Maintaining Ecological Connectivity between the Protected Areas of south-central Tanzania: Evidence and Challenges

Trevor Jones[a,b], Clinton Epps[c,d,e], Bakari Mbano[f], Pete Coppolillo[f], Benezeth Mutayoba[c] and Francesco Rovero[b,g]

[a] Environmental Sciences Research Centre, Anglia Ruskin University, East Road, Cambridge CB1 1PT, United Kingdom.
[b]Udzungwa Ecological Monitoring Centre, Box 99, Mang'ula, Tanzania.
[c]Sokoine University of Agriculture, Department of Vet. Phys., Box 3017, Morogoro, Tanzania
[d]University of California, Berkeley, CA 94720-3114, USA.
[e]Oregon State University, Corvallis, OR 97331, USA.
[f]Ruaha Landscape Program, Wildlife Conservation Society, Box 1654, Iringa
[g]Sezione di Zoologia dei Vertebrati, Museo Tridentino di Scienze Naturali, Via Calepina 14, 38100 Trento, Italy.

Abstract

Maintaining ecological connectivity between Protected Areas (PAs) is one of the key environmental challenges facing Tanzania today. In south-central Tanzania, the geographically disjunct Rungwa-Ruaha, Udzungwa and Selous-Mikumi PAs have probably been connected for several centuries through the movements of large mammals, including elephants and, until recently, the Endangered African wild dog. We have investigated current connectivity among these areas and the feasibility of protecting wildlife corridors. We used a combination of methods including ground surveys (both rapid surveys and systematic transects), questionnaires with community members, satellite and aerial data. In the Kilombero Valley, most of the corridors between the Udzungwa and the Selous have been closed off in recent decades as a result of rapid human immigration and widespread changes in land use. Today, no more than two active corridors might remain, though they are seriously threatened and will probably be closed soon unless urgent interventions are taken. We also found evidence for corridors between the Udzungwa, Mikumi and Ruaha ecosystems, and the continued use of these unprotected areas by a surprising diversity of large mammals. Key areas include the Rubeho Mountains, which elephants are entering from the Ruaha-Mbuyuni area to the west and possibly from Mikumi National Park to the east and, and the Ruaha Game Controlled Area north of the Ruaha River in Mpwapwa district of Dodoma region. In all of these places there are increasing human-wildlife conflicts as the options for migrating animals are reduced. Protecting corridors for large mammals is a complex issue, involving a mosaic of habitats and land use types, including settlements and other areas of varying legal and protective status. Management efforts therefore require a flexible approach, strong commitment from communities towards improved land use planning and implementation, including set-aside Corridor areas, and dedicated coordination between all stakeholders of each Corridor area.

Introduction

Tanzania is one of the most species- and habitat-rich countries in the world, with an impressive network of Protected Areas (PAs) that cover approximately 25% of the country. Despite this impressive commitment to conservation of biodiversity, many of these protected areas are rapidly becoming isolated, most often as a direct result of continuing human population growth and the associated conversion of wildlife-friendly habitat for agricultural use (Jones *et al*., 2007; Newmark, 2008). Connectivity between Protected Areas, via corridors along which animals are able to move from one area to another (Dobson *et al.*, 1999), is thought to have been lost in Tanzania at an increasingly rapid rate, and often irreversibly.

The maintenance of connectivity between PAs is of critical importance for at least four reasons:

1) Reducing Human-Wildlife Conflict (HWC): effective management of animal corridors protects human lives and livelihoods through emphasis on HWC mitigation.

2) Gene flow and demographic links are required for maintaining healthy populations of large mammals, especially endangered species.

3) Reducing pressure on ecosystems: habitat destruction resulting from over-abundant wildlife populations can be reduced through maintaining natural migration and dispersal patterns.

4) Insurance against climate change: to keep options for dispersal and movement of animals open as climate change alters distribution of wildlife and habitats.

