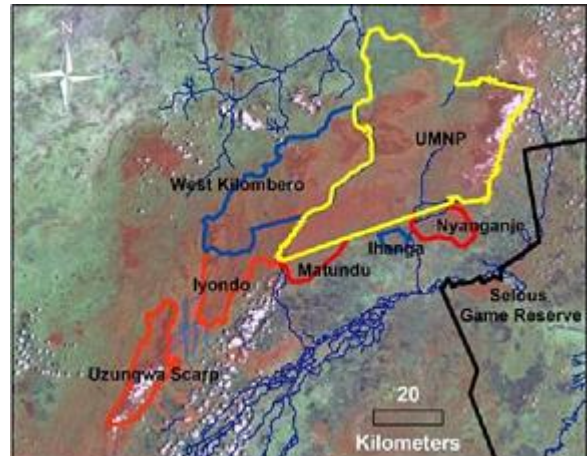


Conservation status, connectivity, and options for improved management of southern Forest Reserves in the Udzungwa Mountains, Tanzania: **urgent need for intervention**



A narrative report to:

CRITICAL ECOSYSTEM PARTNERSHIP FUND

Presented by:

**Museo Tridentino di Scienze Naturali
(Trento Museum of Natural Sciences, Italy)**

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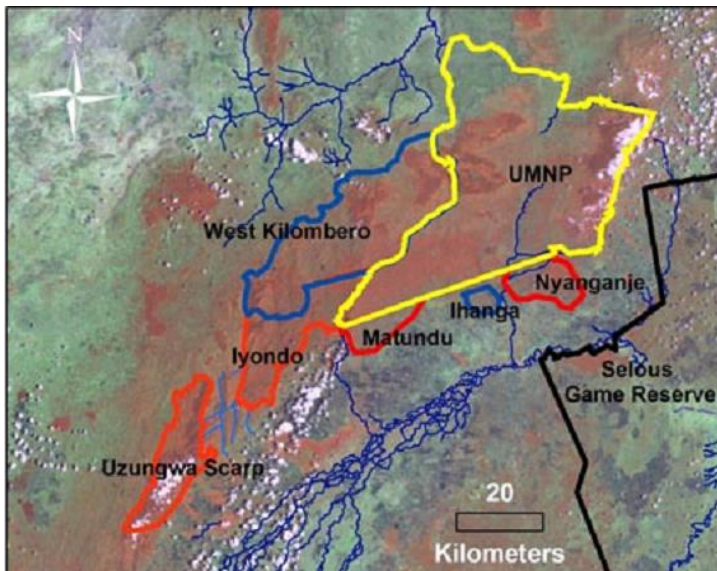


**Museo Tridentino
di Scienze Naturali**



Executive summary

This study evaluates the conservation status of four Catchment Forest Reserves (FR) in the Udzungwa Mountains of Tanzania, which is an area of outstanding biological importance within the Eastern Arc Mountains. The study focuses on southern forests, including the Uzungwa Scarp Forest Reserve that was recommended as one of the key areas for conservation priority during a stakeholders' consultation workshop in 2004. The report reviews the extremely high value of target forests in terms of biodiversity conservation and in terms of the ecological services they provide. The water from these catchment forests is of major importance and critical to the local, regional, and national economies. The study output is an assessment of the status of the habitat, ecosystem integrity, endangered and endemic species, and human impacts in the areas of interest, as well as the identification and mapping of potential corridors connecting the target Forest Reserves. Study results were presented at a meeting held in Morogoro on March 23rd, 2007, where all relevant stakeholders discussed the way forward for improving conservation of these key forests.

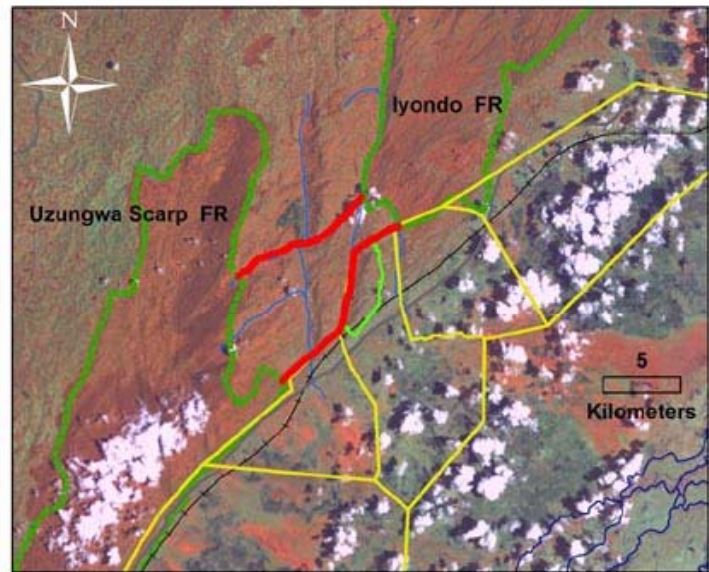


Target Forest Reserves were the following (see map): Nyanganje (69 km²), Matundu (106 km²), Iyondo (280 km²) and Uzungwa Scarp (USFR, 207 km²). Data were also collected in Mwanihana forest, on the eastern part of the Udzungwa Mountains National Park (UMNP, 1990 km²) in order to compare results between UMNP and the Forest Reserves.

We assessed human disturbance in the forests through a standard protocol of systematic surveys. This included counting tree stems along 132 transects in the forest (range of 20-40 transect per forest) and recording the number of pole and tree stems that had been cut. Data on other types of illegal disturbance were also collected, such as pitsawing, firewood collection, charcoal, snares. Data were also collected on signs of wildlife, such as dung and tracks. Key results indicate alarmingly high rates of illegal activities in the target Forest Reserves compared to those recorded in the National Park. Disturbance is particularly high in the southern-most forests, especially Iyondo and USFR.

At the final stakeholders' meeting, representatives from Forest and Beekeeping Division presented the on-going plan for creation of a new protected area, called "Kilombero Nature Reserve", that will include West Kilombero Scarp, Matundu and Iyondo FRs. It was reported that Nature Reserve designation should attract more resources and thus allow for greater protection of these forests. Upgrading the Forest Reserves to the status of a Nature Reserve was currently seen to be the best option, although this would require huge management restructuring, funding and changes in legislation before effective protection is ensured. Moreover, the forthcoming Nature Reserve does not include USFR, which was admitted as an oversight. Workshop participants recommend urgent follow-up by the Government in order to increase effective protection of the outstanding, and still neglected Uzungwa Scarp Forest Reserve.

This study also assessed the potential for developing an important conservation corridor connecting USFR and Iyondo FR. This was identified from careful analysis of aerial digital photography and ground surveys (see map). According to information from the Kilombero District, the villagers, and ground surveys, the proposed “Mngeta corridor” lies in Government land and falls entirely outside village land. It has a length between protected areas of 9.2 - 15.2 km, width of 2.1 - 6.8 km, and an area estimated at 63 km². As much as 80% of the corridor appears to be covered by natural vegetation (grass, shrubs, woodlands or forest), including approximately 25% under natural forest and woodland. Some parts of the proposed corridor are very steep and covered with mixed grassland, shrubs and low-canopy forest. Only about 20%



Legend
 — proposed Mngeta corridor
 — village land boundary
 — Iwungi mngeta PFM
 — road
 — railway

appears occupied by recent farms. It is estimated that less than 100 households live in the corridor area. Most of the people using the proposed corridor are seasonal farmers and, in the case of those from Mngeta village, have been requested to move back inside the village land to allow for the implementation of Participatory Forest Management schemes. Stakeholders’ participants recommended urgent implementation of this corridor.

Conclusions and Recommendations:

- ❑ Increasingly high rates of destruction are occurring in the target Forest Reserves (especially Iyondo and USFR). These forests have not been adequately protected and are in serious danger of suffering irreplaceable losses. In sharp contrast, the UMNP appears to have been well protected, with very few signs of violation in spite of being bordered by human populations that are 4 times greater than those next to the southern FRs. Improved protection of the southern FRs is urgent if biodiversity and ecological services are to be maintained and passed on to future generations.
- ❑ It is important to restore connectivity between USFR and the northern forests through the establishment of the proposed “Mngeta corridor”. This corridor would allow movement of forest dependent species between forest blocks, thereby enhancing gene flow and increasing population viability, both of which are important to conservation. The corridor would also expand the water catchment services to the area.

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David Moyer (WCS Conservation Flight Program) conducted the flight that provided the aerial digital images of the study area. Nick McWilliam (Anglia Ruskin University) helped with training and advice for GIS analysis. Landsat images were kindly provided by the Center for Applied Biodiversity Science (CABS) at Conservation international. Some GIS layers were kindly provided by Dr. Neil Burgess (CMEAMF) and Nike Doggart (TFCG). Trevor Jones helped with advice on data collection and participated on a survey to Iyondo FR. He also coordinated the complementary project on Udzungwa-to-Selous connectivity and provided information relevant to this report.

This report was compiled by Dr. Francesco Rovero (MTSN, Italy).

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Abbreviations and Acronyms:

CEPF	Critical Ecosystem Partnership Fund
CMEAMF	Conservation and Management of the Eastern Arc Mountains Forests Project
DANIDA	Danish Development Assistance
DBH	Diameter at Breast Height
EAM	Eastern Arc Mountains
FBD	Forestry and Beekeeping Division
FR	Catchment Forest Reserve
GCF	Global Conservation fund
GEF	Global Environment Facility
GoT	Government of Tanzania
IUCN	The World Conservation Union
MTSN	Museo Tridentino di Scienze Naturali (Trento Museum of Natural Sciences)
NGO	Non-Governmental Organization
NORAD	Norwegian Agency for Development and Cooperation
PFM	Participatory Forest Management
SIDA	Swedish Agency for Development and Cooperation
TANAPA	Tanzania National Parks
TFCG	Tanzania Forest Conservation Group
UMNP	Udzungwa Mountains National Park
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USFR	Uzungwa Scarp Forest Reserve
WCS	Wildlife Conservation Society
WWF-TPO	World Wide Fund-Tanzania Programme Office

1. Introduction and Background

1.1. Importance of the Udzungwa Mountains for biodiversity and ecological services

The Udzungwa Mountains of south central Tanzania cover an area of about 10,000 km². They are the largest of the Eastern Arc Mountains (EAM), which is an ancient chain of mountains estimated to be approximately 30 million years old that stretch in an arc from the Taita Hills in southern Kenya down to south-central Tanzania (Lovett and Wasser 1993). The EAM are world famous for their great numbers of endemic plant and animal species, found nowhere else on the planet (Burgess et al. 2007), and they have been ranked among the most important biological hotspots in the world (Myers et al. 2000). The Udzungwa Mountains are particularly important because they have the greatest amount of forest cover and the greatest altitudinal range (300-2,576 m asl) in the entire EAM. As a consequence, these mountains rank very highly in terms of international conservation priorities.

Not only are the Udzungwa Mountains important internationally for the conservation of biodiversity, they play a critical role in the local, regional, and national economy of Tanzania. This is because they are a perennial source of water. The forests on these mountains serve as water catchments, feeding streams and rivers that provide abundant supplies of crystal clear water throughout the year. This water is the basis for all agriculture (large and small) and domestic use in the Kilombero Valley. Not only do many thousands of people in the valley benefit from this, but the water from these forests serves 2 hydroelectric installations that provide approximately 70% of Tanzania's hydroelectricity and 52.6% of the country's total energy (years 2000-2005, GoT 2006). In addition, the Udzungwa forests serve the livelihoods of fisherman and pastoralists from the mountains all the way to the coast. The world famous Selous Game Reserve lies to the east of the Udzungwa Mountains and is a major source of revenue for Tanzania. It too is highly dependent on the water from the Udzungwa forests.

Clearly, the conservation of the Udzungwa Mountain forests is of great importance to maintaining the biodiversity of the world and to the economy of Tanzania. While 1,990 km² of these forests are well protected within the Udzungwa Mountains National Park (UMNP), an equal amount of forest, containing many species not found in the park, is essentially unprotected and currently threatened with degradation and total loss by illegal activities. These unprotected forests include the following forest reserves: Ndundulu, Nyumbanitu, and Ukami (W. Kilombero FR), Udzungwa Scarp, Iyondo (also known as Lyondo), and those areas of Matundu and Nyanganje forest which are outside of the park. They are formally gazetted as Catchment Forest Reserves forest under the administration of the Tanzania Forestry and Beekeeping Division and Water Catchment Forest Office (Ministry of Natural Resources and Tourism) (GoT 2006). No extractive activities are legally allowed in these catchment forest reserves.

