Linking two elephant refuges with a corridor in the communal lands of Zimbabwe

F. V. Osborn and G. E. Parker

Mid-Zambezi Elephant Project, Harare, Zimbabwe

Abstract

Wildlife corridors, protected bands of suitable habitat linking core populations of plants and animals, are seen as the best solution to the problem of habitat fragmentation. A corridor between two wildlife refuges was identified in the communal lands of Zimbabwe. Results of tracking the current preferred migration of bull elephants between the two refuges using radio collars were combined with a GIS analysis to examine the zone where conservation of habitat would have least impact on current activities within the communal lands. A suitable corridor was identified using least-cost analysis allowing for the improved conservation of the elephants and therefore potentially increasing the benefits to local residents by both reducing human/elephant conflict and increasing income from sport hunting and tourism in the region. Recent political violence in the corridor region, the illegal killing of elephants and the loss of suitable habitat makes the implementation of this corridor unlikely.

Key words: African elephants, corridors, GIS, wildlife refuges

Résumé

Les corridors sauvages, ces bandes protégées d'habitat encore convenable qui relient des populations importantes de plantes et d'animaux, sont considérés comme la meilleure solution au problème de la fragmentation de l'habitat. On a identifié un corridor entre deux refuges de la faune sauvage, qui traverse les terres communautaires au Zimbabwe. On a fait des recherches au moyen de colliers-radio, pour connaître les voies de migration préférées des éléphants mâles entre deux refuges, et on en a combiné les résultats avec une analyse GIS afin d'examiner où la conservation de l'habitat aurait le moins d'impact sur les activités qui prennent place actuellement sur les terrains communautaires. On a identifié, grâce à une analyse du moindre coût, un tracé de corridor qui permettrait une meilleure conservation des éléphants et qui pourrait donc augmenter les bénéfices des résidents locaux en réduisant les conflits hommes/éléphants et en augmentant les revenus de la chasse sportive et du tourisme dans la région. Cependant, des violences politiques récentes dans la région du corridor, le massacre illégal d'éléphants et la disparition d'un habitat convenable rendent la réalisation de ce corridor peu probable.

Correspondence: F. V. Osborn, 37 Lewisam Avenue, Chisipite, Harare, Zimbabwe. E-mail: mzep@africaonline.co.zw

Introduction

Linking areas of important wildlife habitat or high biodiversity has become an increasing priority in the conservation of natural habitats. In Africa, the widespread conversion of natural habitats into agricultural land has pushed many species into ever smaller, isolated fragments of wild land and brought them into direct conflict with humans. The main threat to many species is now considered to be habitat loss and fragmentation leaving wildlife to survive in 'refuges' linked by areas under high conservation threat (Harris, 1984). It is generally recognized that many formally protected areas are too small to maintain healthy populations of many plant and animal species. Armbruster & Lande (1993) state that linking smaller reserves with other habitat patches through habitat corridors may alleviate the genetic problems associated with small reserves. Creating or preserving protected bands of suitable habitat linking core populations is seen as the best solution to the problem of habitat fragmentation (Harris, 1984). Currently, there are four rationales for maintaining corridors, namely increasing

© 2003 African Journal of Ecology,

immigration rates (Harris & Scheck, 1991), providing movement routes for wide-ranging species, decreasing inbreeding depression (Harris, 1984), and reducing demographic stochasticity (Merriam, 1991). Habitat loss has been identified as the most threatening factor to the survival of the African elephant (*Loxodonta africana africana* [Blumenbach 1797]) (Parker & Graham, 1989; Hoare & du Toit, 1999).