This work is focused on the Udzungwa Mountains of southcentral Tanzania and surrounding ecosystems. The Udzungwa Mountains are well known for their extremely high levels of species endemism and richness (Burgess *et al*., 2007; Rovero *et al.*, in press). In December 2004, a comprehensive stakeholders' workshop was convened in Morogoro, for the purpose of identifying and discussing the most acute conservation problems currently facing the Udzungwa Mountains (Sumbi *et al.*, 2005). One of the four issues identified as most important was the maintenance of ecological connectivity between the Udzungwas and other PAs. The Udzungwas are central to an impressive network of large PAs in southern Tanzania, also comprising the Selous Game Reserve, Mikumi National Park and the Rungwa-Ruaha PA complex (fig. 1).

Anecdotal evidence collected between 2002-2005 suggested continued movement of elephants and other large mammals across all of the unprotected zones between these wilderness areas. However, it was also clear that this ecological network is severely threatened, as the remaining corridors of undisturbed habitat between the PAs become lost to expanding settlements and agriculture. This is particularly true in the Kilombero Valley, where rapid human immigration from all over Tanzania in recent decades has led to widespread land use changes, resulting in increased human-wildlife conflict including

loss of crops, human deaths and increased poaching. A further concern is the potential loss of biodiversity in the Udzungwa Mountains that could result from increased modification of forest habitat by a confined and expanding elephant population.
We therefore investigated two corridor areas:

1) Udzungwa-Selous: the area between the Udzungwa Mountains (including the Udzungwa Mountains National Park and several Forest Reserves) and the Selous Game Reserve;

2) Ruaha-Udzungwa-Mikumi: the area between three National Parks: Ruaha NP, Udzungwa Mountains NP, and Mikumi NP.

The key study aims were the following: to survey presence/absence of large mammals across potential corridor; to improve knowledge of elephant movements and distribution, i.e. is the area a corridor?; to determine whether other species would benefit from conservation of corridor; and to generate recommendations on key corridor areas in need of enhanced protection.

Methods

This research was carried out from 2005 to 2007. The primary data collection methods involved randomly-placed animal (dung, tracks and sightings) and human disturbance transects, and ground mapping of land use and habitat boundaries, using a hand-held GPS. In the area of the Udzungwa-Selous corridors, where much of the habitat was forested or thick bush, 38 dung and 44 disturbance transects were completed (0.5-1 km each, total length 54 km). In the Ruaha-Udzungwa-Mikumi area, 84 walking transects were completed (3-15 km each, mean length 8.3 km, total length 680 km). Aerial imagery provided by the Wildlife Conservation Society's Conservation Flight Program was also used to assess vegetation and land use.

We interviewed several key local stakeholders, including Regional and District Forest Officers, Game Officers and Land Officers, and carried out questionnaire surveys of local communities. We also gathered all existing data on land cover, vegetation, Regional, District, Village & Protected Area boundaries. Materials used included: 1:50,000 topographic maps (Surveys and Mapping Division, Ministry of Lands, Tanzania, 1983); landsat images (Center for Applied Biodiversity Science, Conservation International; and maps of village land boundaries from the Land Office (K1/D/GEN, 28/03/02). The legal status of different areas within the corridors, and the correctness of boundaries, were further verified through consultations with Land Office officials and Village Chairmen.

Results were inputted into a Geographical Information System (ArcGIS 8.1, ESRI). All newly generated layers were integrated with the high-resolution aerial imagery, vegetation maps and other relevant layers obtained. All data were then analysed, and recommendations generated, with reference to questionnaire, interview and transect

results. Our recommendations regarding management options also benefited from discussions with stakeholders following the presentation of results at the Udzungwa Workshop in Morogoro on 23rd March, 2007 (WWF-TPO, 2007).

Table 1. Summary of data types and sources. For more details on methods, refer to Jones *et al.* (2007) and Epps *et al.* (2008).