The single greatest threat to the forests of the Udzungwa Mountains is the rapidly increasing human population. This rapid increase is particularly apparent along the eastern side of the mountain range, where birth and immigration rates are high. For example, in 2002 the total population in just 15 villages between Kiberege and Udagaji, inclusive, was 69,956 and increasing at the rate of 3.4% annually (Harrison 2006). Seventy percent of the heads of household in these villages were immigrants. More than half (55.3%) of this immigration occurred in the last 16 years (1990-2006). This trend is in line with the pattern throughout the Rufiji Basin where the human population

increased by 144.4% between 1988 and 2002 (1,250,000 to 3,055,051), representing an annual rate of increase of approximately 10% (GoT 2006). The great majority of this growth was due to immigrants seeking agriculture land (Harrison 2006, GoT 2006). Clearly, rapid population growth throughout Tanzania is a major issue resulting in great pressure for arable land, which in turn is leading to a land and environmental crisis around the Udzungwa Mountains

1.2. Biological values of the Udzungwa Mountains

1) The Udzungwa Mountains are part of the EAM, renowned for their high levels of endemism, e.g. 96 endemic species of vertebrates (Burgess et al. 2007). Furthermore, the Udzungwa Mountains have the greatest amount of forest cover, the greatest altitudinal range (300-2,576 m asl.), and more endemic species of vertebrates (17) than any of the other mountains in the entire EAM (Burgess et al. 2007).

2) The forests of the Udzungwa Mountains contain two endemic monkey species (Udzungwa Red Colobus and the Sanje Mangabey), a new species of giant sengi or elephant-shrew discovered only in 2006 (Rovero and Rathbun 2006), two species of shrews, three endemic bird species (Udzungwa Forest Partridge, Rufous-winged sunbird, and *Nectarina fueleborni*), at least 6 endemic reptiles, and 7 endemic amphibians. None of these are found anywhere else (Burgess et al. 2007). Another new monkey species was discovered in the Ndundulu forest of the Udzungwas in 2004. It is found only there and in the Rungwe-Livingston Mountains of the Southern Highlands, Tanzania (Jones et al. 2005). This new monkey is now thought to belong to an entirely new genus; re-described as *Rungwecebus kipunji* (Davenport et al. 2006). These forests also contain major populations of several other plant and animal species with very restricted ranges that are threatened with or vulnerable to extinction, e.g. Abbott's duiker (found in only 5 sites within Tanzania); the mountain galago *Galogoides orinus*; at least 9 other threatened species of birds, and numerous plant species.

3) The Sanje Mangabey has so far been found in only two forests: Mwanihana, and the Uzungwa Scarp Forest Reserve. Estimates indicate that less than 1,500 individuals of this species remain. At present, only the Mwanihana population is protected by the park. The other population of this endemic primate lives in the unprotected Uzungwa Scarp Forest Reserve (USFR). Greater protection of the Uzungwa Scarp Forest Reserve is important for the conservation of this species because this forest appears to contain at least 50% of the entire population (Dinesen et al. 2001, Rovero and Menegon 2005, F. Rovero, unpub. data).

4) The endemic Udzungwa Red Colobus monkey is found in all of the forests recommended for improved conservation management. Most of the red colobus populations in these forest patches are relatively small, i.e. unlikely to exceed ~2,000-3,000 individuals. As a consequence, their vulnerability to extinction is high.

5) The bulk of the population of the endemic Udzungwa Partridge lives outside the park in the Ndundulu and Nyumbanitu forest within the West Kilombero Forest Reserve, which was earlier recommended for increased protection status.

6) The majority of the endemic Rufous-winged Sunbirds live outside the park in the Ndundulu and Nyumbanitu forests, and USFR.

7) The same applies to Abbott's duiker, which is considered a Vulnerable species by the IUCN Antelope Specialist Group; recently reassessed as Endangered. This large forest duiker occurs only in a few isolated mountain forests, including Kilimanjaro, Usambara, Uluguru, Udzungwa, and Rungwe. It is estimated that perhaps only 2,500 of these duikers remain throughout their entire

range. They occur in 4 of the forests recommended for greater and more effective protection: Ndundulu, and Nyumbanitu forests, USFR, and Matundu FR.

8) USFR contains a rich diversity of amphibian and reptile species. 21.7% of them are endemic to the Udzungwa and 53.6% endemic to the EAM. Seven species of amphibians and one species of reptile are found only in the USFR, which is outside the park (Rovero and Menegon 2005).

1.3. Economic Values of the Udzungwa Mountains

1) Water Catchment and Hydropower:

The forests of the Udzungwa Mountains serve as critical water catchment areas for the Kihansi (Gerstle et al. 1997) and Kidatu hydroelectric installations. These are the two most important hydroelectric installations in Tanzania, producing approximately 70% of Tanzania's hydroelectricity and 52.6% of the country's total energy during the years from 2000 through 2005 (GoT 2006). Production of electricity dropped significantly at both the Mtera and Kidatu dams during the period of 2000-2005. This was because of a significant decline in the water level of the Great Ruaha River, due in part to increased off take of water for irrigation further upriver (GoT 2006). As a result, the role of the Udzungwa forest catchment area in serving the Kidatu dam is now of even greater importance than previously.

The Kihansi Hydropower Project receives approximately one-third of its water from USFR. Kihansi produced as much electricity as did Kidatu in both 2004 and 2005. Furthermore, Kihansi was much more consistent in energy production than was either Kidatu or Mtera between 2000 and 2005 (GoT 2006). During this 5-year period, Kihansi generated 28.4% of Tanzania's hydroelectricity and 21.4% of its total energy supply (GoT 2006). Kihansi's relative importance has increased as electricity production at Mtera and Kidatu have declined. For example, in 2005 Kihansi produced 35% of Tanzania's hydroelectricity. Both the Kidatu and Kihansi hydroelectric installations are in jeopardy without maximum protection of the Udzungwa water catchment forests. The implications for Tanzania's economy are obvious. Maximum protection of these forests is paramount. The option of using thermal energy to generate electricity is economically unattractive because production costs using this resource are said to be 137 times greater than electricity generated by hydropower (GoT 2006).

2) Agriculture:

a) General: The UMNP and all the forest reserves recommended for improved protection serve vital roles as water catchments. They supply water via streams, rivers, and subterranean drainage for agricultural and domestic uses at lower elevations. In 2002 there were 323,000 people living in Kilombero District whose livelihood was linked to the water from these forests (GoT 2006). The importance of the Udzungwa forests is, however, far greater than this as demonstrated by the fact that they are the major source of water to the Kilombero River sub-basin, which contributes 62% of the total annual runoff to the Rufiji River Basin. This basin is the largest river basin in East Africa and represents 20% of Tanzania's entire land surface. It is estimated that the water from this catchment area serves an estimated 3.2 million people (GoT 2006). Furthermore, the Udzungwa Mountain range and its forests also generate a microclimate that increases rainfall in the area. This effect is particularly pronounced on the eastern and windward side of the range. As the moisture-laden winds travel westward from the Indian Ocean, the first major mountain they encounter is the Udzungwa range. Correspondingly, rainfall is high on the eastern side of the range and this is critical to the vast agricultural area in the Kilombero Valley below. All agriculture in the Kilombero

Valley is directly dependent on the rainfall and catchment effects of the UMNP and those forest reserves that are being recommended for better protection.

b) Sugar Production: In the year 1999 more than **50,000 tons of sugar** were produced in the Kilombero Valley adjacent to the Udzungwa Mountains through the combined efforts of the ILLOVO Kilombero Sugar Company, ULANGACO, and several small holdings. This production was **valued at more than T.Shs. 17 billion per year**. Nearly 10,000 ha. (4,400 ha. irrigated) was planted in sugar cane and more than 2,800 people were employed in this industry, either permanently or on a part time basis (IRA 2000). By the years 2004-2005, the area planted in sugar in the Kilombero Valley had increased to 17,930 ha., including that of the Kilombero Sugar Co. Ltd. and 5,062 smallholders. All of this is heavily dependent on water from the Udzungwa forests. For example, it has been estimated that approximately 18,740,160 L of water are used daily for irrigation by the Kilombero Sugar Co. Ltd. (GoT 2006).

c) Rice, Maize, Banana, and Cassava Production: Rice production in the Kilombero Valley for 1999 exceeded **40,000 metric tons**. Total production of rice and maize (34,000 metric tons) combined was estimated to be worth more than **T.Shs. 4 billion** in 1999. Bananas and cassava accounted for another 34,000 metric tons of food produced in this area (IRA 2000).

d) Teak Production: Teak grown in the Kilombero Valley was estimated to have the potential of generating more than T.Shs. 20 billion in exports (IRA 2000).

3) Benefits to Fisheries and Livestock:

The water catchment services of UMNP and the forest reserves recommended for greater protection also serve fisheries and livestock. It is more difficult to put a monetary value on these services because, for example, fisheries are positively influenced by the Udzungwas over great distances from the Kilombero River to the Rufiji River delta. Likewise, virtually all livestock in the Kilombero Valley and downstream to the coast are heavily dependent on water originating from the Udzungwa catchment forests.

4) Protection Against Soil Erosion and Flooding:

The forests of the Udzungwa also reduce levels of flooding and soil erosion. These too are ecological services that are difficult to value in monetary terms. However, one indication of their value is given by the costs of silt removal from the irrigation system of the ILLOVO Kilombero Sugar Company. In 1999 they spent more than T.Shs. 418 million to remove silt that came from deforested mountains to the north of the Great Ruaha River and outside the UMNP (IRA 2000). Furthermore, soil erosion greatly increases by approximately 0.37 tons more per ha per year when forest is replaced by cultivation (GoT 2006). This has obvious negative impacts on water quality and quantity.

5) Domestic Water Supply:

The Udzungwa mountains supply water for consumption and other domestic uses to more than 700,000 people living in 146 villages near the Udzungwa Mountains (Harrison 2006) and to hundreds of thousands more living further downstream (GoT 2006).

6) Tourism:

In 2006, the UMNP had approximately 1,500 tourists, generating approximately \$75,000 to \$80,000 in park fees, as well as providing employment and revenue to service industries. The Tanzania National Parks (TANAPA) also pays an income tax of 25% to the central government of Tanzania. In addition, 7.5% of the UMNP budget is contributed to projects that directly benefit local community projects. In 2006 this amounted to approximately \$28,000-29,000. Expansion of this protected area to include the catchment forest reserves currently outside UMNP would offer the potential for increased revenues from eco-tourism. Downstream and a few km to the east of the Udzungwa Mountains lies the Selous Game Reserve. This reserve is a major source of revenue to Tanzania, generating about one million U.S. dollars annually. Much of the water in this reserve comes from the Udzungwa Mountains via the Kilombero and Great Ruaha Rivers.

1.4. Threats and needs for greater protection

It has been long recognized that the outstanding biological and economic importance of the Udzungwa Mountains are only partially protected in an effective manner. Despite clear evidence publicized during the past decade on the alarming status of Forest Reserves, especially USFR (e.g. Zilihona et al. 1997, Moyer and Mulungu 2004, Rovero et al. 2005, Ndangalasi et al. 2007), no effective protection has yet been implemented. With very few exceptions, only the forests protected in UMNP are effectively protected. It is important to emphasize here that the forests which are being so seriously violated are all central government Catchment Forest Reserves that are legally protected against all forms of human exploitation. In spite of this legal status, illegal activities are abundant and widespread in these forests.

This report provides a quantitative assessment of the disturbances threatening the FRs on the eastern side of the Udzungwa Mountains and the information obtained is used to develop and propose options for improving protection of these forests. Unless the forest reserves listed above are given greater, effective protection, then they are likely to dwindle away within the next decade. With the loss of these forests, Tanzania will lose an invaluable natural heritage and a major economic resource. The consequences of these losses would likely be devastating for the people, the economy, and the biodiversity of Tanzania. From a global perspective, we will have lost an irreplaceable and unique centre of biodiversity.