Using a wide-ranging and ecologically influential species helps to define the size and shape of the landscape needed to ensure the long-term persistence of other wildlife populations and the underlying ecological processes upon which they depend (Sanderson *et al.*, 2001). Understanding the ecological processes that influence the movement of species such as elephants is essential when designing or conserving a corridor through cultivation (Johnsingh & Williams, 1999). The distribution and patterns of relative abundance of animals depends largely on the seasonal availability of food and water. It is generally accepted that seasonal variations in food availability and quality affect elephant ranging patterns and migration (Leuthold, 1977; Sukumar, 1989; Viljoen, 1989), modified by water availability, which is in turn dictated by rainfall (Leuthold, 1977; Afolayan & Ajayi, 1980; Western & Lindsay, 1984). In regions where water availability is highly seasonal, researchers have reported a concentration of elephants near water points in the dry season, followed by an expansion of range in the wet season. In Zimbabwe Taylor (1983) noted wet season dispersal of elephants in the Sebungwe region, as did Conybeare (1991) in Hwange National Park. Movements in less seasonal regions, in the forests of West and Central Africa, for example, may be dictated by the fruiting patterns of certain trees (Short, 1983). Thouless (1996), in a review of the literature, points out that some elephant populations are 'sedentary' (e.g. Lake Manyara NP; Douglas-Hamilton, 1971) while others are nomadic or disperse in the wet season (Leuthold, 1977; Viljoen, 1989; Lindeque & Lindeque, 1991). Most of these studies report bulls are far more likely to move large distances (over 30 km) or disperse than cows.

The management of elephants in a human-dominated landscape is a challenging problem. In southern Africa the responsibility increasingly falls on local wildlife authorities, many of which manage their wildlife under national Community Based Natural Resource Management (CBNRM) programmes. Elephants may provide the greatest financial returns to these schemes, and can be powerful agents for development. Elephants are also a problematic resource as they come into conflict with humans through crop raiding, raiding food storage containers and restricting the collection of natural resources. In Zimbabwe, many Rural District Councils (RDCs) manage their wildlife through the CAMPFIRE (Communal Areas Management Programme for Indigenous Resources) programme. The wildlife authorities, who administer large areas of land, have to make land management decisions balancing agriculture, settlement and the needs of wild animals. The Mid Zambezi Elephant Project (MZEP) was established in 1997 and, in collaboration with the Zambezi Society, provides information to the RDCs in the study area regarding elephant management, specifically studying elephant movements, defining elephant refuges and examining ways to reduce conflict between elephants and people.

This paper outlines the processes involved in preliminary identification and development of an elephant movement corridor in a fragmented landscape. Through analysis of elephant location data, refuges and seasonal movement patterns were identified. We then used aerial photography to map the 'path of least resistance' for elephants through cultivated areas. The goal was to compare the remaining connected areas of bush and the actual ranging patterns of elephants that move through this area. This case study highlights many of the problems with implementation of a corridor through a mosaic of unprotected bush, cultivation and dense human settlement. Conservationists interested in the long-term survival of elephants may be able to apply these methods to identify and conserve movement corridors between elephant refuges.

Materials and methods

The study area encompasses nearly 6000 km^2 of the Zambezi Valley, extending across Muzarabani and Guruve districts in north-eastern Zimbabwe and Magoe district in north-west Mozambique. The area is divided into two distinct geographical regions: the flat Zambezi Valley to the north (350–500 m), and a broken mountainous band of escarpment mountains (900–1650 m) to the south (Fig. 1).

The Mavuradona Wilderness Area (MWA) covers 650 km^2 of escarpment mountains and is bordered to the south by commercial farms on the highveld, to the east and west by communal farms in the mountains, and to

