes, R.F.W., Barnes, K.L., Alers, M.P.T. & Blom, A. (1991) Man determines the distribution of elephants in the rain forests of north-eastern Gabon. *Afr. J. Ecol.* 29, 54-63.

Dudley, J.P., Mensah-Ntiamoah, A.Y. & Kpelle, D.G. (1992) Forest elephants in a rainforest fragment: preliminary findings from a wildlife conservation project in southern Ghana. *Afr. J. Ecol.* 30, 116-126.

Hall, J.B. & Swaine, M.D. (1981) Distribution and ecology of vascular plants in a tropical rain forest: forest vegetation in Ghana. *Junk*, The Hague.

Hawthorne, W. & Musah, J. (1993) Forest protection in Ghana. Unpublished report, ODA and Forest Inventory and Management Project Planning Branch, Forestry Department, Kumasi.

Merz, G. (1981) Récherches sur la biologie de nutrion et les habitat préferes de l'éléphant de foret, *Loxodonta africana cyclotis* Matschie, 1900. Mammalia 45, 299-312.

Merz, G. (1986) Counting elephants (Loxodonta african cyclotis) in tropical rain forests with particular reference to the Tai national Park, Ivory Coast. *Afr. J. Ecol.* 24, 61-68.

Kpelle, D.G. (1993) Evaluation of past management and resource use of Kakum and Assin Attandanso forest reserves. Unpublished report, Department of Game & Wildlife, Accra.

Laws, R.M., Parker, I.S.C., & Johnstone, R.C.B. (1975) *Elephants and their Habitats.* Clarendon press, Oxford.

Short, J. (1981) Diet and feeding behaviour of the forest elephant. *Mammalia* 45, 177-186.

Sukumar, R. (1991) The management of large mammals in relation to male strategies and conflict with people. *Biol. Cons.* 55, 93-102.

White, L.J.T. (1994) *Saco glottis gabonensis* fruiting and the seasonal movements of elephants in the Lopé Reserve, Gabon. *J. Trop. Ecol.* 10, 121-125.

White, L.J.T., Tutin, C.E.G. & Fernandez, M. (1993) Group composition and diet of forest elephants, *Loxodonta africana cyclotis* Matschie 1900, in the Lope Reserve, Gabon. *Afr. J. Ecol.* 31, 181-199.

World Bank (1994) Commodity trade and price trends, 1989 - 91 edition. John Hopkins University Press, Baltimore.

Photo credit: Kadzo Kangwana

A maize crop damaged by elephants.