1.5. Summary of CEPF project goals

Long-term Goal:

To contribute to more effective long-term conservation of the Udzungwa Mountains ecosystem.

Conservation Outcomes:

Effective protection of the biodiversity, the threatened and endangered endemic species, and the water catchment services of four important forest blocks of the Udzungwa Mountains.

Project Purpose:

To develop a conservation action plan for the Udzungwa Forests that is accepted by protected area authorities, central and local government authorities, conservation organizations and other relevant stakeholders.

Project Output:

An assessment of the status of the habitat, ecosystem integrity, endangered and endemic species, and human impacts in and near the areas of interest. Identification and mapping of potential corridors connecting forests of concern.

1.6 The 2004 Udzungwa Mountains workshop and conservation priorities

CEPF funded a stakeholders' workshop that was held in December 2004 in Morogoro (Doody 2005). All relevant stakeholders (TANAPA, FBD, NGOs, researchers and private sector) participated. Following presentations on the key issues and areas in need of urgent conservation, they agreed on the following four major areas for intervention:

- Magombera
- West Kilonbero Scarp FR
- Southern FRs especially USFR
- Wildlife corridor between Udzungwa and other ecosystems.

We refer to Doody (2005) for details on the workshop presentations and outcomes. The conservation priorities translated into a number of projects, including the present one, that were funded mainly by CEPF.

1.7. Summary of complementary studies and projects:

WWF socio-economic study:

WWF-TPO conducted a socio-economic assessment of forest-adjacent communities in the same area targeted by our project. This assessment was indeed meant as complementary to our biological assessment and planned jointly. Detailed results are reported in Harrison (2006). The study targeted 15 villages adjacent to the forests from Nyanganje FR to USFR and key findings were the following:

- the communities rely to a significant degree on forest resources to meet mainly their energy needs, for which there are currently few alternatives; however, interviewees declared that only a minority of them enter Forest Reserves to access these resources while the majority of respondents declared that they use farms and community forests, or purchase the resources. The percentage of respondents entering FRs for various use is as follows: grazing pasture (1% of respondents); fuelwood (14.4%), medicines (6.9%), building poles (18.6%), charcoal (5.2%), beekeeping activities (6.2% of respondents relied on FRs).
- there is a need for greater efforts to be made in offering alternatives to reduce forest dependence whilst still offering benefits;
- 70.3% of the population are immigrants, implying that the majority of people do not have a historical claim to the area, only a recent one;
- even if the majority of people stated that they know the regulations governing the FRs, their understanding of permitted and forbidden activities varied greatly between villages and was often not correct; however, all villages knew that cutting live trees was illegal.
- in terms of management regimes, the study recognized that the current regime of catchment FR is proving insufficient as it stands. Communities invariably wanted joint management of FRs in future scenarios;
- Providing that local management is allowed, communities showed variable positions in respect of the two broad options of maintaining management under FBD or shifting management under TANAPA; for example, communities near Nyanganje are cautious of TANAPA while those near USFR "would support management by TANAPA providing they are given environmental education leading to collaborative management".

The study also involved institutional consultations:

- Kilombero District Council: Joint Forest Management schemes, which retain control at central and district levels, were planned with funds from DANIDA and NORAD, but implementation has developed very slowly, and only in Nyanganje there were some developments. On the contrary, Community-based forest management was not seen as appropriate due to the importance of conserving watershed services of these forests
- TANAPA-UMNP: this institution recognized that the necessary local support needed for annexation to UMNP of the adjacent FRs was not currently in place but that they would generally be willing to annex the area in the presence of positive attitudes by the community.
- FBD (Regional Catchment Forest Office, Iringa and Morogoro regions): plans of creating a Kilombero Nature Reserve of ca. 1400 km² were declared to be in process of being implemented. This Nature Reserve would include West Kilombero, Matundu and Iyondo FRs. This intention was re-enforced at a technical meeting that was held in Morogoro in January 2007 organized by WWF-TPO.

Previous socio-economic assessments:

A socio-economic assessment of 14 villages on the eastern side of UMNP found a general lack of community involvement in activities, such as tree planting, that provide alternatives to exploitation of UMNP and forest reserves. This study also noted a lack of awareness and interest in conservation (Hoyle 1997 for WWF-TPO).

A more recent socio-economic study of 8 villages on the eastern side of UMNP found a significant improvement in the level of conservation awareness (WWF-TPO 2004), indicating that community education programs implemented by WWF-TPO and TANAPA were successful. A similar conservation education program could make an important contribution to improving the conservation status of the southern Udzungwa FRs that are the focus of concern here.

Corridor Learning Initiative project to assess corridors between Udzungwa and Selous ecosystems:

This project has been coordinated by T. Jones (Anglia Ruskin University, UK) and F. Rovero (MTSN, Italy) with funds from Conservation International and it was implemented in conjunction with our CEPF assessment of FRs. Results show that two areas on the eastern side of the FRs are crucial for maintaining a wildlife corridor between the Udzungwa Mts and the Selous for elephants and other large mammals (see report, Jones et al. 2007). These areas are at Nyanganje and Matundu FRs (Fig. 1.) Improved conservation of these two FRs is also crucial for maintaining connectivity between Udzungwa and Selous.

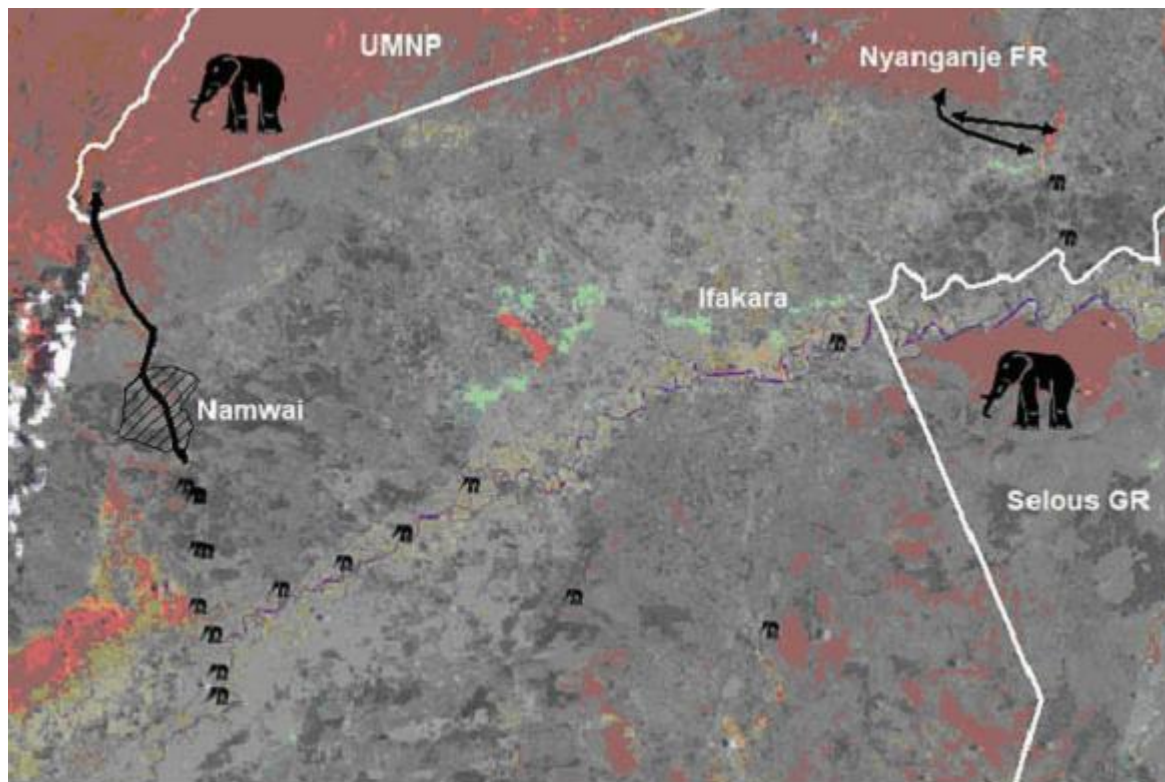


Fig. 1. Map of corridors between Udzungwa and Selous ecosystems that are still used by elephants and involve Matundu and Nyanganje areas in the Udzungwa. Black lines represent key corridor routes consistently used by elephants, the elephant symbols represent spot records of elephants and the large elephants represent the two populations connected by corridors (Map by T. Jones).

On-going ecological research and monitoring:

Although some biological surveys have been conducted in the southern Udzungwa FRs, most of the more detailed biological research has focused on West Kilombero Scarp Forest Reserve and UMNP, e.g. a primate monitoring program has been conducted in the Mwanihana forest of UMNP since 1998 (Struhsaker et al. 2004, Marshall et al. 2005, Rovero et al. 2006).

However, F. Rovero and collaborators also conducted primate and duiker censusing in USFR during 2004-2005. This has been re-initiated as part of the program of the newly established Udzungwa Ecological Monitoring Centre.

2. Study area and Methods

2.1. Study area

The four FRs targeted by this study are Nyanganje, Matundu, Iyondo and Uzungwa Scarp, as shown in the map in Fig. 1. Table 1 presents some key characteristics of these forests.

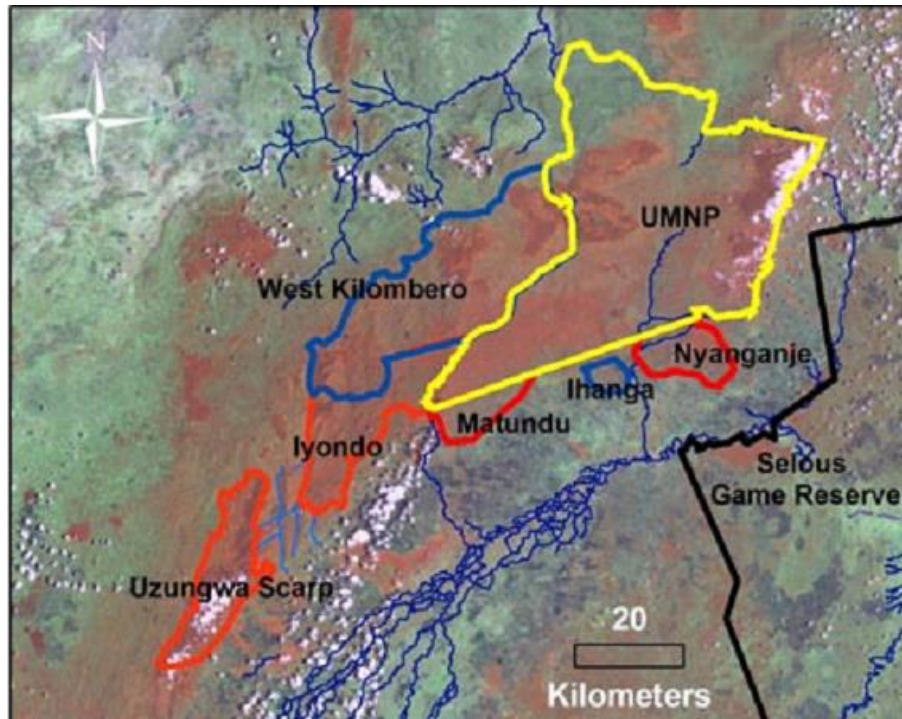


Fig. 2. Landsat image of the Udzungwa Mountains (more intense red corresponds to closed-canopy forests) with boundaries of UMNP (yellow), FRs targeted by this study (in red) and FRs not targeted by this study (in blue)

Table 1. Description of Forest Reserves considered in the study (source: Lovett and Pócs 1993)

Forest Reserve	Area (Km ²)	Gazettment Year	District (Region)
Nyanganje	69 ¹	1958	Kilombero (Morogoro)
Matundu	106 ²	1958	Kilombero (Morogoro)
Iyondo (or Lyondo)	280	1958	Kilombero (Morogoro)
Uzungwa Scarp	207	1929	Mufindi + Kilolo (Iringa), Kilombero (Morogoro)

¹Original area was 189 km², before the inclusion of part of it in UMNP.