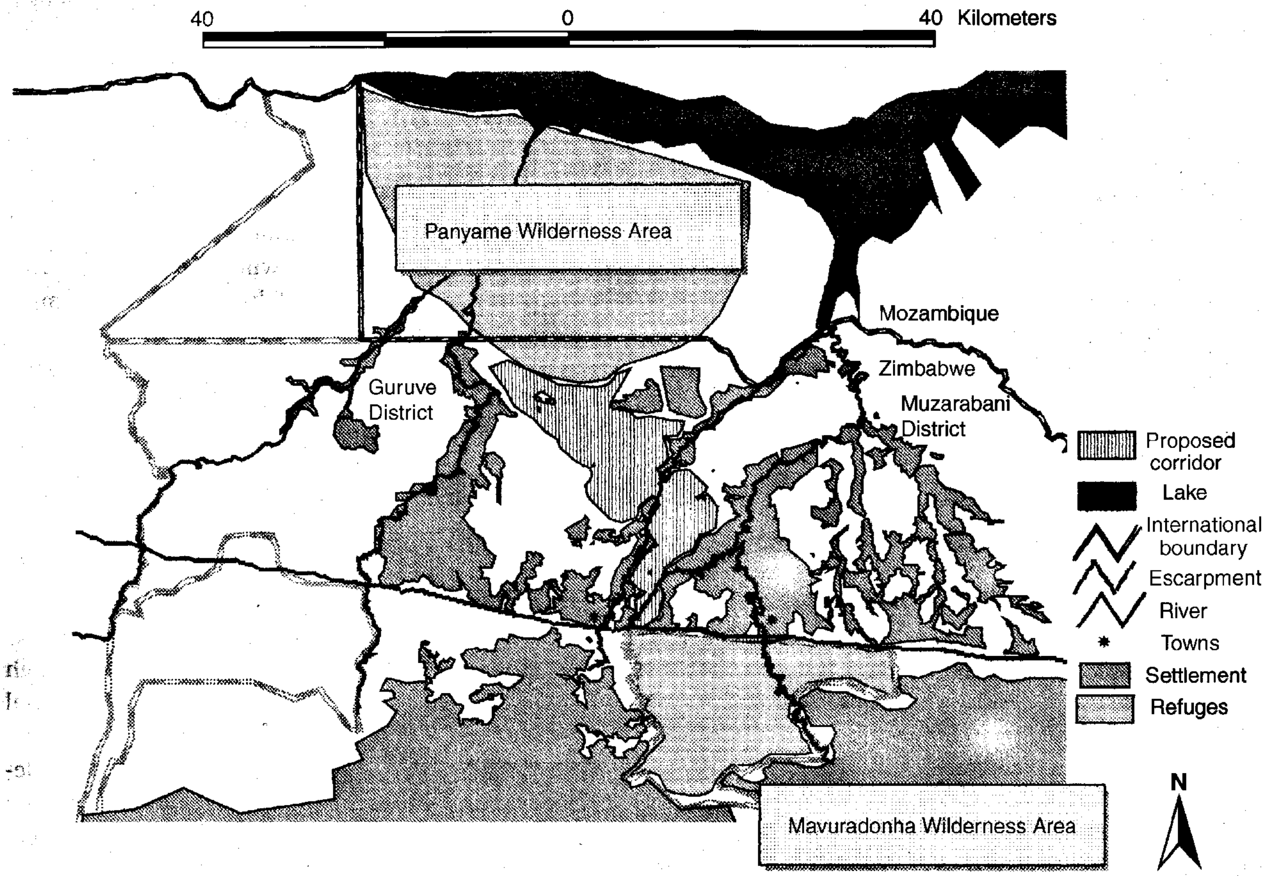

Fig 1 Map showing study area with the Panyame and Mavuradona Wilderness areas and the proposed corridor between them

the north by a near continuous boundary of communal farms in the Zambezi Valley. The escarpment habitat is a mixture of escarpment woodland and miombo woodland (*Brachystegia* spp. and *Julbernadia* spp.) with a rainfall of 800–1200 mm per year. The Zambezi Valley woodlands are dominated by *Mopane-Terminalia* spp. and *Mopane-Combretum* spp. woodlands with dense riverine thicket of mixed species along the major rivers. The Zambezi Valley experiences low annual rainfall (650–850 mm per year) between December and mid March. There is a long dry season from April to November. The Panyame Wilderness Area (PWA) has recently been proposed as a community-managed wildlife area and is located on the border of Zimbabwe and Mozambique.

Cultivation in the communal lands occurs mainly along water courses and in areas with fertile soils. In the Zambezi Valley cultivation occurs on the colluvial soils along the base of the escarpment and the alluvial soils bordering the major rivers. As a result the district comprises a mosaic of transformed habitat (cultivation) and relatively untransformed habitat (bush). Most farming is small-scale dry land cultivation and the main wet season crops include maize (*Zea mays*) and cotton (*Gossypium hirsutum*). These rain-fed crops are planted extensively in November and harvested between April and June. Agricultural activities are expanding rapidly due to the profitability of cotton and the associated clearance of new land, and to resettlement of people from other parts of the country. The human population in this section of the valley is growing at 9% per annum, due in part to immigration (Cumming & Lynam, 1997).