Data		Source
Primary	Presence of wildlife in corridor areas	Animal Transects (dung, tracks, sightings)
	Land use and forest/woodland degradation	Disturbance Transects
	Land use and habitat types	Ground mapping
	Vegetation type and land use	Aerial imagery
Secondary	Wildlife movements, human-wildlife conflict, local attitudes	Questionnaires and interviews
	Legal status of corridor areas	Government maps; interviews

Results and Discussion

1. Udzungwa-Selous Corridors

Our study confirmed that several previously used mammal corridors have been closed off by human settlements and agriculture in the last twenty years. However we found that two remaining, narrow corridors are still used by elephants, buffalo and (in the case of one of the corridors) other large mammals moving between the Udzungwa and Selous ecosystems. We have called these corridors the "**Nyanganje Corridor**" and the "**Ruipa Corridor**" (Fig. 1).

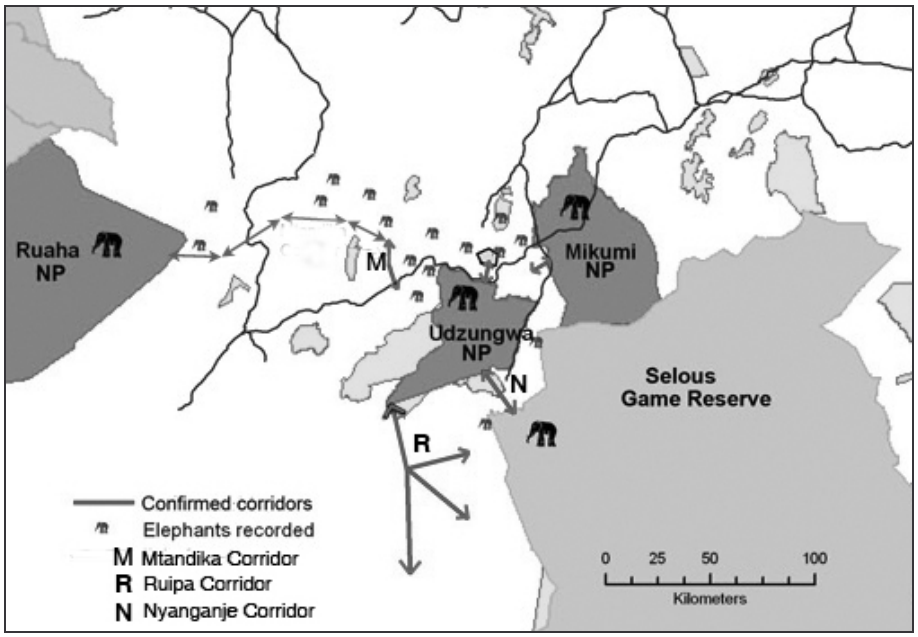

Figure 1. Summary of confirmed and suspected occurrence and movements of elephants between Udzungwa Mountains National Park and neighbouring Protected Areas, 2005-2007. Refer to Figures 2, 4, and 7 below for more detailed information.

1a. Nyanganje Corridor

Evidence of a seasonally active large mammal corridor adjacent to Nyanganje Forest Reserve (fig. 2) was obtained from observations of animal sign, and from the responses of local farmers who were questioned.

