Biodiversity Values, Threats and Conservation Strategies of the Selous - Niassa Wildlife Corridor, Tanzania

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ABSTRACT

The Selous-Niassa miombo woodlands of southern Tanzania and northern Mozambique are one of the largest and for the global biodiversity most significant, trans-boundary natural ecosystem in Africa, covering over 154,000 km^2. The Selous-Niassa Wildlife Corridor serves as migratory route between the Selous and the Niassa Game Reserves hosting the world's largest elephant, buffalo and sable populations. The Corridor will be protected with a network of WMAs (Wildlife Management Area) under the management of Authorised Associations excluding any agricultural activity. This aims to empower local communities in the natural resource management in view of improving their livelihoods and maintaining the integrity of the wildlife corridor and its biodiversity.
In 2006 the main ecosystems have been assessed and the plant biodiversity and conservation values of the different vegetation types described. In total, 371 species have been recorded including three threatened species from the IUCN Red List, six from the CITES list and three species which are endemic for Tanzania. One of the taxa, *Xylopia* sp. nov. (*Annonaceae*) found in the riverine forest along the Ruvuma River is new to science. The results of this habitat study are essential for the identification and participatory land-use planning and resource-use zoning process with local communities of new WMAs in the southern part of the Corridor. It will also enhance the natural resources management of WMAs under establishment. Current threats are a) harvesting of highly searched timber species, b) hot late dry season fires leading to a regress of the species-rich dry evergreen forest and to a more open and uniform structure of miombo woodlands and savannas, thereby reducing the species number, c) prospecting and mining activities, d) poaching (although declining since one year), and e) uncontrolled and unplanned conversion of forests areas into farmland.

INTRODUCTION

The Selous-Niassa miombo woodlands of southern Tanzania and northern Mozambique are a vast trans-boundary ecosystem with low human disturbances covering over 154,000 km^2. Miombo woodlands perform vital ecosystem services such as nutrient cycling and watershed protection and are of great importance for the livelihood of rural communities mainly for subsistence farming and animal husbandry (Rodgers 1996; Luoga 2000). The local population relies on these ecosystems for an array of diverse biological products either for subsistence use within households, e.g., building materials, firewood, fruits, medicinal plants and mushrooms or for commercialisation, e.g., charcoal, timber and honey (Luoga 2000).
Through a network of various protected areas about 111,000 km^2 of this ecosystem are conserved including the Selous GR in Tanzania, which covers about 47,000 km^2 making it the largest protected area in eastern and central Africa, and the Niassa GR in Mozambique (Timberlake et al. 2004) covering about 42,000 km^2 (see Fig. 1). The Selous-Niassa Wildlife Corridor provides a significant biological link and migratory route between the two game reserves hosting the world's largest elephant (*Loxodonta africana*), buffalo (*Syncerus caffer*) and sable populations (*Hippotragus niger roosevelti*). In addition, the Corridor supports a large number of globally threatened animals cited in the IUCN Red List and CITES (mammals like e.g. wild dogs (*Lycaon pictus*)). However, uncontrolled and unplanned conversion of land for agricultural purposes, ribbon development along the major roads, unsustainable and often illegal use of natural resources including the high value poaching of

ivory across the national boundaries and uncontrolled fires are severe threats to its continued existence.

Presently the Global Environment Facility (GEF) finances the project with its implementing agency United Nations Development Program (UNDP). The project entitled "The development and management of the Selous-Niassa Wildlife Corridor" is executed by the Gesellschaft für Technische Zusammenarbeit-International Services (GTZ-IS) under the Wildlife Division of the Ministry of Natural Resources and Tourism. The overall objective is the long-term integral conservation of the miombo woodland ecosystems within the Corridor.