Different land use types were individually weighted to represent the risk to elephants moving across them, then combined as layers in a GIS model. From aerial photographs, the area of forest and settlement were determined and digitized. The areas that are not settled or cultivated represented a 'suitable habitat' layer. These areas consist of open woodland and patches of thicket forest following

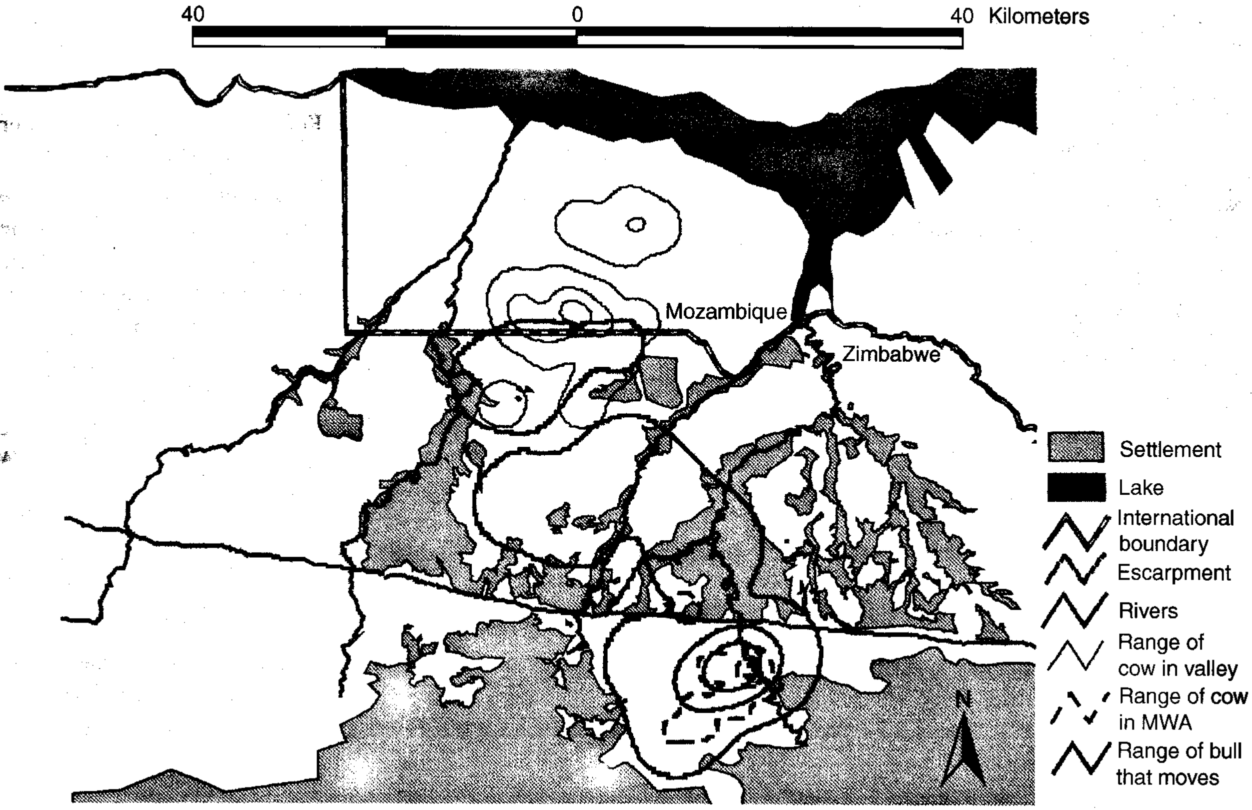

Fig 2 Study area with the Kernel ranges of three different elephants. Note the outlines of the range of a cow resident in the MWA, the bull that moves and a cow resident in the Zambezi Valley

the drainage network, and are the optimum areas for a corridor. The proximity to rivers was considered a factor for corridor location because, in addition to providing a source of fresh water, there are many areas of thicket forest along the rivers, and elephants use these for shelter and food. This factor was represented by a 250 m buffer to take into account the riverine forest patches, and patches of 'sacred' forest left untouched by local people in surrounding settlements.