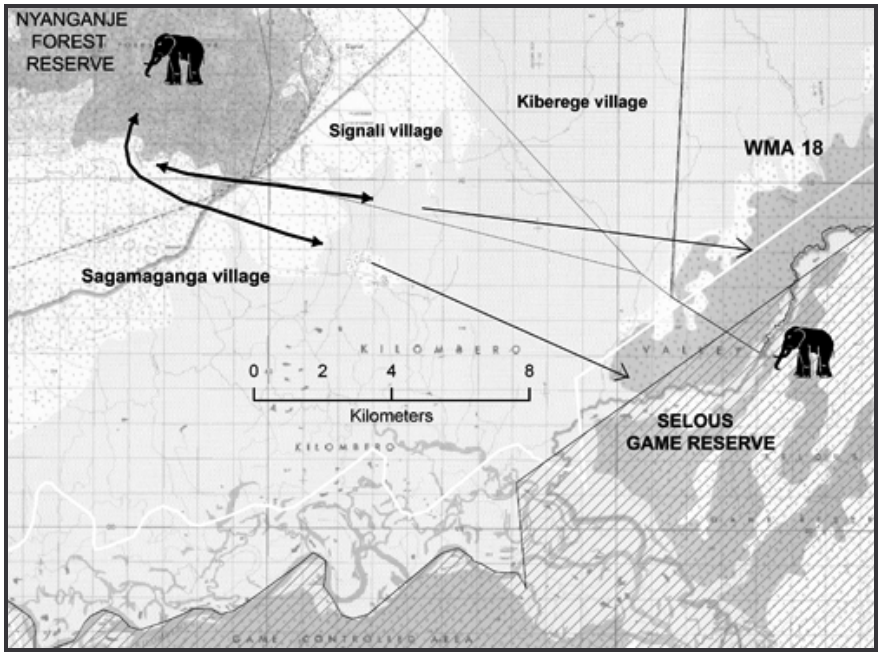

Figure 2. Map of the Nyanganje Corridor, an active corridor for movements of elephants and other large mammals between the Udzungwa Mountains and the Selous Game Reserve.

Results from dung and disturbance transects confirmed the presence of several large mammal species less than 1 km inside the boundary of Nyanganje Forest Reserve (69 km^2, centred on 36 ^{o}47'E, 8 ^{o}00'S), including Udzungwa red colobus, black-and-white colobus, red duikers and notably, a relatively high density of elephants compared to other forests in the Udzungwas (e.g. Mwanihana, fig. 3). Transects and ground mapping did not record sign of elephants in the valley, but those transects were not sampling during the months when elephants are reported to be present in the corridor area.

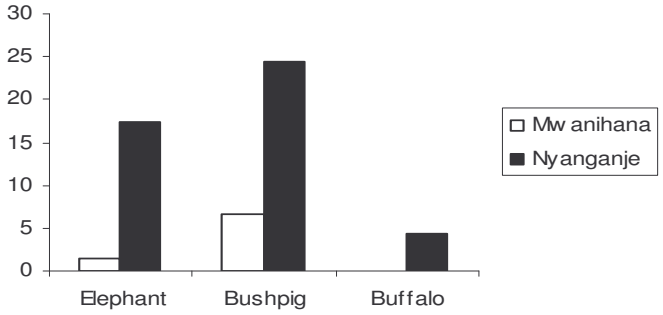

Fig. 3. Mean number of sign detected per km of transect, for elephants, bushpigs and buffalos in Mwanihana and Nyanganje forests. Data derived from disturbance transects randomly placed in Mwanihana forest (within UMNP) and in an area of Nyanganje Forest Reserve adjacent to the Nyanganje Corridor.

Questionnaires were completed by 52 respondents in the villages of Signal (Maili Mia and Mbalaji subvillages) and Sagamaganga (subvillage Sagamaganga A). Key results were as follows:

- 80% of respondents have elephants passing through their farms
- 47% have buffalo on their farms
- 29% perceive conflict with wildlife
- Elephants are passing each year during the rainy season months of January, February and March; buffalo are moving across farms all year round

In the Nyanganje area elephants are reported to use two narrow routes only out of Nyanganje forest and across the farms (the thick lines in Fig. 2), and aerial photos show that at about 3 km southeast of the forest, the cultivated areas become much more scattered and interspersed with bushes and occasional trees. Moreover, there are very few settlements among the cultivated fields. The low perception of conflict by farmers compared with the percentage reporting elephants on their farms suggests that the elephants mostly travel rapidly across this area, probably at night, without pausing to raid crops. It is also not surprising that this Corridor is still active since geographically it represents the shortest possible direct route from the Udzungwa Mountains to the Selous Game Reserve (minimum straight distance of approximately 13 km).

The thick arrowed lines in Figure 2 therefore represent the narrow stretches of corridor which were identified as active for elephants from January to March. To the east of these lines we have no ground data but there appear to be no serious barriers to elephant movement, and thus the dashed lines represent speculative routes along which they may continue. The route that heads directly south in Figure 4 seems particularly likely since there are many records of elephants crossing the Kilombero River in that area (Starkey *et al*., 2002; F. Rovero & T. Jones, unpubl. data).