²Original area was 176 km², before the inclusion of part of it in UMNP.

UMNP covers an area of 1990 Km² in the northeastern portion of the Udzungwa Mountains, while the four FRs we considered cover altogether ca. 664 Km² of mainly closed-canopy forest habitat. A brief description of forest habitat types is following (Lovett and Pócs 1993):

- Nyanganje is mainly represented by deciduous, miombo woodland, with some portions of evergreen, riverine forest and dry evergreen forest. The altitude range is 300 to just about

1000 m a.s.l. Other than considerable timber value, the forest is an important catchment area protecting part of the Lumemo river catchment.

- The portion of Matundu forest which has not been included in UMNP is represented mainly by deciduous miombo with some portions of semi-deciduous, ground-water forest and evergreen forest. Matundu has been severely logged in the past, except for some interior parts, and it is now a regenerating forest and among the largest, lowland forests in East Africa. The altitude range is 300 to ca 500 m a.s.l.
- Iyondo forest is a lowland and midland forest (300 to 1000 m a.s.l.) mainly represented by semi-deciduous forest, with areas of riverine and sub-montane evergreen forest. Lovett and Pócs (1993) report this forest as “completely undisturbed” which contrasts strongly with our finding that the forest has been logged in the past and still suffers from severe, illegal pitting.
- USFR is one of the 3 largest Udzungwa forest blocks, together with Mwanihana and Ndundulu-Luhomero forests, with a large area of closed-canopy sub-montane and montane evergreen forest. USFR has continuous forest cover 300 to over 2000 m a.s.l. which, along with Mwanihana in UMNP, is unique in the region. The water catchment value is enormous, for both rivers flowing on the west side (such as Kihansi) and on the east side (tributaries of the Kilombero river).

2.2. Data collection and analysis

1. Review of maps and information on biodiversity

The following material was used:

- Topographic maps scale 1:50,000 produced by the Surveys and Mapping Division, Ministry of Lands, Tanzania (1983)
- Landsat images provided by the Center for Applied Biodiversity Science at Conservation International.
- Various GIS layers made available mainly by TFCG and the UNDP/GEF Conservation and Management of the Eastern Arc Mountains Forests Project.
- Maps of village land boundaries, from the Land Office, Kilombero District Authority.

Geo-referenced maps and layers were uploaded into a GIS program (ArcGIS 8.1) to create maps and integrate information with aerial photo and data collected in the field.

2. Review of biodiversity studies conducted in the target FRs. Most relevant studies were the following:

- Study focusing on herpetofauna and mammals – especially primates and forest antelopes - in USFR by Trento Museum (Rovero and Menegon 2005);
- Ornithological and small mammal surveys in USFR (Moyer 1993a-b, Stanley et al. 1998);
- Intense study in Matundu forest on primates and forest antelopes by Marshall (2007) and F. Rovero (2006);
- Broad zoological surveys in the area (e.g. Ehardt et al. 1999; Dinesen et al. 2001).

3. Aerial photo-mapping (WCS)

Digital Aerial Photograph Mosaic was provided by the WCS’s Flight Program in 2 formats: as a single medium spatial resolution (10 m) mosaic of the entire area surveyed, and as a collection of

contiguous high resolution (range of 0.5 to 1 m depending on altitude of image acquisition) 5 km x 5 km tiles. Data-sets were processed by WCS with the objective of providing auxiliary information for ground truthing and to provide general land cover information. These photographs were especially utilized in this project for the area between Iyondo FR and USFR to assess the corridor options.

4. Field data collection:

We conducted approximately 120 day of field work by a field team composed by Francesco Rovero, John Msirikale and Richard Laizzer, plus several field assistants from local villages (Fig. 3); preliminary ground and aerial surveys were also conducted by F. Rovero, T. Struhsaker and T. Jones with support from D. Moyer (WCS' flight program). Data collection deployed the following methods:



Fig. 3. Members of the field team that conducted the study.

- General biodiversity surveys:

These were aimed at assessing habitat status and disturbance levels and selecting areas for further work. They were conducted in all four FRs.

- Systematic transects for disturbance:

Two sets of transects were conducted, a first set mainly aimed at assessing disturbance in FRs and a second set mainly aimed at assessing wildlife signs.

The first set of transects followed a method adapted to assess disturbance that has been routinely used in other Udzungwa and Eastern Arc forests (e.g. Doggart 2006). At least 20 transects per FR were walked by two researchers. The length of transects was 0.5 km measured by hand held GPS unit (Garmin ltd., UK). Transects were randomly sited, however, they generally started from FR

boundary or forest edge (in case the boundary was not within the forest) and proceeded as straight lines into the forest perpendicular to its boundary. All stems within a strip of 5 m each side of the researcher that were greater than 5 cm DBH were counted and classified as follows: poles (DBH 5-15) and timber (DBH >15) and divided into 4 classes: alive, cut (fresh and old cut), and dead. Fresh cut is when the panga or saw mark is visible and the surface is clean. Thus, an old cut is defined as anything other than clean (usually darkened by fungi or bearing regenerating stems). Other disturbance signs such as snares, pitsawing sites, charcoal burning sites, etc. were recorded.

For each FR we computed the mean values per km of transect walked of the various variables measured (see Table 2 in Results for a list). We also computed an index of freshly-cut stems (and of freshly-cut timber trees) as the ratio of stems (or timber trees) to the total number of both cut and live stems (or timber trees) counted. This represents the proportion of all stems in the sample that were cut and gives an estimation of disturbance easily comparable across forest habitats that may vary in stem density as a result of old management regimes or habitat type. In order to compare disturbance results with data from the UMNP, and therefore compare conservation effectiveness, data were also collected in Mwanihana forest (eastern UMNP), which is very comparable to the targeted FRs as this forest is adjacent to several villages and therefore represents a similar situation, in terms of both habitat and potential disturbance levels.

Additional transects (n=74) were conducted with the aim of counting dung to collect data on wildlife presence, especially in the potential corridor area between USFR and Iyondo. The difference from the previous set of transects was that (a) they were conducted both inside and outside of FRs such as the corridor area, and (b) they were especially focused on recording wildlife signs instead of disturbance by humans. Inside FRs these transects were interspersed with the transects established to measure human disturbance. They were 0.5 to 1 km long, measured by GPS, and followed straight line routes. All duiker and other mammal dung was counted within 2 m of the transect. We analysed these data in terms of mean number of sightings (primates) and signs (all other species) per km of transect walked.

- Land use mapping in the potential corridor area between Iyondo and USFR

Ground-truthing of potential corridor areas, as determined from maps and aerial digital photographs, consisted of random walks along natural boundaries, such as rivers, valleys and ridges, forest boundaries, etc. Key features and changes in habitat type were recorded and mapped using GPS. Results were analyzed by uploading data on GIS software (ArcGIS version 8.1) and overlapping data with aerial photos and other relevant information.

- Village interviews

This was a minor activity of our project, since the study conducted by WWF-TPO (see chapter 1.7) addressed the socio-economic component of this project. However, we targeted households living near FR boundaries specifically to gather information on wildlife conflicts and awareness of FRs. Key questions were the following:

- Existence of a conflict with wildlife
- Species passing through farm/damaging farms
- Collection of firewood in the FR
- Awareness on presence of a protected area

3. Results and discussion

3.1. Summary of biodiversity importance of target FRs

Comparison of forest-dependent mammals across FRs

Table 2 shows that the most protected forests hold more healthy populations of forest-dependent mammals than those forests lacking effective protection. –As will be shown below, this can be largely explained by the negative impact of hunting and habitat degradation. Sanje mangabey is an exception to this trend, as population in USFR appears as healthy as in Mwanihana (see below for detailed data). Some of the differences are of course also due to habitat differences. Altitudinal range and forest types are for example more similar in USFR and Mwanihana than between other forests. Furthermore, if hunting were prevented in USFR, the Sanje mangabey population might increase even more so.

Tab 2. Presence of forest-dependent, medium to large mammals in the largest Udzungwa forest blocks. The dash means the species is absent, question mark means that presence needs confirmation.

Forest-dependent mammals (IUCN globally threatened)	FRs targeted by this study				Other large forest blocks	
	Nyanganje	Matundu	Iyondo	USFR	Mwanihana (UMNP)	Ndundulu, Nyumbanitu
Sanje mangabey (EN)	-	-	-	common	common	-
Udzungwa red colobus (EN)	rare	common*	rare	rare	common	uncommon
Angolan colobus	rare	common	rare	rare	common	uncommon
Mountain galago	-	-	-	common	common	common
Abbott's duiker (EN)	-	rare	-	rare	common	common
Harvey's duiker	common	common	rare	rare	common	common
Blue duiker	-	-	-	rare	rare	uncommon
Jackson's mongoose (VU)	-	rare	-	-	-	-
Lowe's servaline genet	?	rare	?	rare	uncommon	uncommon
Tree hyrax	-	rare	-	common	common	common

* more abundant in the UMNP side of Matundu forest than in Matundu FR portion of the forest.

Overall vertebrate importance of USFR

Extensive surveys have been conducted on the amphibians, reptiles and mammals of USFR by M. Menegon and F. Rovero of the Trento Museum.

A total of 36 species of amphibians belonging to 6 families and 33 species of reptiles belonging to 7 families are found in USFR. Among them, 20% of the amphibian and 50% of the reptile species are endemic or near endemic to the Udzungwa Mountains and to the Eastern Arc. At altitudes above 1600 m, this percentage of endemism raises to about 83%. This suggests that several endemic and forest-associated species of the USFR are cool-adapted species. At present, 7 amphibian and 1 reptile species are considered to be strictly endemic to USFR. Clearly, USFR is an extremely “productive” centre of endemism and among the most important in the entire Eastern Arc chain.

Table 3 summarizes the overall vertebrate species' richness of USFR. The density of endemic species is 30.8 species per 100 km², much higher value than that reported for the entire Eastern Arc (4.5). This is particularly significant given the fact that the Eastern Arc has the highest density of endemic species in the world (e.g. Burgess et al. 2007).

Table 3. Summary of biodiversity value of USFR as the number of Eastern Arc endemic and near-endemic vertebrate species. The last column shows the number of endemics in USFR only.

Taxa	N. of Eastern Arc endemics	N. of USFR endemics
Amphibian ¹	24	7
Reptiles ¹	18	1
Birds ²	22	0
Small Mammals ³	3	1
Large Mammals ¹	3	0
Total	70	9

¹ Rovero & Menegon 2005; ² D. Moyer (pers. comm.); ³ W. Stanley (pers. comm.)

Comparison between USFR and Mwanihana in primate and antelope abundance

Primate and forest antelopes census results are presented in Figure 4 as the mean number of sightings per km walked, and compared to long-term results from Mwanihana Forest. USFR and Mwanihana are the only two sites where the threatened Sanje mangabey, Udzunwga red colobus *Procolobus gordonorum* and Abbott's duiker *Cephalophus spadix* are present together. Primate relative abundance is lower in USFR than Mwanihana. This difference is accounted for mainly by the two colobus monkeys. In contrast, sighting rates of Sanje mangabeys in USFR were almost twice those in Mwanihana. This is despite the fact that hunting of monkeys by humans is common in USFR (Moyer and Mulungu 2004; this study), but rare or absent in Mwanihana. Antelopes were very rarely seen in USFR: Harvey's duiker *Cephalophus harveyi* 8 times, blue duiker *C. monticola* once and Abbott's duiker *C. spadix* once. Snaring of antelopes in USFR is frequently reported. Camera-trapping rates of forest antelopes were also very low in USFR when compared to forests inside UMNP.