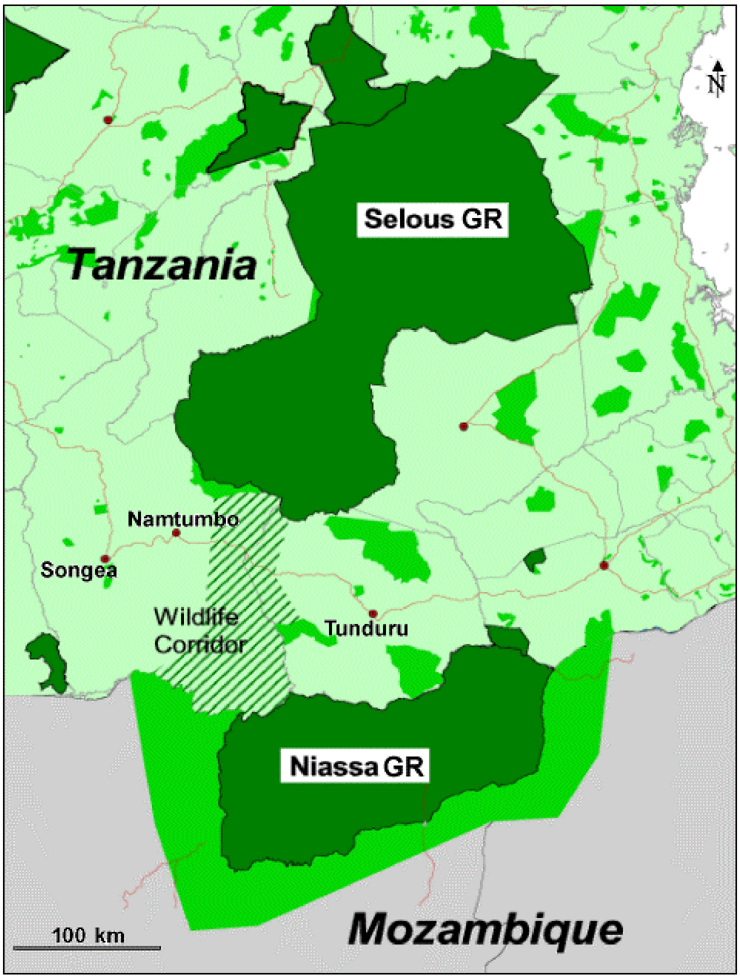

Fig. 1. Map of the Selous – Niassa Wildlife Corridor connecting the miombo woodland ecosystems

The Selous-Niassa Wildlife Corridor will be protected with a network of WMAs under the management of five Authorised Associations formed by 29 villages. During a participatory land-use planning process with the local communities, the future natural resources use will be defined along with a zoning plan of these areas. WMAs are multi-natural resources use areas excluding any agricultural activity. Economically most important activities in the Corridor will be related to wildlife i.e., substantial extra income from hunting companies, non-consumptive tourism and/or own consumption. Other activities may include the domestic use and/or commercialisation of wood products like fuelwood, poles or timber or non-wood forest products like honey, fruits, ropes, medicinal plants or mushrooms and the development of the fresh water fisheries management in Ruvuma River and various streams and natural ponds by community-based projects.

With this study the main ecosystems within the SNWC and the biodiversity and conservation values of the different vegetation types and their threats have been assessed. Research focussed on potential plant biodiversity hotspots such as vegetation formations along watercourses, in swampy areas, on rock outcrops or other arid areas. The results of this habitat study will contribute to the management of the Mbarangandu (Namtumbo District) and Nalika (Tunduru District) WMAs under establishment and will be considered during the identification and land-use planning of three new WMAs in the southern part of the Corridor.

MATERIALS AND METHODS

Study area

The proposed Selous-Niassa Wildlife Corridor (*Ushoroba*) in Ruvuma Region of Southern Tanzania has an area of about 10,000 km^2 (see Fig. 1) extending approximately from 10° S to 11°40’ S. The larger part of the Corridor is located in Namtumbo District while a smaller part in the east incorporates Tunduru District. The Corridor borders the Selous GR (North East Undendeule FR) in the north and the Niassa GR in Mozambique along the Ruvuma River in the south. Biogeographical baseline data are very scarce for this very remote area.

The northern part is generally hilly while the area towards the Ruvuma River is slightly undulated to flat with isolated hills, some of them having prominent rock outcrops (inselbergs). Mtungwe Mountain (1284m a.s.l.) in the centre of the Corridor is the highest elevation. The plateau slightly slopes to the Ruvuma River which reaches its lowest level of about 460m a.s.l. in the south-eastern corner of the Corridor. The soils are generally very sandy and washed-out. Two drainage basins exist in the SNWC. North of the watershed, located roughly along the main Road Namtumbo-Tunduru, the rivers drain into the Rufiji River while the area south of the watershed is part of the Ruvuma drainage basin. Some of the major tributaries like Mbarangandu, Lukimwa, Luchulukuru, Luego or Msanjesi are usually permanent watercourses.