In summary, the Nyanganje Corridor is still used year-round by buffalo and seasonally by elephants, and being the shortest route between the two PAs it may be the best opportunity to preserve connectivity between the two populations. Moreover, the most critical area of corridor that is closest to the road and in danger of being blocked by intensified cultivation is only about 5 km^2 (0.5 – 2.5 km wide and ~3 km long).

1b. Ruipa Corridor

Evidence of an active large mammal corridor close to the Ruipa River (Fig. 4) was obtained from observations of animal sign, and from the responses of local residents who were questioned. Unfortunately, however, there are now indications that this corridor is being closed off.

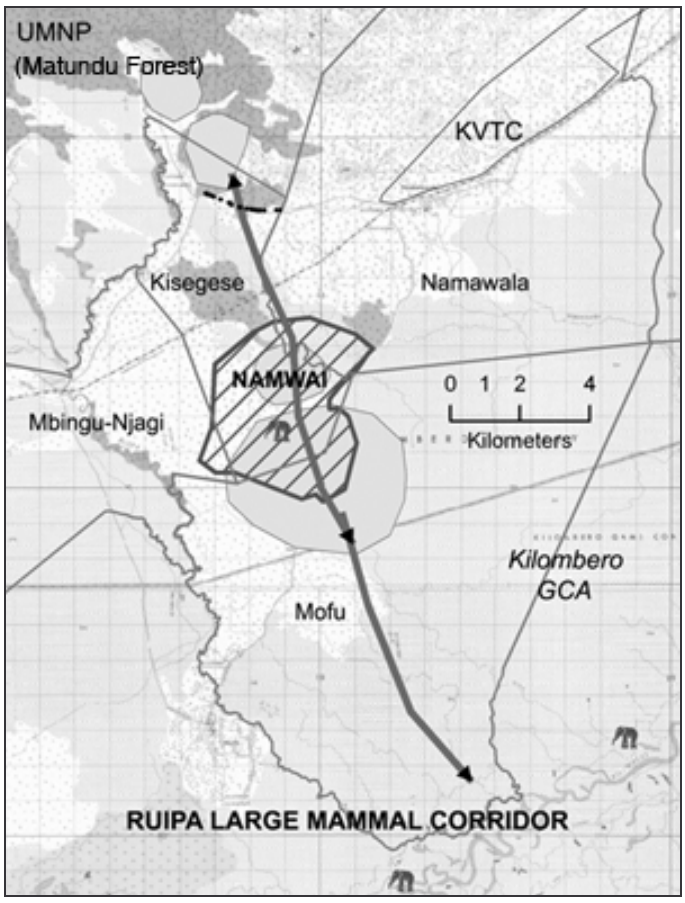

Figure 4. The Ruipa Corridor, an active corridor for movements of elephants and other large mammals between the Udzungwa Mountains National Park and the Selous Game Reserve, via the Kilombero Valley.

Matundu forest (ca. 250 km^2, centred on 36^{o}21'E, 7^o 86'S) is known to have a rich large mammal community including elephant, hippos and leopards, with a higher density of primates and duikers within the Udzungwa Mountains National Park (east of the Ruipa River) than in the Matundu Forest Reserve (west of the Ruipa) (Marshall, 2007). Our dung and disturbance transects confirmed the presence of all these species within the forest along the Ruipa river, and the presence of large mammals along a corridor area which extends south from the forest as far as the Kilombero River (Fig. 5).

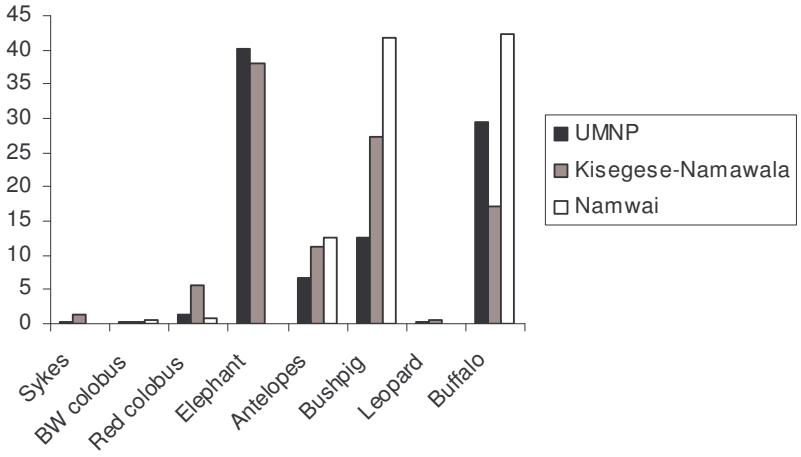

Figure 5. Mean numbers of sign of different mammal species encountered per km inside the UMNP, and along two sections of the Ruipa Corridor. These results were derived from both dung and disturbance transects (see methods).