Primate and duiker abundance, comparison between Mwanihana and Udzungwa Scarp forests

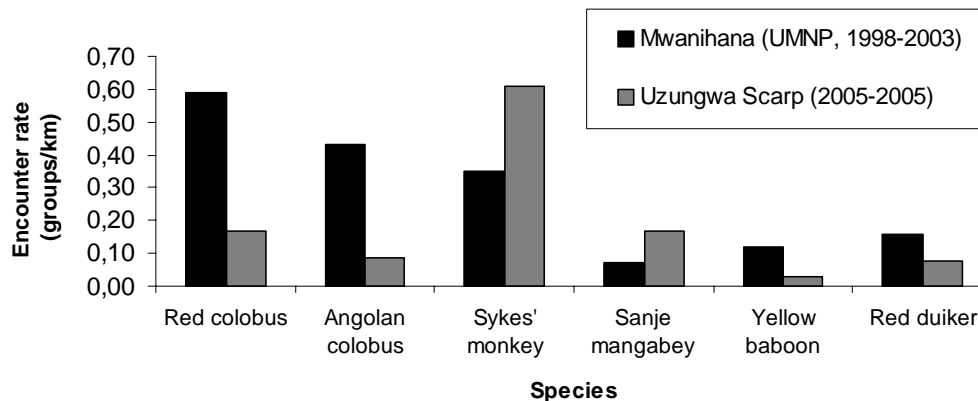


Figure 4. Results of primates and red duiker line-transect censuses in Uzungwa Scarp Forest Reserve (N = 14 transect repetitions of 4 transects) and Mwanihana Forest in the Udzungwa Mountains National Park (N= 54 transect repetitions of 3 transects).

Importance of Matundu and Iyondo FR for forest-dependent mammals

An extensive study of primates and duikers was conducted in Matundu forest by A. Marshall (2007). Additional studies of duikers and other large mammals were conducted by F. Rovero. Marshall (2007) found that Matundu holds large populations of the two colobus and Sykes' monkey. The relative abundance of the Udzungwa red colobus in parts of the forest which are inside UMNP (0.57-0.62 groups/km walked depending in transect) was similar to those recorded in the Mwanihana forest of UMNP (mean of 0.59 groups/km). However, red colobus abundance in the SW part of the Matundu study area, which is mainly in the Matundu FR and represented by secondary, regenerating, semi-deciduous forest, are much lower (0.03-0.48). This lower abundance is probably due to poorer habitat as a consequence of extensive logging that occurred in parts of Matundu in the past (Marshall 2007), rather than to present hunting, as the proximity of this area to UMNP seems to have insured good protection from poaching.

In fact, some areas of Matundu FR presents exceptional species' diversity and hold the greatest abundance in the entire Udzungwa ecosystem of large mammals, such as elephants, buffalo and hippos. For example, both census and camera-trapping revealed unusually high densities of Harvey's duiker in Matundu forest, including the regenerating areas in Matundu FR. New records of Abbott's duiker were also documented in Matundu forest, especially inside the UMNP.

Of exceptional importance is the new discovery of a rare, small carnivore, the Jackson's mongoose in an area at the boundary between Matundu FR and UMNP (De Luca & Rovero 2006)., This rare species was not previously recorded anywhere else in the Udzungwa Mountains or Tanzania. Prior to this it was known only from Kenya.

Fewer data are available for Iyondo FR because little research has been done there. However, in contrast to Matundu FR, our surveys found alarmingly high rates of illegal human activities within Iyondo FR.

3.2. Human disturbance in each FR compared with Mwanihana forest in the UMNP

A total of 132 transects (66 km walked, distance computed by GPS) were conducted in Mwanihana forest (UMNP) and in the four targeted Forest Reserves (range of 20 to 40 transects per forest). Results are shown in the Table 4 and the bar charts in Figure 5-8. All measures show very clearly that disturbance by humans is much higher in the FRs than in the UMNP, with a drastic increase in the southern FRs, reaching highest values in USFR and Iyondo FR.

Table 4. Summary of data from transects measuring disturbance by humans in Mwanihana forest (UMNP and in the 4 Forest Reserves targeted by the study

	Mwanihana (National Park)	Nyanganje	Matundu	Iyondo	USFR
Number of 0.5 km transects	20	24	40	23	25
Total km walked	10	12	20	11,5	12,5
Freshly-cut poles (n/km)	1,0	1,5	2,1	22,5	33,7
Mean freshly-cut pole index*	0	0,01	0,01	0,07	0,15
SD of pole index	0	0,01	0,02	0,07	0,12
Freshly-cut timber trees (n/km)	0,3	2,6	0,3	11,2	27,3
Mean freshly-cut timber index*	0	0,01	0,00	0,03	0,07
SD of timber index	0	0,02	0,00	0,03	0,07
Recent and active pitsawing sites (n/km)	0	0,3	0,1	0,4	0,2
Snares (n/km)	0	0	0,4	1,5	0,1
Charcoal-making sites (n/km)	0	0	0	0,3	0,2
Snares+charcoal+recent pitsawing (n/km)	0	0,3	0,5	2,2	0,6
Old cut poles (n/km)	26,4	22,4	11,0	15,3	32,6
Old cut timber trees (n/km)	10,3	14,0	6,4	10,6	19,4
Old pitsawing sites (n/km)	1,8	0,4	0,5	1,6	1,0

* Index computed as: number of poles cut / (total number of poles counted + poles cut). It is the proportion of poles cut on the total number of stems counted in the transect strip (see Methods for details).

For example, the number of freshly-cut poles encountered per km of transect varied from 1 in Mwanihana forest (UMNP) to nearly 34 in USFR. Similarly, the number per km of freshly-cut timber trees varied from 0.3 to 27.3 in UMNP and USFR, respectively. We did not encounter active pitsawing sites in UMNP, while the number per km varied from 0.1 to 0.4/km in the targeted FRs. The same trend occurred in the number of snares and charcoal-making sites. Interestingly, when data on old disturbance signs were considered, results for Mwanihana forest are well within the range of the southern FRs. In fact, the number of old pitsawing sites is highest in Mwanihana. This presumably indicates that protection in the National Park in recent years was effective in decreasing or completely stopping illegal activities. When Mwanihana was a Forest Reserve or during the first few years after National Park gazettement in 1992, Mwanihana forest seemed to be heavily disturbed to levels that were comparable to the southern FRs. This may have been the consequence of greater human pressure in the northern Kilombero valley.

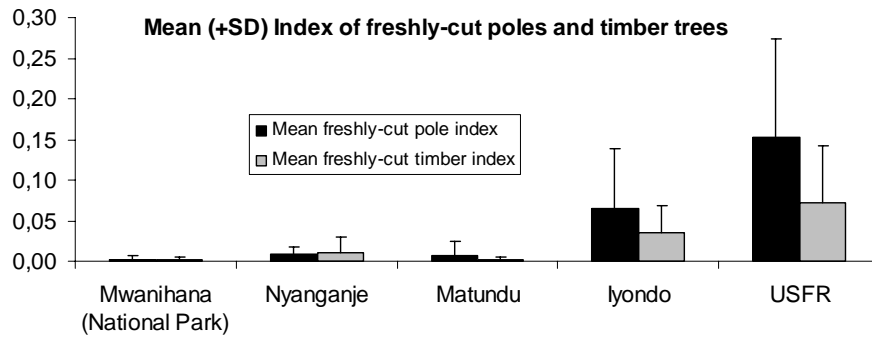


Fig. 5. Index of fresh signs of human disturbance in Mwanihana forest within UMNP and target FRs (see methods and Table 4 for details)

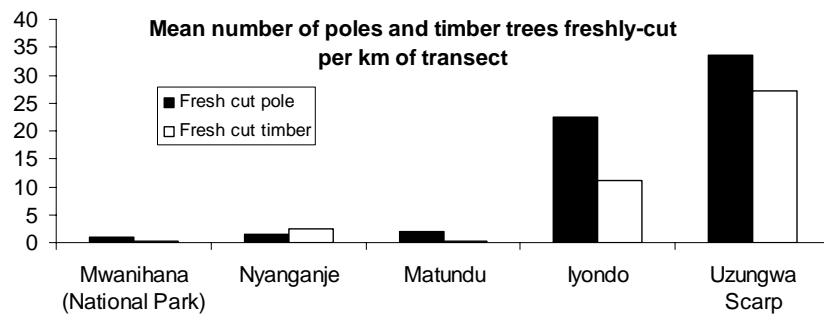


Fig. 6. Number of fresh signs of human disturbance in Mwanihana forest within UMNP and target FRs (see methods and Table 4 for details)

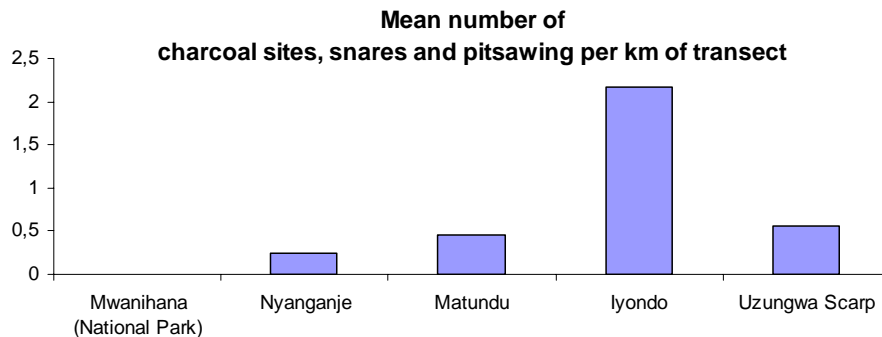


Fig. 7. Number of human disturbance signs in Mwanihana forest within UMNP and target FRs (see methods and Table 4 for details)

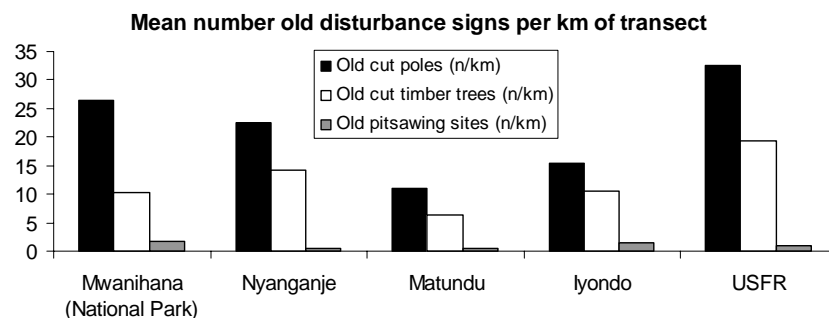


Fig. 8. Number of old signs of human disturbance in Mwanihana forest within UMNP and target FRs (see methods and Table 4 for details)

Available data clearly indicate that human population density in the Kilombero Valley is far greater in the northern part near UMNP than in the central and southern parts. Hoyle (1997) reported 58,621 people living in 14 villages (Kidatu to Kiberege) along a linear distance of about 40 km strip on the eastern side of UMNP. This was in 1997-1998. Assuming a population growth rate of at least 3% annually, the total for this area must now exceed 76,200 people. This figure includes Kiberege which is partly bordering Nyanganje FR. Harrison (2006) gives a figure from the 2002 census of 60,182 people in 14 villages from Signali (east of Nyanganje FR) to Udagaji (adjacent to south-eastern USFR). These villages border the eastern side of the area considered in our study. Assuming an annual growth rate of at least 3%, the population in these 14 villages was approximately 67,735 in 2006. These villages (Signali to Udagaji) extend along a linear distance of about 140 km. Even though these are rough figures and for the southern FRs they might be an underestimate, they indicate that the population along the eastern side of UMNP is at least 4 times greater than along the southern FRs. Furthermore, current rates of immigration are now surely greater near the southern FRs than along the already saturated areas along the eastern side of UMNP.

This all reinforces the conclusion that, in spite of greater human population densities and potential threats from people, protection of UMNP by TANAPA has been far more effective than protection of the southern FRs by FBD.

Numerous, qualitative evidence of greater disturbance in the southern FRs has been collected both in the course of our study and by other researchers. This is summarized here. The most evident signs of disturbance were the following:

- **Bush fires** in the forest initiated by hunters or by farmers clearing land near the borders of FRs. This was recorded in Iyondo and USFR.
- Additional evidence of **hunting** was recently recorded in Iyondo and USFR. Shot-guns were heard several times in USFR especially at higher altitudes, during wildlife censuses conducted by F. Rovero (Rovero and Menegon 2005). A survey in Iyondo in October 2006 by our field team together with T. Jones recorded presence of hunters. Bushmeat markets were found in Ikule and Chita villages. Clear evidence of hunting in USFR was also reported by several others including Moyer and Mulungu (2004). Hunting is primarily for duikers, but primates, tree hyrax, giant pouched rats are also taken. Elephants are poached in all FRs where they occur. Hunting methods include the use of shotguns, dogs and a variety of snares and traps.
- **Farming** right near the border or inside the boundaries of FRs was found throughout the edge of USFR and Iyondo FRs. For example, in October 2003, T. Struhsaker and A. Marshall (pers. comm.) observed an extensive area of illegal agricultural encroachment just inside the border of USFR along a major path only 20 minutes walk from the forester's house in Chita. They also observed a fresh pitsawyer's site near this same area.