The mean annual rainfall at Soluti Agricultural Sub-research Station (about 8 km from Namtumbo town) is about 1220 mm (1993-2005). It is expected that the northern part of the Corridor receives about 1200 mm rainfall per year. The rainfall generally decreases towards the south and the mean annual rainfall might be about 800 mm along the Ruvuma River. The aridity of the sites towards the Ruvuma River is further enhanced by higher evapotranspiration due to lower altitude and more sandy soils.

The Corridor has the typical unimodal rainfall system of the miombo woodland ecosystem (Bloesch 2002). The southeast monsoons, bearing moisture from the Indian Ocean, are responsible for the rainy season chiefly occurring from mid-November to mid-May, however inter-annual variations are important. Northeast winds prevail in the dry season and there is usually no measurable rain for at last five months but fog may sporadically occur at higher elevations. The variability of mean annual rainfall is quite high with 24.1% using the coefficient of variation defined as standard deviation expressed as % of the mean (Norton-Griffiths et al. 1975). The coefficient of variation is an indicator for the predictability of rainfall and therefore an important factor for crop production. The mean annual temperature is about 21°C and the climate type following the Köppen system is Aw (Köppen 1931).

Freely drained soils are prevalent at different topographic positions in the Corridor, mainly covered with miombo woodlands and partially by savannas. Dry evergreen riverine forests of limited extent occur along perennial or intermittent watercourses. Vast areas are annually burnt and late dry season fires are severe due to the prolonged dry drought.

Namtumbo District is sparsely populated having only 11 people per km^2 according to the population census 2002. The economy depends on agricultural crop production. Maize, beans and paddy are mainly cultivated for subsistence while in some areas cashew-nuts, sesame and tobacco are grown as cash crops. In contrast to other miombo woodlands, livestock keeping is poorly developed and the Corridor area is not used for cattle ranching.

Methods

The vegetation was surveyed using both quantitative and qualitative criteria. Quantitative data for all types were obtained from standard-sized sampling plots following the method of Braun-Blanquet (1932). In total, 15 vegetation plots have been surveyed in the following vegetation types:

Miombo woodland on plateaus:	3
Miombo woodland on rocky ridges (summits):	3
Miombo woodland on slopes:	3
Savanna woodland:	2
Groundwater forest:	2
Gully forest:	2

At each plot, the tree and shrub layer was studied in an area of 25x25m where possible (some vegetation communities were of smaller size) and the herb layer was studied using a subplot of 5x5m in the centre of the plot, following consideration of the appropriate minimal area for these vegetation types as defined by Bloesch (2002). Cover value and height of each layer and other habitat notes including the coordinates of the site were taken for each plot. The cover-abundance value of all species was recorded, separately for each layer of the reference area using the following scale:

5:	Any number, with cover more than ¾ of the reference area (> 75 %)
4:	Any number, with cover ½ - ¾ cover (50-75 %)
3:	Any number, with cover ¼ - ½ cover (25-50 %)
2:	Any number, with cover 1/20 - ¼ cover (5-25 %)
1:	Numerous, but less than 1/20 cover, or scattered, with cover up to 1/20 (5 %)
+:	Few, with small cover

Qualitative assessment is based on opportunistic collection and observations of tree, shrub and ground floras throughout the fieldwork either along the road to the next destination or during investigation tours on foot. Opportunistic sampling allowed to supplement the data from the vegetation plots. We focused on a) vegetation communities of restricted distribution, either unique assemblages or highly localized in extent and b) taxa of restricted distribution which are either endemic to a small area or are highly disjunct. Vegetation communities of limited extent such as woody plants fringing in patches small drainage channels (Korongos), thickets on termitaria or vegetation patches on rock outcrops were surveyed opportunistically since their size did not allow a full sampling by a vegetation plot.