Questionnaires were completed by 65 respondents in the villages of Kisegese (Kisegese and Bomamzinga B subvillages), Namawala (Bomamzinga A and Idandu subvillages), and Mofu (Mwaya subvillage), confirming the annual movements of elephants in recent years between Matundu forest and the Kilombero Valley floodplain. Key results were as follows:

- 78% of respondents have elephants on their farms
- 59% have buffalo on their farms
- 45% perceive conflict with these animals
- Elephants crossing March, April, May
- Buffalo present all year round
- Udzungwa red colobus, Black-and-white colobus, Duikers, Waterbuck, Aardvark and Leopard are also present along the Corridor, especially in the Namwai area. Sable antelope were also found until recently along the Corridor.

However respondents also stated that elephants *did not* pass the Mofu area to the south in 2005, for the first time in living memory, nor subsequently in 2006, and only one elephant was reported in 2007 (Frontier Tanzania, pers. comm.). In general, the number

of animals using the corridor annually has declined considerably over the last 10 years, in particular in the area around Kisegese village, where a large area of forest has been cleared for agriculture. Of equal concern is the unprotected Namwai forest, a mosaic of lowland moist and riverine forest, miombo woodland and grassland of approx 18 km^2, which harbours buffalo, red duikers, and the Udzungwa-endemic red colobus. The forest forms a critical section of the Ruipa Corridor but is being rapidly destroyed (Fig. 6). In addition to snares, pitsawing and charcoaling, problems facing Namwai include clearance for agriculture, burning, cattle grazing and commercial logging (Jones *et al*., 2007). A further worsening threat is the increasing number of cattle herders grazing cattle, settling and planting crops along the banks of the Kilombero River, within the Kilombero Game Controlled Area and to the east of the Mofu Village boundary. These activities are likely to increase human-elephant conflict in other areas of the Corridor also.

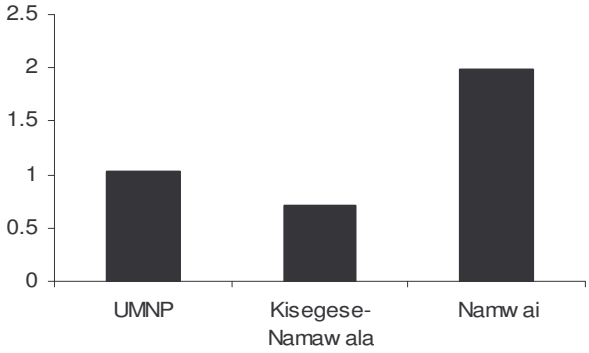

Figure 6. Mean number of traps, pitsawing and charcoal sites within UMNP and two sections of the Ruipa Corridor. Data derived from disturbance and dung transects.

Until 2-3 years ago, there were other routes for elephant, sable antelope and buffalo moving south out of the UMNP, in the area to the east of the currently active corridor, including through Ihanga FR. However, these corridors are no longer used because of increased levels of hunting and the barriers of the KVTC teak plantations (fig. 4).

In summary, the whole of the remaining corridor area between the UMNP and the Kilombero River (0.5 – 6 km wide, 20 km long; a total area of ~ 25 km^2) is now critically threatened by human activity and land uses incompatible with large mammal movements.