The areas of settlement themselves were considered particularly unsuitable for the location of the corridor. In addition, a 500 m buffer around the outside of the settled areas was created to take into account the influence of human disturbance. Lastly, the distance from roads is an important factor due to the threat of disturbance by traffic or human contact and noise. Habitat close to roads may be considered unsuitable for elephants and, accordingly, this factor was represented by a buffer at a distance of 250 m either side of the roads. These four data layers were created as vector themes in ArcView (ESRI, 1996). This analysis was undertaken by K. Aitken for an MSc at the University of Leeds (Aitken, 2000).

Twenty-four elephants (five cows and eighteen bulls) were fitted with radio transmitters and monitored between November 1997 and August 2001. A sample of eleven elephants was collared in Muzarabani district in the 1st year and a further thirteen were collared in the Zambezi Valley in the 2nd and 3rd years. Researchers tracked collared elephants on the ground, from fixed towers and from light aircraft. Ranges of elephants were analysed using the Kernel method (Worton, 1989) placing 15, 50 and 95% of fixes inside these contours. Kernel analysis and range asymptote were run using Animal Movement (Hooge & Eichenlaub, 1997) (Fig. 2).

Results

Figure 1 shows a map of least-cost corridor output from the model, together with the settlement data layer. The

Table 1 Range analysis of collared elephants

Date collared	Age	# of fixes	15% km^2	50% km^2	95% km^2
MWA resident (cows)					
Dec – 97	20–25	101	3.1	14.5	170.7
Nov – 97	35–40	97	3.2	20.7	130.1
Mean					150.4
MWA resident (bulls)					
Mar – 99	15–20	122	1.7	7.4	83.4
Nov – 97	15–20	137	3.3	13.7	69.2
Nov – 97	35–40	176	2.4	10.4	64.8
Mar – 98	40–50	117	2.8	12.5	67.4
Mean					71.2
Valley resident (cows)					
Mar – 99	25–35	36	3.4	61.2	794.2
Mar – 99	20–30	52	34.3	258.6	713.9
Mean					754.0
Valley resident (bulls)					
Aug – 98	35–45	43	38.3	173.5	1933.7
Aug – 98	35–45	28	33.3	384.8	1733.3
Mean					1846.6
Moving bulls					
Dec – 97	35–40	54	67.8	268.7	1583.2
Nov – 97	20–30	67	69.2	284.1	1763.5
Mar – 99	15–20	53	64.1	368.9	2219.4
Mean					1855.4

corridor covers an area of approximately 350 km^2, and passes between the settlements in Muzarabani district as it leaves the MWA, and traverses roughly northwards between settled areas in Guruve district to the southernmost part of the PWA (Aitken, 2000). The least-cost path from the MWA to the PWA is 41.6 km in length, and the corridor itself varies in width from approximately 2.3–5 km in the south, to 15–20 km in the north where it joins with the PWA. The narrowest section is located just outside the MWA boundary. For the elephants that moved, 85% of fixes were located in the proposed corridor.

Data for thirteen out of the 24 collared elephants (four cows, nine bulls) used in the analysis, are given in Table 1. When analysing the radio tracking data for the collared elephants, three broad categories emerged. First, three cows and three bulls collared in the MWA did not leave its boundaries, and were called 'MWA resident'. Second, three bulls collared in the MWA and on the valley floor moved between the MWA and PWA during the study period, called 'moving bulls'. Third, cows and some bulls collared in the valley did not undertake large scale movements and were called 'valley resident'. Figure 2 illustrates the differences in range size of the three categories used in this analysis. The three contours drawn for each animal using the Kernel method show the inner (15%), intermediate (50%) and outer 95% of the locations. The three bulls in the MWA had the smallest mean 95% contour of 71.2 km^2 and the two cows collared in the MWA had a mean range of 150.4 km^2. The ranges of the moving bulls, some of which were collared in the MWA, were among the largest (1855.4 km^2) and included areas in Mozambique. Bulls resident in the valley had large ranges (1846.6 km^2) but did not make large seasonal movements to the MWA. The two cows living in the valley had much larger ranges than cows in the MWA (754 km^2).