All flowering plants and ferns have been recorded and at least one specimen per species has been collected. When possible, flowers and fruits were taken to help identification of individuals (occasionally, also conspicuous mosses and lichens were collected). Trees were identified a) using slash and bark characters, b) observing canopy leaves with binoculars and/or c) taking coppices, low branches and fallen leaves. In addition, a catapult was used for breaking off small branches with leaves, where needed. Uncertain or not known taxa were identified at the herbaria of the University of Dar es Salaam and Royal Botanical Gardens in Kew. Flowering plants and ferns have been named following the nomenclature of the Flora of Tropical East Africa. A provisional plan list of all recorded flowering plants and ferns including scientific names, vernacular names (*ndendeule*) can be downloaded from the SNWC project's website (www.selous-niassa-corridor.com). The endemism of a species was determined by looking at their geographical distribution, and the extinction threat by examining their conservation status as defined by CITES (2006) and IUCN (2006). Duplicates of the plant specimen collected can be found at the University of Dar es Salaam's herbarium.

RESULTS AND DISCUSSION

Two major ecosystems occur in the Corridor: the miombo ecosystem covering the largest part of the Corridor and a drier savanna ecosystem bordering the Ruvuma River in the south. Within the two ecosystems different types of miombo and savanna, respectively occur. In addition, several vegetation types mainly of small size are scattered: riverine forest, gully forest (mainly in the miombo ecosystem), termitophyllous vegetation, vegetation on rock outcrops and grasslands (Mbuga).

Miombo woodlands

Vegetation structure and floristic composition of miombo is fairly homogeneous over large areas and only slightly influenced by the topographic position (see also Rodgers 1996). The canopy cover usually oscillates between 30-40%. Most of the miombo dominants are widely distributed and have wide ecological amplitudes. Vegetation structure and floristic composition of miombo woodland are very different from other vegetation types. In species composition the miombo is distinct from savannas at the generic level for trees and, therefore, in many aspects of its ecology (Rodgers 1996; Bloesch 2002).

Miombo is characterized by trees of the *Caesalpiniaceae* family, and nearly always dominated by species of *Brachystegia*, either alone or with *Julbernardia* species. These typical miombo species do not occur in other vegetation types like the adjacent savanna formations or riverine forests. In total we have identified 8 species of *Brachystegia,* namely: *B. boehmii*, *B. bussei*, *B. floribunda*, *B. longifolia*, *B. microphylla*, *B. spiciformis*, *B. stipulata* and *B. utilis*. Most *Brachystegia* are ubiquitous species, i.e. having a wide ecological amplitude but some species show clear site preferences. *B. floribunda* is more frequent in the higher rainfall area of the northern Corridor. *B. bussei* and *B. microphylla* are virtually confined to rocky hills whereby the latter only occurs on rocky summits or ridge tops. On the other hand, *B. spiciformis* prefers deeper plateau soils which are traditionally used by shifting cultivation. Because the dominants of miombo are extremely gregarious, few other species enter the canopy. The principal canopy associates are *Parinari curatellifolia*, *Pericopsis angolensis* and *Pterocarpus angolensis*.

The understorey tree and shrub layer is variable in density and species composition. Several species of small trees less than 8m do occur scattered in miombo. *Pseudolachnostylis maprouneifolia* is a ubiquitous species and is commonly found in escarpment and plateau miombo woodland. *Diplorhynchus condylocarpon* is often associated with thin, rocky soils such as *Dalbergia nitidula* and *Monotes katangensis*, but it is also a ubiquitous species found in most woodland types. Other ubiquitous species are *Terminalia sericea* and *Uapaca nitida*. *Uapaca kirkiana* and *U. sansibarica* are frequently dominant on shallow soils. Several species of *Strychnos* and *Flacourtia indica* occur scattered in miombo on deeper plateau soils, whereby the latter is also frequent in riverine forests. *Faurea* spp. and *Protea angolensis* are common in more open miombo types. In addition different species of *Combretum* are widespread in the Miombo wood land.