2. Ruaha-Udzungwa-Mikumi Corridors

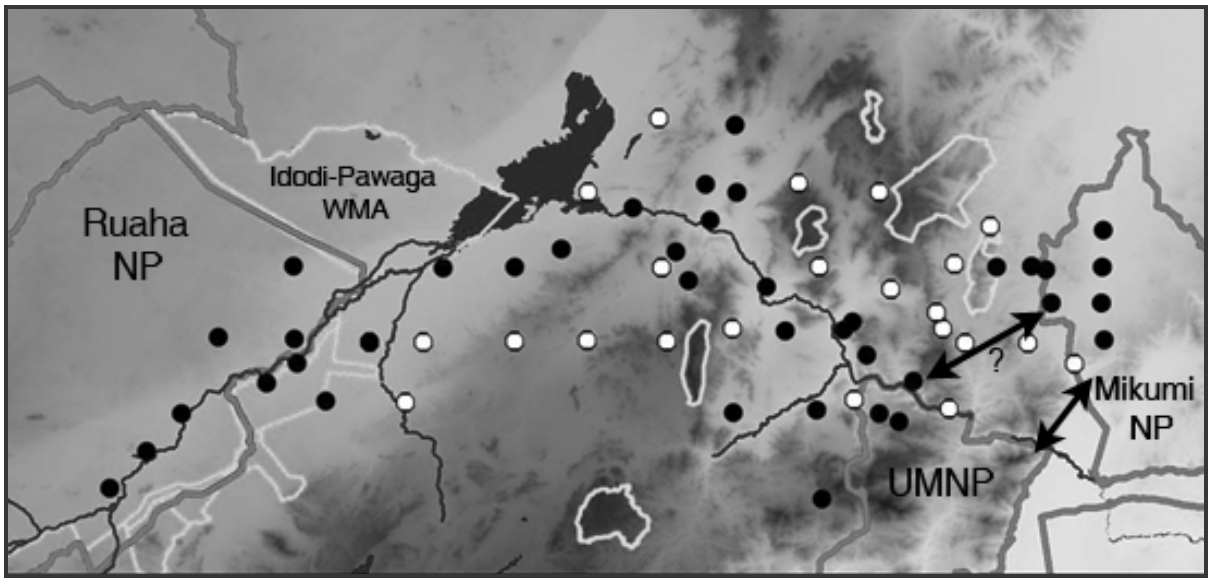

Figure 7. The Ruaha-Udzungwa-Mikumi Corridors area. White dots indicate transects where elephants were detected; black dots indicate transects where no sign of elephants was detected. The white polygons show other known protected areas outside of the NPs; all except the Mang'alisa Forest Reserve (fourth from the right) are known to be used by elephants. Elephant activity was detected across a continuous chain of transect locations between Ruaha NP and Mikumi NP except for the area denoted by the arrow with question mark. The eastern-most arrow depicting movement between Mikumi and Udzungwa NPs was inferred on the basis of elephant dung observed along the Kilombero road and therefore has not been verified. Map by C. Epps.

Results from both ground transects (Fig. 7) and community questionnaires showed that a corridor between Ruaha and Udzungwa Mountains National Parks is still actively used by elephants. However, the elephant corridor allowing direct movement between Ruaha and Mikumi NPs may be highly threatened: current elephant movement across a relatively narrow area between Mikumi NP and the mountains just north of the Udzungwa NP border could not be verified (Fig. 7; arrow with question mark). Rapid conversion of previously unsettled lands east of Mikumi NP has led to reports of elephants abandoning movement corridors between Mikumi NP, Pala Ulanga, and the Rubeho Mountains. Ongoing analysis of 2006-2007 data has showed that elephant corridors are important for many other species (see Epps *et al*. 2008 for more details), as the number of mammal species detected outside protected areas was strongly correlated with the presence of elephants as well as variables describing lower levels of human activity (farming and grazing), habitat, and sampling effort (Epps *et al*., 2008). Other large mammals of note detected in game controlled areas and open areas across the study area included giraffe (an isolated remnant population east of Mtera Dam), buffalo, sable antelope, waterbuck, leopard, hyena, impala, greater and lesser kudu, as well as many other species.