Zilihona et al. (1997) found extensive evidence of illegal activities during a survey of the western and southern areas of USFR. Tree felling and poaching were the most common violations. These activities had negative impacts on tree population densities in USFR. Ndangalasi et al. (2007) found that the illegal cutting of trees for building poles and traditional medicine in USFR resulted in tree densities that were 2.4 to 4.5 times lower than in undisturbed sites. No less than 57 tree species were adversely affected by these violations.



Fig. 9. Photographs of disturbance caused by humans in the target FRs. Top-left: pitsawyer hut in Nyanganje FR; top-right: Harvey's duiker caught in a snare ca. 200 m inside the eastern boundary of Iyondo FR near Njage village; bottom-left: fresh fire in Iyondo FR near Njage village; bottom-right: active pitsawing of *Newtonia* sp. in USFR above Ikule village.

3.3. Results of transects for wildlife signs

A second set of transects was sampled to obtain data on signs of wildlife. These signs included dung and tracks. In particular, we counted dung piles for forest antelopes and dung clusters for elephants. A total of approximately 50 km of transects was sampled in 4 areas: Nyanganje, Matundu, Iyondo FRs and the corridor area between USFR and Iyondo FR. The number of transects in these 4 areas ranged from 9 to 27, with a mean transect length of 0.67 km. Relevant data for USFR and UMNP were already available from previous census studies.

Dung counts are notoriously difficult to interpret in terms of population density and even relative abundance. They do, however, provide an indication of abundance that can be obtained in a

relatively rapid manner. These data are particularly useful in showing that elephants and buffalo are present in Nyanganje and Matundu. This is critical information in terms of developing plans for a wildlife corridor between the Udzungwa and Selous ecosystems. Forest antelope and bush pigs are the species most affected by snaring. Dung counts of forest antelope were relatively low in 3 areas, but higher in the Iyondo sample. Bush pig dung was most abundant in the corridor area and least common in Nyanganje.

What these results show is that, in spite of heavy poaching, these 4 sites still have wildlife populations of conservation value.

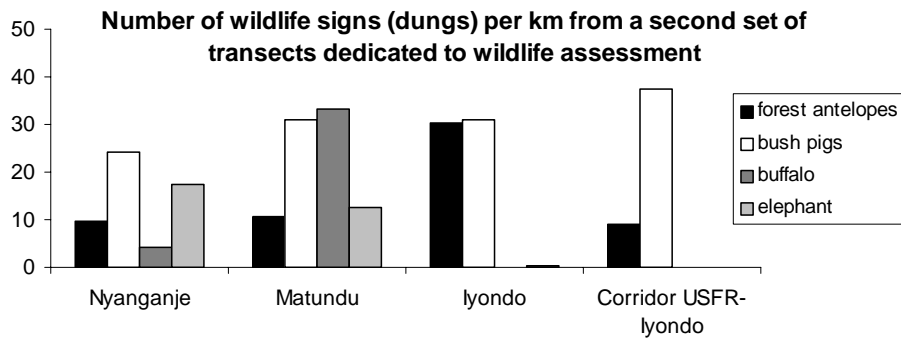


Fig. 10. Results of transects conducted to assess wildlife presence and relative abundance

3.4. Proposed “Mngeta corridor”

Fragmented conservation areas are less effective than those which are united in a single block. With the exception of USFR, all of the other FRs considered here are contiguous with one another and are directly or indirectly linked with UMNP. In terms of wildlife movements and gene flow, the establishment of a wildlife corridor between USFR and Iyondo is seen as being vitally important to the conservation of USFR.

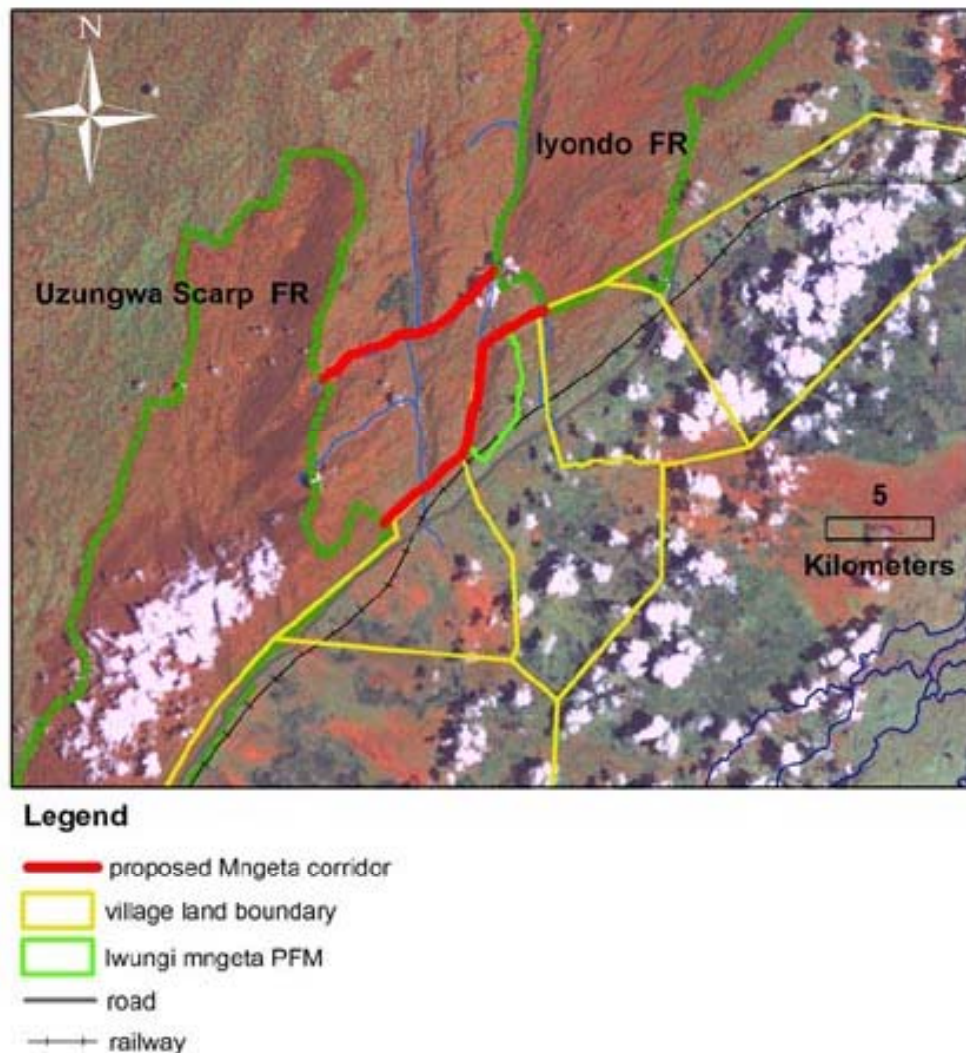


Fig. 11. Satellite map of the proposed corridor linking Iyondo FR to USFR. The dark green shade is the boundary of Iyondo FR and USFR, while the small, light green oval is the Mngeta PFM. Village land boundaries are also indicated (yellow).

In line with this reasoning, the strip of land between Iyondo FR and USFR was carefully analyzed in terms of its potential to serve as a protected-area corridor joining the two FRs. The criteria used to evaluate the feasibility of establishing a corridor were: presence of land with low human presence, especially a minimum of permanent settlements; extent and quality of vegetation cover; land morphology and features that could define boundaries, such as rivers; and legal status of the land, with preference to public (Government) land rather than village or privately-owned land. When all these factors were considered, the best possible compromise was the proposed corridor shown in Fig. 11. This proposed “Mngeta corridor” has the following dimensions: minimum length

between protected areas of 9.2 km, maximum length of 15.2 km, minimum width of 2.1 km and maximum width of 6.8 km. The area is estimated to be approximately 63 km².

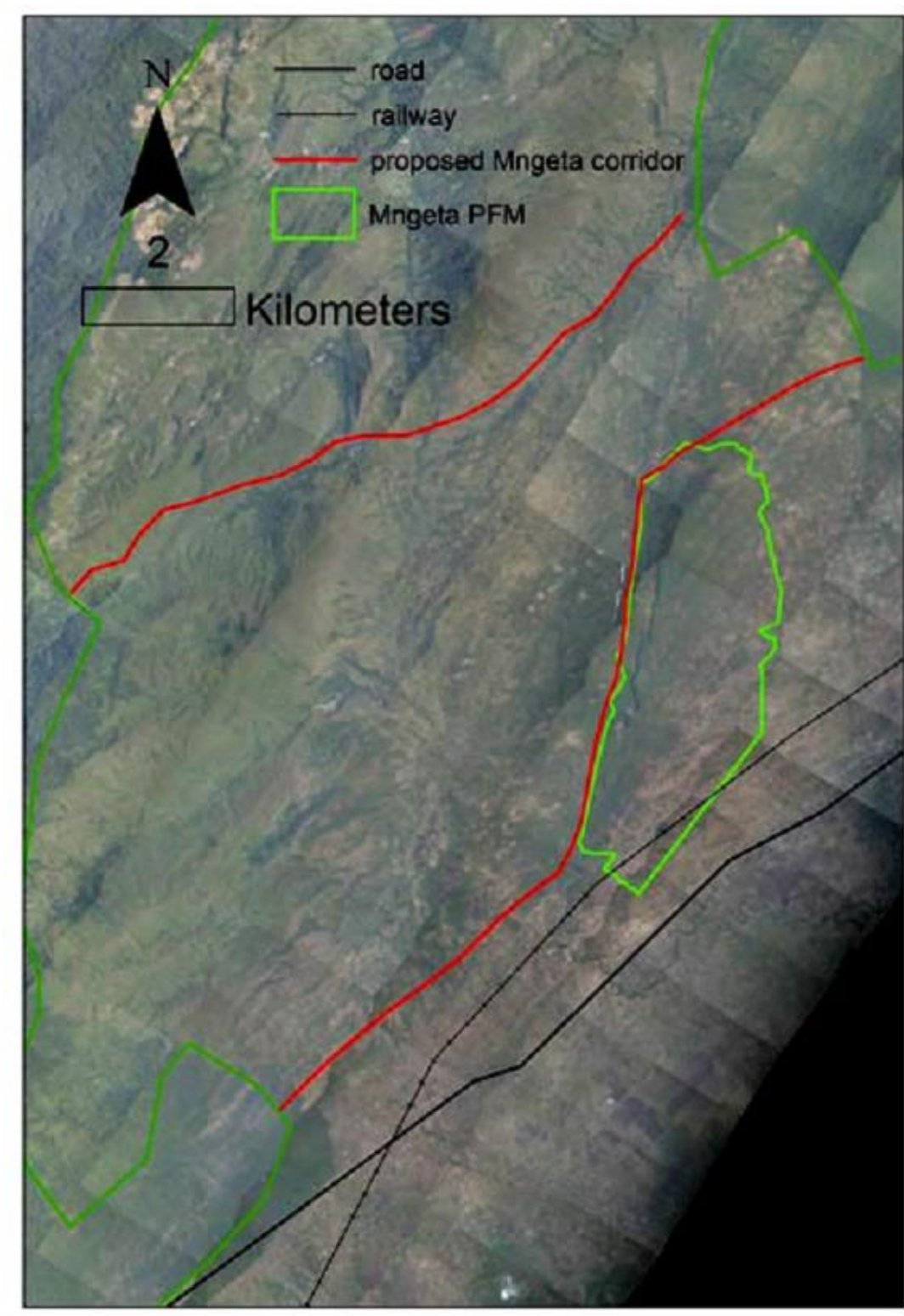


Fig 12. Digital aerial photocomposition of the proposed Mngeta corridor

The proposed corridor falls within public (Government) land and not within village land; land belonging to Mkangawalo, Mngeta and Mchombe villages (according to maps from the Kilombero District, ground surveys and village interviews) marks the south-eastern (lower) boundary of the corridor. The middle portion of this lower corridor boundary follows the Mngeta river and the Mngeta village area allocated to Participatory Forest Management (PFM) (Fig. 12). The PFM area effectively expands the potential area for wildlife movements.

