for species conservation. *BioScience.* 31: 131–134.

Spinage, C.A. 1982. *A Territorial Antelope: The Uganda Waterbuck.* Academic Press, London.

Sukumar, R. 1985. Ecology of the Asian elephant. *(Elephas maximus)* and its interaction with man in South India. Ph.D. thesis, Indian Institute of Science, Bangalore.

Sukumar, R. 1989. *The Asian Elephant: Ecology and Management.* Cambridge University Press, Cambridge.

Sukumar, R. 1991. The management of large mammals in relation to male strategies and conflict with people. *Biological Conservation.* 55: 93–102.

Tennent, J.E. 1867. *The Wild Elephant and Taming it in Ceylon* Longmans, Green & Co. London.

Vancuylenberg, B.W.B. 1974. The feeding behaviour of the Asiatic elephant in southeastern Ceylon. M.Sc. thesis. University of Sri Lanka, Peradeniya.

Vancuylenberg, B.W.B. 1977. Feeding behaviour of the Asiatic elephant in southeast Sri Lanka in relation to conservation. Biological Conservation. 12: 33–54.

Watson, R.M. & Bell, R.H.V. 1969. The distribution, abundance and status of elephant in the Serengeti region of Northern Tanzania. *J. App. Ecol.* 6: 115–132.

Wanigasundara, M. 1990. Elephants slaughtered in civil war. *The Jakarta Post.* 1 Nov. 1990. (reprinted in the Asian Elephant Specialist Group Newsletter No. 6. Spring 1991).

Whitehead, G.K. 1953. *The ancient white cattle of Britain and their descendents.* Faber & Faber, London.

Woodford, M.H. 1979. Assistance in the capture of wild buffaloes for animal draught purposes. Sri Lanka. Consultant Report. TCP/SRL/8908. FAO Rome. 15 pp.

Acknowledgement

Our thanks to the Director of Wildlife Conservation in Sri Lanka, Dr. Sarath W. Kotagama for the facilities provided in Ruhuna National Park and for his support for the programme. We would also like to thank the WWF-International for its provision of financial and manpower assistance. Park Warden Mr. B.M. Muthubanda and his Deputy, Mr. B.V.R. Jayaratne gave us their unstinted help in the park. We thank Mr. Tissa Alagoda of the Dept. of Zoology, University of Peradeniya, Sri Lanka for preparing the maps and to Prof. Mangala de Silva (at the same institute) for helping with the computer analysis of the data.

MANAGING ELEPHANT DEPREDATION IN PLANTATIONS IN SABAH

Mahedi Andau
(Director of Wildlife Conservation, Sabah)

and

Junaidi Payne
(World Wildlife Fund Malaysia, with Sabah Forest Department)

a paper presented at the
9th MALAYSIAN FORESTRY CONFERENCE SARAWAK
6 – 13 OCTOBER 1986

SUMMARY

Wild elephants cause enormous losses in Sabah by destroying plantation crops, notably oil palm. An ecological approach to minimising such damage, through such measures as careful siting of Reserves and plantations, offers limited prospects in the state, because bounda-

ries for Reserves have already been decided and gazetted. It is strongly recommended, however, that existing Forest and Wildlife Reserves are maintained at their present size, especially Tabin Wildlife Reserve, large enough to maintain self-contained viable breeding populations. Further excisions would produce more elephants without a home.

Data are presented to indicate that properly-maintained electrified fencing is not only effective in keeping elaphants out of plantations, but that installation of fencing at an early stage in plantation development is cheaper than the damage that is likely to be done by elephants in the absence of such fencing.

Electrified fencing may be ineffective (i) against certain solitary, adult bull elephants, which should be killed if they learn to destroy fencing at high voltage, and (ii) in flood-prone areas, where the fencing becomes ineffective when water reaches the wiring.

It is recommended that a novel physical barrier against elephants, in the form of sharp stones embedded in the ground, be considered by plantations which have not yet completely erected fencing.

1. INTRODUCTION

Asian elaphants *(Elephas maximus)*, once distributed throughout much of Asia, have been raiding crops for thousands of years. As a result of loss of natural habitat and of deliberate killing by Man, the elephant population has been reduced to a few scattered remnants. The rate of decline of elephant numbers has been accelerated in recent decades by sharp increases in human population growth coupled with large-scale clearance of natural forest habitat for agriculture. The cost of elephant depradations on plantations in Malaysia is enormous: FELDA and the Sabah Land Development Board alone have lost many millions of ringgits to elephants during the 1970's to 1980's (Blair *et al*, 1979, Blair and Noor, 1981, and O F Wakefield, pers. comm.).