It was also observed in this area that increased human activity has led to greater human-elephant conflict and rapid declines in other wildlife populations. Key areas within the

corridor were mapped, such as the Mtandika highway crossing (Fig. 1). This is a critical section of elephant corridor which needs to be protected, and plans are underway for a project to pursue this goal.

Conclusions and Recommendations

Our study identified several remaining wildlife corridor areas of critical importance if ecological connectivity is to be maintained between the exceptionally rich Protected Areas of south-central Tanzania. For each corridor, there are several management options (summarized in Fig. 8). Corridors can comprise areas under differing management regimes and legal status. Thus, it may be effective at the local level to protect different sections of the corridor in different ways, involving cooperation and coordinated planning between different stakeholders. All parties will benefit from advice and guidance throughout the process of planning and implementing effective protection for the Corridor areas. We therefore recommended that for each corridor project, a local conservation NGO take on the role of facilitating the process.

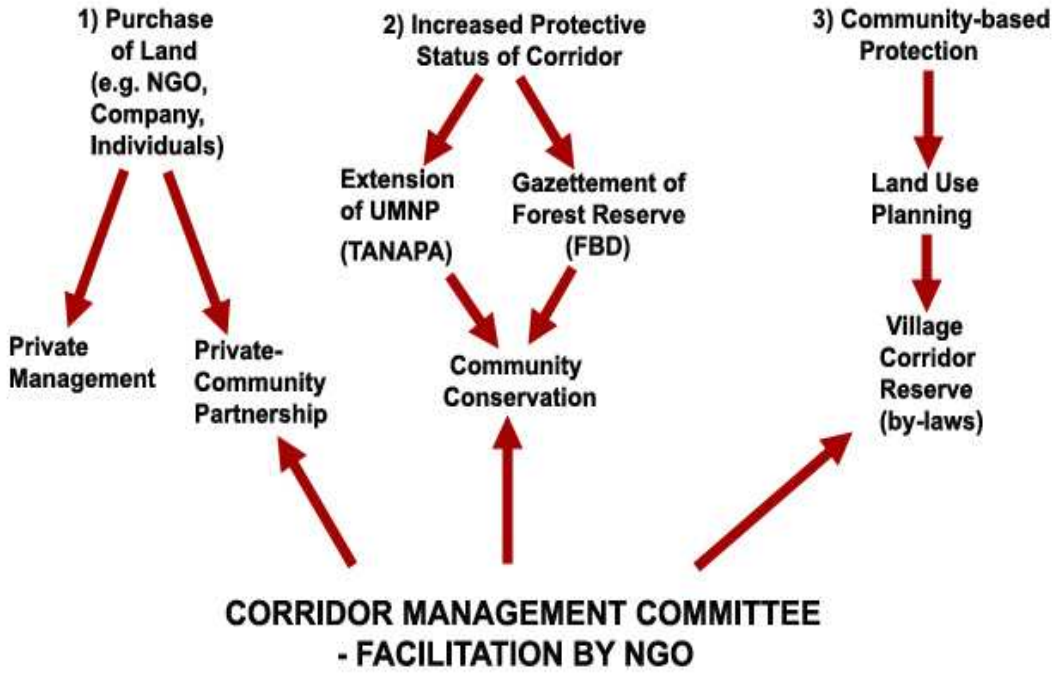

Figure 8. Summary of Management Options for Corridors between Protected Areas.

To this end, and as a result of our findings, three corridor projects have been initiated, attempting to conserve the Nyanganje, Ruipa and Mtandika corridors respectively (fig. 1).

These projects are supported by the World Wide Fund for Nature Tanzania Programme, the Wildlife Conservation Society, and private donors. In each case, the first steps involve consultation with all stakeholders to reach a concensus on the most appropriate management strategy.

We contend that ecological connectivity is an extremely important issue for Tanzania and the Tanzanian people: one of the major conservation challenges for the 21st century. In the case of Udzungwa-Selous, an ancient connectivity is on the verge of being lost – probably forever. Without successful intervention, we predict that both Udzungwa-Selous corridors might be lost within 2009. However, the opportunity does still exist to save and effectively manage these remaining corridors, for the benefit of wildlife, ecological integrity, and the livelihoods of the local population.

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