Lianas are generally sparse in miombo woodland. *Landolphia parvifolia* is a scandent shrub or liana often associated with rocky outcrops. The epiphytic lichen *Usnea barbata* and vascular epiphytes like the orchids *Angraecum stolzii*, *Bulbophyllum mahonii* or *Microcoelia exilis* are more frequent in the moister miombo type. Many *Brachystegia* species are host to the hemi-parasitic mistletoes of the family *Loranthaceae* like e.g., *Phragmanthera dschallensis*, *P. usuiensis* or *Agelanthus sansibarensis*.

As many tropical grasses, also most of the miombo grasses are typical pan-tropical. *Themeda triandra* is widespread and occurs at different *topographic* positions. On deeper plateau soils tall grasses of *Hyparthelia dissoluta* and *Andropogon gayanus* having a height of about 2m dominate. On hill slopes, *Hyparrhenia newtonii* and *Andropogon schirensis* having a height of 1.2-1.4 m, are very frequently present. On leached soils grasses are mostly 0.6-0.8m tall, *Aristida adscensionis* being mostly dominant.

White (1983) distinguishes two types of miombo woodland: wetter miombo, usually having more than 1,000 mm of rainfall per year and drier miombo, usually having less than 1,000 mm of rainfall per year, respectively. The very high sand content of the soil increases the dryness of the habitat all over the Corridor. Therefore, also the structure and floristic composition of the woodland in the northern part of the Corridor with slightly more than 1,000 mm of mean annual rainfall resemble White's drier miombo type. In the higher-rainfall areas of the north, some trees are evergreen but most are deciduous for a short time. Towards the south most trees are deciduous for at least some weeks. The old leaves are shed as the new leaves unfold some weeks or even months before the end of the dry season. Some trees like *Parinari curatellifolia* or *Boscia angustifolia* or several shrubs like *Protea angolensis* or *Memecylon flavovirens* are strictly evergreen all over the Corridor. On the other hand, *Pterocarpus angolensis* is strongly deciduous and is tightly synchronized with precipitation: flowering and leaf flush occur during August – December and leaves are shed in May and June. Leaf fall begins early in the dry season and is more complete and prolonged than most other species (Schwartz et al. 2002).

Most miombo tree species are quite resistant to fire at adult stage (*Brachystegia* species however are quite sensitive to fire, see Rodgers 1996) contrary to their seedlings and saplings which are vulnerable to intense fire since they are lacking the protection of a thick bark. Therefore, regular late burning has favoured miombo stands with a very open understorey. Frequent cultivation and excessive burning may transform miombo woodland into a savanna landscape with species tolerating drier conditions.

As a consequence of fire, browsing and agricultural activities around the villages the structure and floristic composition have been altered and probably simplified favouring generally savanna species. Miombo on deeper plateau soils has been subjected to agricultural practices although, due to low population density, the fallow period at a same site lasted certainly more than a decade. Once the cultivated land becomes again fallow, the cut miombo trees sprout vigorously, and the trees recover if left untouched for 10-15 years. These secondary miombo woodlands are often uniform in age and size as a result from sprouting trees after mutilation during the previous cycle of cultivation. On rock outcrops and on stony slopes, however, the miombo woodland has most probably not been modified by agricultural activities.

Two particular miombo woodland types were identified:

On shallow, mostly bare soils open stunted miombo with a canopy cover of 10-20% occur. This vegetation type is largely dominated by *Uapaca kirkiana* and *U. sansibarica*. Few other stunted trees such as *Brachystegia utilis* or shrubs such as *Ximenia caffra* or *Garcinia* livingstonei are associated. The soil of these sites are almost exclusively composed of quartzite sand without nearly any finer soil particles which are important for the cohesion of the soil. As a consequence these sites are highly eroded.

A particular woodland dominated by tall *Burkea africana* and *Erythrophleum africanum* occurs inland of a narrow fringing forest along Ruvuma at Namakungwa fishing camp on alluvial soil. The tree canopy cover is about 40%. The dominants reach tree heights of over 20m on this fertile site (most probably a former floodplain). Other *Caesalpiniaceae* trees such as *Tamarindus indica* and *Piliostigma thonningii* also occur but none of the dominating miombo species *Brachystegia* and *Julbernardia* are present.