Discussion

The ranges of the cows and bulls in MWA indicate that family groups and breeding males appear to be able to maintain themselves with the resources available. Thus the MWA can be considered a refuge as can the area of the PWA, because elephants are able to live there year round without moving large distances. The cows living in the valley had much larger ranges than cows in the MWA, which may indicate that water and food are less abundant and that there are higher levels of contact with humans than animals resident in the MWA. Many studies have shown that bulls undertake long distance movements to find new food sources, whereas cow groups and cows stay in relatively small areas due to the availability of resources and reluctance to move far with young. However, the localized impact by humans on these patterns is considerable.

The area identified as a corridor reflects the remaining natural habitat in the area between the two refuges. The radio-tracking data show that only the bulls still use this route, but threats to the preservation of this corridor area are great. There is persistent and growing pressure for land by subsistence farmers and little tangible reason to forgo cultivation in the proposed corridor. Many of the intact woodlands in the corridor are areas conserved by the community for their spiritual value, but these forests are under pressure for building material, firewood and agriculture.

Human settlement patterns have had a profound effect on ranging patterns of elephants in Africa. Rapidly expanding human populations maintained by a subsistence economy, are changing land use patterns in a way that results in a contraction of habitat available to elephants. Encroachment by people into elephant habitat cuts off the channels of response by elephant populations to environmental fluctuations, such as emigration and dispersal. For example, seasonal migrations of elephants are affected by human pressures in the elephant wet season range in Amboseli (Western & Lindsay, 1984). Human interference and harassment influence movement patterns of elephants in the forests of Central Africa. (Barnes, Alers & Blom, 1991; Ruggiero, 1992; Tchamba, Bauer & De Iongh, 1995). Kangwana (1995) found that elephant movements are strongly affected by competition with pastoralists over livestock forage and access to water in Amboseli NP. In Zimbabwe Hoare & du Toit (1999) found ranges of communal land with reduced populations of elephant because of cultivation.

The main reason to conserve this link is that it will help maintain a healthy elephant population in the two districts. The benefits of living with elephants are high in this area through income generated by sport hunting, but little of this money makes it back to individual farmers and the benefits do little to ameliorate the costs of crop loss (Van der Wittenboren, 1999).

The main findings from this research are the identification of two elephant refuges linked with a corridor that runs through fairly densely settled land. The least-cost path method is useful for keystone species such as elephants, verified with data from animals using the proposed corridor. Elephants are the most valuable and problematic natural resource in this area. Rapid human settlement has created increasingly common conflict situations as elephants and other wildlife compete with humans. The goal of this corridor is to allow elephants passage with the minimum of conflict with farmers. However without effective schemes to reduce crop loss to farmers, agricultural expansion and associated forest clearance, this corridor will disappear.

Recent political violence in the corridor region has made the people in the study area fearful of any projects of this nature for some time to come. In addition the illegal killing of elephants and 'problem animal' hunts are unsustainable. Anecdotal evidence suggests that at least eight bulls were killed in the first 3 months of 2002. These factors combined with the rapid loss of the remaining forest areas makes the implementation of this corridor unlikely before the movement route is severed and the MWA elephant population isolated.

Acknowledgements

We thank the Guruve and Muzarabani Rural District Councils and the research Council of Zimbabwe for permission to carry out this research. The Wildlife Conservation Society, US Fish and Wildlife Service and the National Geographic Society provided funding for this research. K. Aitken conducted the GIS analysis. Thanks to G. Patterson, R. Hoare, R. Taylor and an anonymous reviewer for comments on this manuscript.

References

Afolayan, T.A. & Ajayi, S.S. (1980) The influence of seasonality on the distribution of large mammals in the Yankari Game Reserve, Nigeria. *Afr. J. Ecol.* 18, 87–96.

Aitken, K. (2000) Using GIS to Develop an Elephant Corridor using a Least Cost Path Analysis in the Communal Lands of Zimbabwe. MSc Thesis, University of Leeds, UK.

Armbruster, P. & Lande, R. (1993) A population viability analysis for African elephant: how big should reserves be? *Conserv. Biol.* 7, 602–610.