In terms of human activities, the proposed corridor lies outside village land in an area of relatively low human density between the heavily populated Kilombero valley and Iringa highlands to the north of USFR. The proposed corridor has no permanent settlements, but only scattered farms and seasonally-used houses. Higher densities of farms are along the Mchombe and Mngeta rivers near the south-western corner of Iyondo FR, along the Mngeta river (west of the Mngeta PFM), and again near the southern boundary of the corridor above Mkangawalo village towards USFR. It should be noted that this area is very steep (see photographs in Fig. 13) and, therefore, farming occurs mainly in flatter areas along rivers.



Fig. 13. Photographs of the proposed Mngeta corridor: top left, view towards USFR from the Iyondo FR side of the corridor, with fresh slash and burn in front view; top right, aerial photo of the slopes in the central part of the corridor; bottom left, the Mngeta river marking the north-eastern corner of the corridor; bottom right, the south-western corner of Iyondo FR, with regenerating and secondary forest.

Our feasibility study was not able to derive an estimate of the human population size in the proposed corridor. This will require more prolonged and detailed ground surveys should this proposal be considered for implementation. However, most of the people using the area are seasonal

farmers who mainly come from nearby villages in the Kilombero valley (Mchombe, a sub-village of Mngeta, Mngeta and Mkangawalo). It is unlikely that more than 100 households rely on this area for farming. Moreover, at the time of our surveys (October 2006), measures from Mngeta Village Government were in place to re-locate people living inside the PFM and the corridor area.

As much as 80% of the corridor appears to be covered by natural vegetation (grass, shrubs, woodlands or forest), including some 25% of remaining natural forest and woodland. Some of these areas are very steep and covered with mixed grassland, shrubs and low-canopy forest. Thus, only about 20% appears occupied by recent farms.

3.5. Interviews

Interviews were conducted in 7 villages as follows: Signali (n=31 respondents) and Sagamaganga (n=21) bordering Nyanganje FR; Mkangawalo (n=26) bordering the northern USFR and southern Mngeta corridor; Kisege and Namawala bordering Matundu FR (n=50); Mngeta and Njage bordering Iyondo FR and northern corridor (n=125). A total of 253 individuals were interviewed, of which 56% were males and 44% were females. Results are summarized in the Table 5: 13 to 51% of respondents claimed to have experienced a conflict with wildlife, most typically represented by crop-raiding animals (elephants, baboons, bush pigs).

The percentage is highest in Matundu FR (51%) and remarkably low (13%) in USFR. This might be explained by the abundance of elephants in Matundu FR versus other FRs. Twenty-one to 50% of the respondents claimed they collect firewood inside the FRs, with lower percentages in Matundu and Iyondo FRs (21-28) compared to Nyanganje FR and USFR (37-50%). This might be explained by the fact that the villages are much closer to the Nyanganje and USFR (with the eastern side bordering the road along these villages), while only a smaller portion of Matundu and Iyondo FRs borders the road and densely populated villages. The percentage reported by Harrison (2006) from the more detailed socio-economic assessment conducted in parallel to this study is 14.4% of respondents going into the FRs for firewood. This relatively low value, however, is judged by Harrison (2006) to be likely an underestimate due to the unwillingness of many community members to declare what is known to be an illegal activity. Interestingly, the proportion of people that claim to be aware of the presence of a protected area seems to decrease from Nyanganje FR (75%) to Iyondo FR and USFR (49-54%), indicating the need for increased efforts in education and awareness campaigns.

Table 5. Summary of answers (values are % of respondents) to questions asked to stakeholders in villages adjacent to FRs (n= 253 interviewees, see text for sample size for each village)

Question	Nyanganje	Matundu	Iyondo	USFR
Presence of a conflict with wildlife	33	51	38	13
Collection of firewood in the Forest Reserve	50	21	28	37
Awareness of presence of a protected area	75	65	49	54
Wildlife species moving through farms:				
Elephants	72	84	27*	0
Forest antelopes	23	9	23	36
Buffalo	42	51	18*	12*

Baboon	35	23	18	31
Bush pig	42	32	21	39

* The declared presence of elephants and buffalos in villages near Iyondo and USFR is probably due to elephants and buffalo from the Kilombero valley since these species are not present in areas of these FRs which are near villages.

4. Conclusions and recommendations

Our study, combined with available information from previous research, demonstrates the following points:

- 1) The targeted Udzungwa Forest Reserves have great importance as reservoirs of biodiversity, including many endemic species. These forests are a great natural and national resource that is globally recognized for their potential conservation value.
- 2) The Udzungwa FRs have great economic importance to Tanzania from the local to the national level because of their water catchment services that provide water for hydroelectricity, agriculture, domestic consumption, fisheries, eco-tourism, livestock, etc.
- 3) The Udzungwa FRs, particularly those in the south of the mountain range, are very poorly protected and suffer high levels of violations in the form of illegal pitsawing, cutting of poles, collection of firewood, production of charcoal, agricultural encroachment, and poaching. The laws protecting these catchment forest reserves against all forms of human exploitation are not being enforced by FBD. This is due to a combination of inadequate legal mandates and insufficient funds, equipment, and personnel (e.g. Burgess and Kilahama 2005, Madoffe et al. 2005).
- 4) Data on human violations and the status of wildlife clearly demonstrate that UMNP is much better protected than any of the southern Udzungwa FRs in spite of being adjacent to much higher human population densities and the accompanying potential for violations.
- 5) A wildlife corridor linking USFR and Iyondo FR has been identified, surveyed, and deemed feasible.

The question of how to improve the protection status of the southern FRs, together with the protection of the West Kilombero FR on the northwestern side of the Udzungwa Mountains, has been already widely discussed by relevant stakeholders and some initiatives have already been taken. In particular, FBD has designed a proposal to upgrade the current West Kilombero FR to Nature Reserve status (presented at march 2007 workshop, see below). The proposed Kilombero Nature Reserve totalling 1,396 km² would include not only West Kilombero FR (1,040 km²) but also Matundu FR (280 km²) and Iyondo FR (76 km²). No plans, however, have been made to increase protection of USFR. This is a serious oversight because, on the basis of the information presented in this report, as well as previous research, USFR is the single most important forest in the Udzungwa Mountains and the entire Eastern Arc Mountain range for biodiversity. Even more important, USFR is being seriously violated and is in urgent need of protection.

Given this background information, the following 3 options for improving the conservation status of the southern Udzungwa FRs are proposed for consideration:

1. Creation of Kilombero Nature Reserve as currently proposed by FBD, including Matundu and Iyondo FRs, with consequent isolation of USFR and no improvement in its conservation status.
2. Expand the proposed Kilombero Nature Reserve, as described above, to include USFR and the “Mngeta corridor”.
3. Limit the proposed Kilombero Nature Reserve to the current area of the West Kilombero Forest Reserve, and annex the following areas to UMNP: Nyanganje, Matundu, Iyondo, Mngeta corridor and USFR.

Option 1: Kilombero Nature Reserve

This management option has already been proposed by FBD. Nature Reserve is the highest category of protected areas under Tanzanian forestry legislation, and it is comparable to National Park status. It is defined as an “area designated to maintain natural processes and habitats in an undisturbed site for scientific study, environmental monitoring and education”. It is thought to bear the following advantages (GoT 2005, www.easternarc.or.tz):

- The area receives high conservation attention;
- A basis to argue for conservation funding;
- To have better management mechanism with better legal backing;
- Better for developing alternative uses (Ecotourism);
- Possible to develop cost/benefit sharing mechanism.

Since the only existing Nature Reserve in Tanzania is Amani forest in the East Usambara, it is difficult to evaluate before hand how the upgrading of Catchment Forest Reserve to Nature Reserve will actually translate in terms of greater protection. It is fair to assume that the process will require consistent funding, re-structuring (in view of the self-accountability and autonomy of Nature Reserve in comparison to central Government FR) and many years. With these caveats in mind, while this option would upgrade the formal protected status of the target FRs, it does not address the protection of USFR, nor the important issue of connectivity between USFR and Iyondo FR. Should this option be implemented, it will likely take many years before USFR is considered again for improved protection. This would be a major loss for Tanzania and all those concerned with conservation because of the great biodiversity value and precarious state of USFR. Unless effective action is taken soon, USFR will continue to suffer degradation with irreplaceable losses.

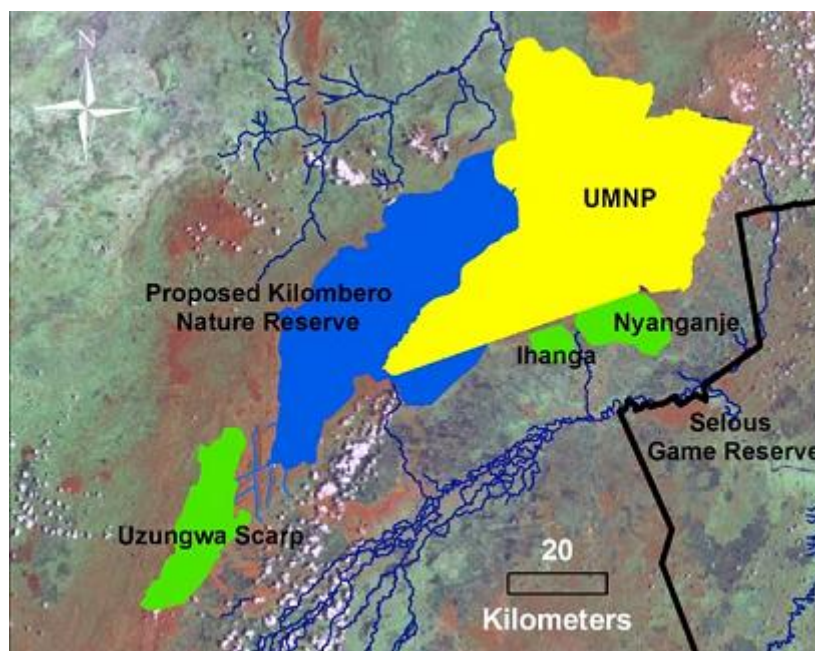


Fig. 14. Possible management option 1: creation of Kilombero Nature Reserve as currently proposed by FBD, including Matundu and Iyondo FRs, with consequent isolation of USFR and no improvement of its conservation status in the foreseeable future

From a biological perspective, it is extremely important that these major forest blocks be united into one protected area. This union will allow movement of forest-dependent species between the forests that are presently separated from one another by grassland and woodland. Movement of individuals between forest blocks will increase the effective population size of these threatened endemic species. Under the present situation in which the forests are separated from one another, those species that cannot cross ecological barriers (i.e. non-forested areas) are much more prone to extinction than if they lived in larger forests and populations. Joining the various FRs into a single unit will also enhance the conservation of species that move over large areas, e.g. elephants and leopard. From a managerial perspective, it will be much easier to effectively conserve one united area rather than several isolated forest patches that are interspersed with human settlements. Thus, from both scientific and practical issues option number one suffers from serious problems and cannot, therefore, be considered the best possible option.

Option 2: Expanding the proposed Kilombero Nature Reserve to include USFR

This option is proposed in order to address the issue of greater protection for USFR and the “Mngeta” Corridor. It is simply an expansion of option 1 whereby FBD creates a larger Nature Reserve.

The significant drawbacks of this option are related to the large size of the area compared to the current administrative and enforcement capacity of FBD. Were option 2 implemented there would need to be a very substantial restructuring of and budgetary increase for FBD to make this fully operational and effective (see comments above under Option 1). It is possible that these necessary changes will take too many years before they can be realized and before effective protection to the area is ensured, especially in view of the current rate of degradation of USFR and other FRs that was here reported. In addition, this option does not mention protection of Nyanganje FR that we have shown it is an important buffer to UMNP as well crucial for connectivity with the Selous.