In the past, elephants raiding crops were generally killed without question. In recent years has come the realisation that agricultural development has proceeded such that there are few areas remaining of adequate size to support even a small population of elephants. If elephants are not to go extinct, therefore, ways have to be found of minimising their damage to plantations without resorting to uncontrolled slaughter.

2. METHODS OF REDUCING ELEPHANT DEPRADATIONS

"As more experience is gained, and post-audit data become available, the expanding body of evidence suggests that it is more cost-effective to manage elephants in and adjacent to project areas from the beginning of the project. This requires careful pre-project planning, project designs which will prevent elephants from entering production areas, and provisions to ensure local elephants' access to critical resource areas, or to provide these through habitat enrichment and other measures." (Seidensticker, 1984). The same author claims that "fencing with electrification usually is ineffective in repelling elephants. Ivory tusks do not conduct electricity. Elephants may push over a tree on the fence or simply shove the fence". Seidensticker argues instead that agricultural and forestry development projects should be sited so as to allow local elephant populations continuing access to all their water, mineral lick and food requirements. In addition, he suggests that the boundary region between forest or wildlife reserves and the plantation should in some way be made ecologically unattractive to elephants, so that they will be unwilling to move between their reserve and plantations. Indeed, this would be ideal, but many decisions on land use have been made already without reference to elephants, and there are many cases where it seems that only the construction of physical barriers will keep elephants out of plantations.

Andau and Payne (1985) argue that the policy of the Sabah Forest Department (the government agency charged with conservation of elephants in the state) should be to: (1) encourage all larger plantations to erect and adequately maintain electrified fencing, (2) maintain Tabin Wildlife Reserve (about 123,000 ha

in area) as Sabah's major elephant reserve, and (3) chase elephants out of agricultural areas whenever called upon to do so, and destroy them only after repeated and irreconciable conflict. This paper attempts to assess the value of electrified fencing in reducing elephant depradations on plantations in Sabah, and suggests an as-yet untried method for keeping elephants out of plantations.

3. AN ASSESSMENT OF THE VALUE OF ELECTRIFIED FENCING

3.1 METHODS

Prior to 1984, only one (oil palm) plantation in Sabah had erected electrified fencing; it has suffered no damage from elephants. In April of that year, the authors of this paper organised a one-day course on electrified fencing, in each of the towns of Sandakan and Lahad Datu in eastern Sabah (Payne, 1984), presented by a supplier of such fencing, and attended by over thirty representatives from plantations in the region. Subsequently, at least nine plantations installed electrified fencing designed to keep out elephants. Seven responded to questionnaires asking for data related to the costs and benefits of installing the fencing, and key data are summarised here (Table 1). So many variables are associated with this limited amount of data (for example, the cost of damage varies with age at which the plants are destroyed, while data from plantations where the fence does not completely encircle the boundary cannot be interpreted objectively), that we have decided to interpret it on a case-by-case basis, rather that draw and overall conclusion.

3.2 INTERPRETATION OF TABLE 1

The money value of one destroyed plant varies from less than M$3 for a nursery seedling to many tens of M$ for a plant which has been growing in the field for several years. Since damage on any particular plantation either involves different age classes of plant or has not been specified by the plantation management, we assume that loss of an "average" plant represents a los of M$10 unless otherwise specified.

Plantation 1. Installation of fencing and maintenance for four years would cost about M$115,000. Instead, an estimated M$180,000 was lost in the four years preceding installation. The solitary bull elephant learned how to penetrate the fence, even with pulses at 7.5 kv, and should be destroyed. Female/young herds which had been damaging palms previously have not penetrated the plantation since installation of fencing. In any case, this plantation is well-advised to install fencing because it shares a common boundary with Tabin Wildlife Reserve, which contains many elephants.

Plantation 2. Installation of fencing and maintenance for four years would cost about M$62,000. Instead, an estimated M$300,000 was lost in two years preceeding installation. Penetration of elephants after installation was attributed to inadequate voltage. This plantation will ultimately be far from Forest Reserve, but is now in one of the highest elephant concentrations in Sabah, and installation of properly-maintained fencing is worthwhile.