Savannas

With increasing aridity towards the south the proportion of more drought tolerant species typical for savanna ecosystems gradually increases: *Acacia* spp., *Adansonia digitata*, *Annona senegalensis*, *Combretum* spp., *Dalbergia melanoxylon*, *Dichrostachys cinerea*, *Euphorbia candelabrum*, *Oxytenanthera abyssinica*, *Piliostigma thonningii*, *Sclerorcarya birrea* and *Stereospermum kunthianum*. Finally the miombo dominants *Brachystegia* and *Julbernardia* disappear and miombo woodlands are replaced by savanna formations.

Different species of acacia and locally also of *Combretum* spp. dominate the savannas in the drier area along the Ruvuma River. Stands with tall *A. clavigera*, *A. nigrescens* and *A. xanthophloea* and with shorter *A. goetzeii* ssp. *goetzei* are widespread. These acacias as most other savanna trees are absent from the miombo woodlands. Most of the pan-tropical grasses, however, occur in both biomes. Patches of particular savanna woodland are found adjacent to the fringing forests along the Ruvuma River. The canopy is an open nearly monospecific stand composed of emergent *Acacia clavigera* having a height of about 18m. The very thick almost impenetrable understorey consists of mainly deciduous much-branched coppice-like shrubs of *Boscia angustifolia*, *Maerua kirkii*, *Combretum paniculatum*, *Combretum* sp., *Croton pseudopulchellus, Garcinia livingstonei* and *Grewia mollis*. Open shrub savannas with a canopy cover of less than 10% are frequent and locally almost completely composed of *Combretum fragrans*.

Riverine forests

The levees of perennial and intermittent watercourses and small drainage channels on flat areas (Korongos) are usually covered with riverine forests of limited extent. Dry evergreen riverine forests occur also in areas with a high water table. They occupy a transitional zone between aquatic and terrestrial ecosystems. The riverine ecosystem is linear and narrow in form as it parallels the stream channel and has either diffuse or sharp edges attributable to the nature of species interactions across the ecotone and disturbances. It is rare to find undisturbed examples of riverine forest since this vegetation is often broken or fragmented in response to the dynamic nature of the aquatic stream system and has been kept open by the movements and browsing of large mammals.

Dry evergreen riverine forests have a distinct and rich floristic composition (Medley & Hughes 1996) and only a few species in common with miombo woodlands and savannas. According to the topographic position and the water supply, riverine forests are quite heterogeneous regarding species composition. Species with wider ecological amplitude are the timber species *Breonadia salicina* and African Mahogany (*Khaya anthotheca*), *Polysphaeria braunii*, *Sorindeia madagascariensis, Syzygium guineense* subsp. *guineense* and the giant liana *Entada gigas*.

Discontinuous fringing forests of about 15(20)m height occur along the Ruvuma River mainly composed of species like e.g., *Antidesma venosum*, *Dalbergia armata*, *Deinbollia borbonica*, *Ficus sycomorus*, *Kigelia africana*, *Polysphaeria braunii*, *Sorindeia madagascariensis*, *Syzygium guineense* subsp. *guineense*, *Treculia africana*, *Voacanga africana* and the liana *Saba comorensis*. Moreover, we found a new *Annonaceae*, *Xylopia* sp. nov., (see Fig. 2) which occurs quite frequent in these riverine forests.

At Mkolesya, several islands occur side by side in the Ruvuma River. Due to the meandering of the river size and location of sandbanks and levees are constantly changing. Therefore the islands are mostly colonised by pioneer species. Woody plants such as *Dalbergia armata*, *Mimosa pigra*, *Phyllanthus reticulatus*, *Syzygium guineense* subsp. *guineense* and *Trichilia dregeana* are usually covering the levees bordering the sandbanks. Older sandbanks are vegetated in patches mainly with *Phragmites mauritianus* and other grasses and sedges. Additional islands in the Ruvuma River exist but could not be visited during this first survey.