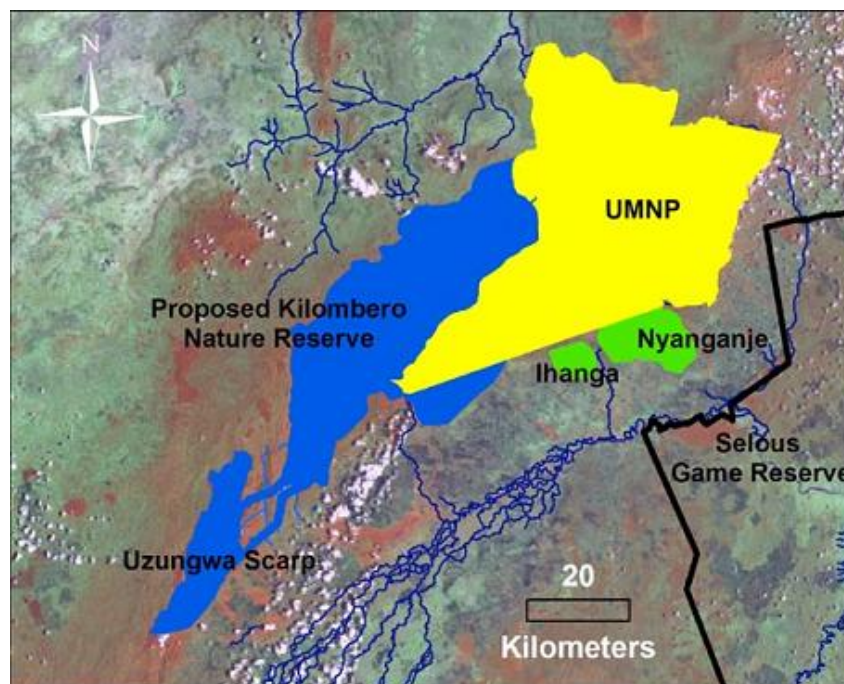


Fig. 15. Management option 2: expand the proposed Kilombero Nature Reserve, as described above, to include USFR and the “Mngeta corridor”.

Option 3: Limit Kilombero Nature Reserve to the current West Kilombero FR and expand UMNP to include the four forests targeted by this study as well as the “Mngeta corridor”.

The option of expanding UMNP (originally proposed by TANAPA to include West Kilombero FR) has already been widely discussed by the relevant stakeholders. USFR has been already proposed twice for National Park status, in the 1980s when UMNP was first proposed and again in the 1990s following the World Bank Environmental Impact Assessment of Kihansi. The strongest arguments in favor of this option are that TANAPA has an excellent record of protecting habitat and wildlife. They have a better record in this regard than does any other agency in Tanzania. Furthermore, they have the infrastructure, experience, capability, and legal powers allowing them to effectively protect habitat and wildlife and to enforce the national laws regarding natural resources. The increased budgetary costs associated with expanding the boundaries and responsibilities of UMNP would not be insignificant, but they would certainly be less than if this responsibility is placed within another agency.

TANAPA’s current infrastructure at UMNP is already well-placed to afford some protection to the southern FRs. There are two ranger posts and a third under construction near the SW. and SE. borders of UMNP. These posts currently allow patrols of Nyanganje, Matundu, and parts of Iyondo FRs. As our results indicate, these patrols have already resulted in better protection of Nyanganje and Matundu compared to Iyondo and USFR. Additional and consistent funding will, of course, be needed to implement option 3, but the sums will not be nearly as great as they would be for options 1 and 2 because of TANAPA’s existing infrastructure at UMNP.

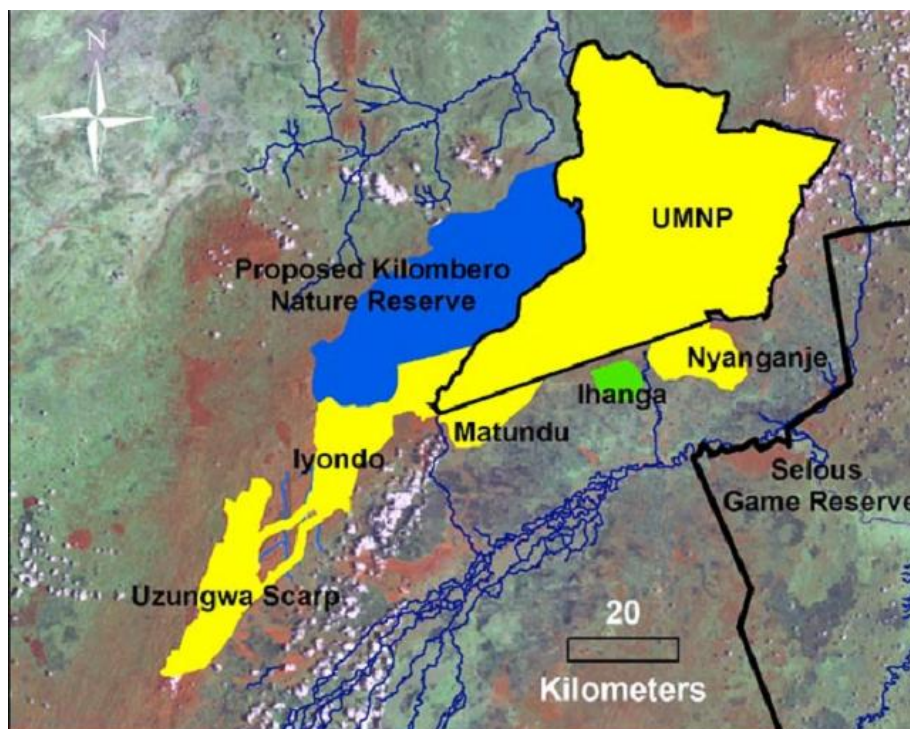


Fig. 16. Management option 3: limit the proposed Kilombero Nature Reserve to the current area of the West Kilombero Forest Reserve, and annex to UMNP Nyanganje, Matundu, Iyondo, Mngeta corridor and USFR.

There have been concerns that TANAPA will require full support from the communities in order to be “accepted” and therefore to be able to protect the forests adequately (Harrison 2006). These concerns by community members probably originate from the fact that TANAPA strictly enforces the laws protecting the forests. The same presumed conflict, however, will be present in any of the management options considered, since it is assumed that the upgrading to Nature Reserve will also involve greater protection and therefore law enforcement. The conflict might have originated from the misconception held by some villagers that they are currently allowed to use the resources from Catchment Forest Reserves, which is not the case.

Whatever option is implemented, there remains a great need for community education and generating awareness of the importance of biodiversity conservation. Greater attention must also be given to encouraging the development of alternative sources of firewood, poles and timber, such as through the implementation of community-based forest management schemes on village land or in Government land outside protected areas (Harrison 2006). The cases of proposed PFM areas managed by Mngeta and Mkangawalo villages in the corridor area between USFR and Iyondo are important steps in this regard. Community education and community-based conservation projects have been initiated in many villages, in conjunction with the district authorities and with support from WWF, MTSN and other agencies.

Possible Funding Sources and Mechanisms

Regardless of the option, the costs of effectively protecting the FRs considered in this study will be significant and might best be met by a trust fund. A trust fund would provide the necessary financial security needed to conserve this unique resource in perpetuity. Such a fund should include not only the direct costs of the protected areas, but those associated with community education and the expansion of agroforestry projects outside the protected forests. Agroforestry in the areas surrounding the park is seen as a necessary strategy to reduce the potential threats on the forests.

Possible donors include all those agencies associated with the construction of the Kihansi Hydroelectric Project because of the negative environmental impacts of this project. Their contribution to a trust fund for these forests would, in part, compensate for the damage to biodiversity caused by the Kihansi project. Equally important, it would contribute to the long-term security of the Kihansi Hydroelectric project (by protecting its major catchment area), the Kidatu Hydroelectric Plant, and to the agricultural productivity and general well being of those living in the Kilombero Valley. Protection of these forests should be of great appeal to international donors because it is a relatively cost effective way of contributing to Tanzania’s long-term economic welfare, while at the same time conserving one of the world’s biodiversity hotspots. Potential donors include: World Bank, GEF, GCF, NORAD, SIDA, DANIDA, and USAID. The size of the fund should be determined after study, but it would likely have to exceed U.S. \$ 5million.

4.1. The way forward: Udzungwa stakeholders’ workshop of march 23rd, 2007

Study results and recommendations were presented at a workshop funded by CEPF through MTSN, and organized by WWF-TPO, that was held on the 23rd of march 2007 in Morogoro, Tanzania. The workshop represented a platform for discussion to reach a consensus on the best conservation management strategies for the target FRs. Over 60 participants attended, representatives of all stakeholders from community’s members to Government agencies (FBD, Tanapa, etc.) to NGOs, private sector and researchers. The key recommendations relevant to this study are reported here, while for more details reference is made to the full workshop report (WWF-TPO 2007).



Fig. 17. Participants to the Udzungwa stakeholders' workshop, held on 23rd march 2007 as final forum to present, discuss and recommend upon results of this and other studies conducted

Recommendations on management options for corridors and Forest Reserves:

- FBD is well ahead on its plan to propose the Kilombero Nature Reserve, a new protected area that will include West Kilombero, Nyanganje and Iyondo FRs; therefore, the option of annexing target FRs to UMNP cannot be longer considered. However, even though the upgrading of Forest Reserves to the status of a Nature Reserve was currently seen as the best option, criticisms were raised that this would require a huge management restructure and funding before effective protection was ensured.
- USFR was not included in the proposed Nature Reserve, and this was admitted as a serious oversight that needs to be re-considered. Workshop participants, through group discussion, recommended the status of USFR be upgraded (which can only be through Nature Reserve or through National Park). It remains task of the Government to decide upon the protection of USFR.
- The proposed “Mngeta corridor” was considered feasible and necessary, and immediate management interventions by the Government was recommended.
- Incorporation of buffer zones in the village land adjacent to FRs is necessary to smooth the farm-to-reserve borders that have resulted in encroachment and even human-wildlife conflicts.

Recommendations on management of village lands and corridors:

- Land use planning processes should be participatory and coordinated by village leaders, District Councils, interested partners and NGOs.
- Land adjudication and zonation within villages should include setting aside Village Forest Reserves; forest management should address tree planting and land/water resources

management as per the Government Directives (i.e. 20 trees/year planted by every household) and woodlots established to sustain wood requirement at household level.

- Planting of invasive plant species that have negative impact on the environment should be discouraged and communities should be advised on reforestation and agro-forestry systems including availing a list of suitable tree species.

Recommendation on local communities' participation:

- FBD should prepare guidelines for community participation in managing Nature Reserves and communities should be trained on how to apply such guidelines.
- District councils should facilitate and support villages in preparing and implementation of respective by-laws for implementing village land use plans and resource management in the Nature Reserve and wildlife corridors.
- Management Plans for Nature Reserves should provide access for communities through clearly demarcated utilization zones (for firewood, thatching grasses, and worshipping etc.). But see in the final remarks in last chapter that the legal mandate of Nature Reserve excludes all forms of extraction by humans.
- Community's benefits from revenue sharing should be clearly defined and MOUs between the parties prepared and agreed.
- Environmental education, agro-forestry and sustainable farming techniques, alternative sources of livelihoods, energy saving stoves as well as adoption of acceptable indigenous knowledge should be promoted by the different stakeholders.

4.2. Final remarks

The participatory consultations that lead to the above recommendations, some of which resulted directly from this study, are important achievements and it is now hoped that the relevant Government agencies will develop and implement appropriate action plans in a timely manner.

It is also hoped that NGOs active in the area, such as WWF-TPO, TFCG, MTSN, etc. will join hands and collaborate with the Government to implement the most important recommendations on the side of community' natural resource management on village land. As Nature Reserves are gazetted, non-consumptive status and thus full protection should be allocated to these forests, and therefore the access of communities for firewood, thatching grasses, etc. should not be permitted. The very negative effects of these practices on the biodiversity have been clearly shown from a study in Mwanihana forest (Nyundo et al. 2006). Deadwood collection is also coupled with snaring of duikers and other animals (F. Rovero and UMNP, unpubl. data). TANAPA has now reduced and will soon end deadwood collection in UMNP. This lesson should be taken into account and mistakes not repeated elsewhere.

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