Plantation 3. Installation of fencing and maintenance for four years would cost about M$33,000. Only an estimated M$2,500 was lost prior to installation, while a larger amount was lost afterwards. However, penetration occurred during flooding, when water reached the wiring, rendering the fencing ineffective (see notes on Plantation 7.). In principle, fencing would seem advisable, because elephants are fairly abundant locally, but the area is highly flood-prone in further problems are likely for this reason.

Plantation 4. Installation of fencing along the boundary with Tabin Wildlife Reserve and maintenance for four years would cost about M$220,000. The difference in elephant damage before and after installation of fencing is dramatic: an estimated M$2,850,000 before and no damage after. It is essential that fencing is maintained and extended as necessary.

Plantation 5. Total cost of installation and maintenance cannot be calculated, but the dramatic difference in elephant damage before and after installation — an estimated M$500,000 before and non after — led this plantation's

manager to comment "installation of Electric Fence is the most effective way to prevent .... elephant attack on 1 - 4 year old oil palm".

Plantation 6. The perimeter of this large plantation, which is in the middle of a high concentration of elephants far from permanent Forest Reserve, is still being fenced, but an estimated M$106,000 was lost before the first installation, while the manager has stated that subsequent elephant penetration has been through unfenced portions.

Plantation 7. Protection of this plantation from elephant damage is especially problematical. Rotan, a favoured natural food of elephants, is planted under forest cover in an area often used by elephants, and so installation of fencing would seem necessary. However, the cost of planting rotan and the expected income are low in comparison to other crops, and so the proportion of development cost incurred by electrified fencing is relatively high. Furthermore, being under forest cover contiguous with adjacent forest, fence maintenance costs are high. The whole region is highly flood-prone, as is Plantation 3. Also, there is a possibility that once the entire perimeter has been fenced, it will be found that some elephants are trapped inside.

4. PROPOSAL FOR A NEW FORM OF PHYSICAL BARRIER

Recently, William Xanten of the National Zoo, Washington D.C. has suggested to the authors another method which we would recommend be tried by plantations in suitable situations. A number of zoos in North America and Europe find that captive elephants will not cross a barrier of closely-spaced sharp stones embedded in the ground — because the soles of the feet are broad yet rather soft — and we can think of no reason why wild elephants should act differently. We suggest that it would be worthwhile to experiment with such a barrier at least 8 feet and preferably 10 feet wide, more than the stride of an adult bull elephant.

Several factors must be considered before embarking on this novel method. Firstly, whether crops are damaged primarily by elephants, or by a range of mammals including pigs, deer and primates. Electrified fencing can help to keep out all these animals, while sharp stones would be a barrier only to elephants. Secondly, costs will vary from place to place. In many areas where elephants are abundant, hard stone does not occur and it would have to be brought in at high cost from elsewhere. Sharpened short bamboo stakes could be a cheaper alternative but would have to be inspected and replaced from time to time. We do not have data available to estimate likely costs of laying down a chain of stones 10 feet wide, but would guess that initial costs would generally be greater, while maintenance costs over the long term would be less than that for the installation of electrified fencing. Thirdly, the realities of proper maintenance must be assessed. Electrified fencing can be well-maintained if daily inspections are made and if tree-falls are unlikely to occur, but experience has shown that maintenance of high voltage is sometimes neglected. Satisfactory fence maintenance under forest cover in seasonally-flooded areas (such as Plantation 7, Table 1), for example, is an almost-impossible task. The sharp stone barriesr requires almost no maintenance. Plantations such as this may find that a judicious combination of electrified fencing and sharp stones is most cost-effective.

5. ADDITIONAL METHODS FOR REDUCING ELEPHANT DAMAGE

Sections 3. and 4. indicate that physical barriers can reduce elephant damage to plantation crops, but do not touch upon the other side of the same story: welfare of the elephants and conservation of viable breeding populations. If we consider the likelihood that elephants given access to adequate water, mineral licks, food and mates inside Reserves are less likely to come out into plantations, then it is clear that the welfare and conservation of elephants should be viewed in relation to control measures.

In some areas, notably the region between the lower Kinabatangan and Segama Rivers, there are hundreds of elephants where, in the

TABLE 1. COSTS AND BENEFITS OF INSTALLING ELECTRIFIED FENCING FOR PROTECTION OF CROPS AGAINST ELEPHANTS IN SEVEN PLANTATIONS IN SABAH.