Dry evergreen forests may occur also as dense narrow ribbons along deeply dissected erosion gullies in steep side valleys with heterogeneous species composition. Characteristic species of these gully forests are e.g., *Albizia amara*, *Millettia dura*, *Xylopia parviflora* and the scandent shrubs *Combretum pentagonum* and *Smilax anceps*. These sites are important refuges for leopards (*Panthera pardus*).
Semi-evergreen groundwater forests occur on floodplains along Mbarangandu River. The tallest trees reach a height of up to 20m with a canopy cover of more than 50% locally. The dominating trees are *Afzelia quanzensis*, *Lettowianthus stellatus*, *Rauvolfia caffra*, *R. mombasiana* and *Trichilia emetica*. Common species of the rich understorey are *Kigelia africana*, *Polysphaeria braunii*, *Syzygium guineense* subsp. *guineense* and *Xeroderris stuhlmannii*.
Two particular groundwater forests having each a size of about 2 ha exist near Mkundi/Mbarangandu River. These evergreen monospecific stands of African Mahogany up to 40m tall, forming a dense canopy cover of about 70%. The understorey is mainly composed of African Mahogany recruitment, *Catunaregam spinosa*, *Polysphaeria braunii* and the scandent shrub *Combretum pentagonum*. The swampy area is frequently visited by elephants.

Mbugas
Mbugas are irregularly scattered all over the miombo ecosystems occupying flat areas often in small depressions. These seasonally waterlogged grasslands on black cotton soils are usually treeless and only their fringes are colonised with *Syzygium cordatum*. The vegetation is usually dominated by tall tussock grasses of over 2m height, mainly *Hyparrhenia variabilis*, *Miscanthus violaceus*, *Panicum maximum*, *Pennisetum purpureum* and some conspicuous herbs like *Pycnostachys dewildemaniana*. Mbugas are frequently burnt.

Thickets on termite hills
Termite hills are widespread in the Corridor. In the centre and towards the Ruvuma River conspicuous active termitaria built by *Macrotermitinae* are plentiful. Both moribund and occupied termite hills may be protected from erosion by a dense thicket (Pullan 1979; Bloesch 2008), often with one or more emergent trees such as *Acacia clavigera*, *Boscia angustifolia*, *Euphorbia candelabrum*, *Manilkara mochisia*, *Pappea capensis* and *Tamarindus indica*. Small trees, scandent shrubs and lianas are commonly found but grasses, mainly *Panicum trichocladum*, occur only sporadically when the thicket is dense. *Aloe* sp. and *Sansevieria ehrenbergii* occasionally form a ground cover beneath trees on the summits of the hills. Elephants may cause important damage to termite hills by excavating the mounds using their tusks for feeding on the mineral rich soil.
The composition of the thickets varies considerably and the flora is distinct from that of the surroundings (see also White 1983; Bloesch 2002). The termitophilous vegetation shows xeromorphic tendencies. Many plants have prickles such as *Commiphora* spp. or *Ziziphus mucronata*, sclerophyllous leaves such as *Boscia angustifolia*, *B. coriacea*, *Cadaba kirkii*, *Maerua kirkii*, *Ritchiea capparoides* (all *Capparaceae*) and *Vepris glomerata* or a fleshiness structure (e.g. *Euphorbia candelabrum* or *Sansevieria ehrenbergii*).
Large mound-building termites are fungus growers living in symbioses with *Termitomyces* fungi (Bloesch 2008) which are specific for each termite species. The fungi further digest the faeces of the termites which can be re-ingested by termites. The fungus-combs, rich in proteins and vitamins, act as a reserve and are consumed in periods of food shortage. By eating on the fungus-comb termites include in their gut cellulase necessary to digest cellulose. Once the termites have abandoned the nest *termitomyces* may produce edible fruit bodies emerging on or near the mounds mainly early in the rainy season (see below). The alates, the winged reproductives of the termites are an important source of protein. When they leave the

mound en masse at the onset of the rainy season they are collected and eaten by the local population.

Rock outcrops

Formations of granite boulders of different sizes are scattered mainly in the southern part of the Corridor. Formations of the size of a hill or a small mountain are called inselbergs (or kopje). They abruptly rise from a gently sloping or virtually level surrounding plain of hard bedrock. The genesis of inselbergs is intimately connected with weathering and erosion in a humid climate (Bremer & Sander 2000).