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

Conybeare, A.M. (1991) Elephant Occupancy and Vegetation Change in Relation to Artificial Water Points in a Kalahari Sand Area of Hwange National Park. PhD Thesis, University of Zimbabwe.

Cumming, D.H.M. & Lynam, T. (1997) Landuse changes, wildlife conservation & utilisation and the sustainability of agro-ecosystems in the Zambezi Valley. WWF Multi-species project, Harare, Zimbabwe.

Douglas-Hamilton, I. (1971) On the Ecology and Behaviour of the African Elephant. D. Phil Thesis, University of Oxford, UK.

ESRI (1996) *ArcView GIS*, Ver. 3.1. ESRI, Redlands, CA, USA.

Harris, L.D. (1984) *The Fragmented Forest: Island Biogeography Theory and Preservation of Biotic Diversity.* University of Chicago Press, Chicago.

Harris, L.D. & Scheck, J. (1991) From implications to applications: the dispersal corridor theory applied to the conservation of biological diversity. In: *Nature Conservation 2: the Role of Corridors.* Surrey Beatty and Sons, NSW, Australia.

Hoare, R.E. & du Toit, J.T. (1999) Coexistence between people and elephants in African savannas. *Conserv. Biol.* 13, 633–639.

Hooge, P.N. & Eichenlaub, B. (1997) *Animal Movement Extension to Arcview,* Version 1.1. Alaska Biological Science Center, U.S. Geological Survey, Anchorage, Alaska.

Johnsingh, A.J.T. & Williams, A.C. (1999) Elephant corridors in India: lessons for other elephant range countries. *Oryx* 33, 210–214.

Kangwana, K. (1995) Human–elephant conflict: the challenge ahead. *Pachyderm* 19, 11–14.

Leuthold, W. (1977) Spatial organisation and strategy of habitat utilisation of elephants in Tsavo National Park, Kenya. *Z. Saugetier.* 42, 358–379.

Lindeque, M. & Lindeque, P.M. (1991) Satellite tracking of elephants in northwestern Namibia. *Afr. J. Ecol.* 29, 196–206.

Merriam, G. (1991) Corridors and connectivity: animal populations in heterogenous environments. In: *Nature Conservation 2: the Role of Corridors* (Ed. W. E. Hudson). Surrey Beatty and Sons, NSW, Australia.

Parker, I.S.G. & Graham, A.D. (1989) Elephant decline 1. Downward trends in the African elephant distribution and numbers. *Int. J. Environ. Stud.* 34, 287–305.

Ruggiero, R.G. (1992) Seasonal forage utilisation by elephants in central Africa. *Afr. J. Ecol.* 30, 137–148.

Sanderson, E.W., Redford, K.H., Vedder, A., Cappolillo, P.B. & Ward, S.E. (2001) *A Conceptual Model for Planning Based on Landscape Species Requirements.* WCS Living Landscapes Programme, Bronx, NY, USA.

Short, J.C. (1983) Density and seasonal movements of forest elephant (*Loxodonta africana cyclotis*) in Bia National park, Ghana. *Afr. J. Ecol.* 21, 175–184.

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

Tchamba, M., Bauer, H. & De Iongh, H.H. (1995) Application of VHF-radio and satellite telemetry techniques on elephants in northern Cameroon. *Afr. J. Ecol.* 33, 335–346.

Thouless, C. (1996) Home ranges and social organisation of female elephants in northern Kenya. *Afr. J. Ecol.* 34, 4–297.

Van der Wittenboren, A. (1999) An Evaluation of CAMPFIRE in Muzarabani District, Zimbabwe. BSc Thesis, University of Rotterdam, Holland.

Viljoen, P.J. (1989) Habitat selection and preferred food plants of a desert-dwelling elephant population in the northern Namib Desert, Namibia. *Afr. J. Ecol.* 27, 227–240.

Western, D. & Lindsay, W.K. (1984) Seasonal herd dynamics of a savanna elephant population. *Afr. J. Ecol.* 22, 229–244.

Worton, B.J. (1989) Kernel methods for estimating the utilization distribution in home range studies. *Ecology* 70, 164–168.

(Manuscript accepted 16 May 2002)