Plantation/ size/ crops	Period of fence installation	Damage to crops (a) before (b) after fence installation	Cost per chain of (a) Installation (b) Annual Maintenance
1. 5098 ha cocoa & oil palm	1985 complete around planted oil palm	(a) 18,000 palms in 200 ha in 4 years, (b) 314 palms by one solitary bull (broke through fence)	(a) M$60 (b) M$5 Fence: 1440 chains
2. 4856 ha oil palm	1984 complete around planted oil palm	(a) most palms within 150 ha area destroyed 2 or 3 times within 2 years, (b) initially some; none since voltage kept high	(a) total cost M$38,347 (b) total cost M$6000 Fence length unknown
3. 2023 ha oil palm	1985 complete around planted oil palm	(a) 250 palms (b) none except one occasion during flooding, 1000 seedlings	(a) M$46.50 (b) M$4.80 Fence: 500 chains
4. 80,000 ha oil palm, coconut & cocoa	1985 only along boundary with Wildlife Reserve fenced	(a) 276,814 oil palms 7086 coconuts 1500 cocoa plants (b) none	(a) M$80 (b) unknown Fence: 2200 chains
5. 19,255 ha oil palm & cocoa	1985 only along boundary with Forest Reserve fenced	(a) 50,000 oil palms during 1982–1985 (b) none	(a) M$74 (b) M$8
6. 14,162 ha oil palm, cocoa & rotan	1984–1986, ongoing	(a) 7075 oil palms 3491 cocoa plants 59 rotan plants (b) damage still occuring but no breakthrough of electrified fencing	(a) M$65 (b) M$5
7. 4453 ha rotan	1985– ongoing; about half installed	(a) about 10% of all rotans planted (b) damage continues at similar rate	(a) M$55 excluding manfower (b) unknown

future, there will be inadequate forest to support a breeding population. In such areas, it can only be recommended that forest clearance proceed in a broad front, in one direction, rather than patchily, so that elephant incursion into plantations will be less frequent and the elephants have a chance to shift their range into Forest or Wildlife Reserves.

The pattern of Reserves in Sabah now is such that only two separate areas will be able to support viable populations of elephants in the long-term: Tabin Wildlife Reserve (about 123,000 ha) and the large region of contiguous Forest Reserves covering over one million ha in the central and south-eastern part of the state. We strongly suggest that no further excisions are made from these Reserves, especially Tabin, which is already rather small in terms of elephant habitat, and contains at least seven natural mineral licks which are believed to be important regulators of elephant population density and distribution.

6. CONCLUSIONS

Large plantations situated in areas inhabited by elephants will almost certainly experience crop damage by this species, in the case of oil palm resulting in the loss of tens or hundreds of thousands of ringgit per year in every plantation. Available data indicates that, in most situations, the cost of installation and maintenance of electrified fencing will be less than the cost incurred by elephant damage, if total costs are averaged over several years.

The above conclusion may not apply in areas which are flood-prone, because elephants can penetrate the plantation when flood-water reaches the wiring. In certain situations, such as this, a novel physical barrier in the form of sharp stones embedded in the ground may be more effective than fencing. It is recommended that plantations which have not yet erected electrified fencing around their entire boundary seriously consider this alternative.

Two additional approaches, which integrate the need to conserve viable wild elephant populations with efforts to minimise their depradations, are (i) to clear forest for plantation development in a single, large-scale, orderly front, towards the direction of Forest or Wildlife Reserves, and (ii) to maintain existing Forest and Wildlife Reserves, especially Tabin, at their present size, adequate to support self-contained, viable elephant populations.

ACKNOWLEDGEMENTS

We thank the plantation managers who provided data by filling in our questionnaire and William Xanten for discussion. Junaidi Payne was working with the Sabah Forest Department on conservation projects sponsored by World Wildlife Fund Malaysia while this paper was being prepared.

REFERENCES

Andau, P M and J Payne 1985 The present status of the Elephant in Sabah. WWF Monthly Report, December 1985, pp. 301–305.

Blair, J A S, Boon G G and Noor N M 1979 Conservation or cultivation: the confrontation between the Asian elephant and land development in Peninsular Malaysia. Land Dev. Digest. 2:27-59.

Blair, J A S and Noor N M 1981 Elephant barriers for crop defence in Peninsular Malaysia: the FELDA experience. The Planter. 57:289-312.

Payne, J 1984 Wildlife Conservation Coordinator, Sabah. Final Report. IUCN/WWF Project No. 3050. Kuala Lumpur: WWF Malaysia.

Seidensticker, J 1984 Managing Elephant Depradation in Agricultural and Forestry Project. World Bank Technical Paper, ISSN 0253-7494.