Rock outcrops, especially inselbergs, support a speciose and distinctive vegetation due to dry microclimate and scarce soil cover, which is usually different from nearby normal soils and has much in common with the vegetation on termite mounds (White 1983; Porembski & Barthlott 2000). A number of plants show vegetative adaptations (succulence, poikilohydric plants, carnivorous plants) that may be advantageous in coping with these adverse conditions (Barthlott & Porembski 2000; Seine & Becker 2000). The grey, brown or colourful orange to yellow appearance of inselbergs results from a dense cover of cryptogams mainly lichens with cyanobacteria as the phytobiont. Lichens with chlorophytic algae as phytobiont are restricted to small areas along drainage channels, rock pools, or of elevated microrelief (Seine & Becker 2000). Mats of grasses and sedges are well represented on rock outcrops. Typical inselberg species belong, e.g., to the genus *Xerophyta* (*Velloziaceae*). Woody vegetation is confined to crevices in the rocks, clefts or around boulder bases where water and soil may accumulate (Seine & Becker 2000).

Conservation values

The provisional plant list includes 371 taxa in 268 genera and 76 families. Few species, mainly sterile ones, could only be identified at the general level. The species richest families with more than 20 species are *Fabaceae*, *Poaceae*, *Rubiaceae*, *Caesalpiniaceae* and *Euphorbiaceae*. Additional surveys are necessary and will certainly result in a total species number within the Corridor of more than 500. The vegetation types with the highest species richness according to the vegetation plots are on mesic and less disturbed sites like those in Sasawara FR and in gully forests.

One of the taxa, *Xylopia* sp. nov. (*Annonaceae*) found in the riverine forest along the Ruvuma River at the hippo pond and on Mkolesya islands is new to science (see Fig. 2). *Khaya anthotheca*, *Lettowianthus stellatus* and *Millettia bussei* are all vulnerable according to the IUCN Red List of Threatened Species, all orchids (5) and *Aloe mawii* are included in the CITES list (Appendix II) and *Baphia massaiensis*, *Lettowianthus stellatus* and *Monanthotaxis discolor* are endemic to Tanzania.

Fig. 2. *Xylopia* sp. nov., a new tree of the *Annonaceae* family found in riverine forests along the Ruvuma River.

The following vegetation types are of particular conservation importance and should therefore receive high priority for their protection. Most of these sites have also a certain potential for eco-tourism:

Small-sized riverine forests have high species richness due to the overlap of habitat on gradients (Fjeldså & Lovett 1997). Their linear and variable ecotone with adjacent woodlands or savannas is vital for preserving biodiversity (Smith et al. 2005). From a biogeographic perspective, riverine forests are an important refuge for a diverse range of species which are confined to this vegetation of limited extent (Medley & Hughes 1996). Cover from intense heat, protection from predators, access to water, and a variety of food resources make riverine forest areas important for animals. Moreover, they serve as seasonal migration routes for large mammals, especially elephants. In addition, riverine forests fulfil an important function for soil protection by reducing erosion. Riverine forest edges are fragile toward severe late dry season fires.

African Mahogany groundwater forests at Mkundi/Mbarangandu Rivers are of special interest. These stands may not only be important as seed reservoir but also as tourist attraction all the more the area is rich in game.

Rock outcrops and inselbergs are important elements of the beautiful natural scenery. They may have a relatively high percentage of endemic species (Seine & Becker 2000). In this context, it is noteworthy to mention the Mtungwe Mountain which has rock outcrops and huge boulders along its ridges. Severe late dry season fires may destroy the scarce vegetation on rock outcrops.

In addition also Raphia palm groves (*Raphia farinifera*) should get a high priority protection status. Their extent is dependent on specific site conditions and outside the Corridor they are often replaced by cultivation. Within the Corridor they occur sporadically along permanent watercourses and at the source of the Mbarangandu River nearby Kilimasera. The Raphia palm is also a keystone species upon which many other species depend (Lovett et al. 1997).

Additional vegetation surveys are recommended, especially on the inselbergs of Kisungule and Chuma Mbili (and possibly on other existing inselbergs within the Corridor), Mtungwe Mountain, not yet surveyed riverine forests (e.g. along Mburukasese River) and Mbugas. This will allow to refine the vegetation types and to complete the plant species list.

Threats

Considering that the entire Corridor will be used and protected by Wildlife Management Areas excluding any agricultural activities, several threats for the vegetation and its biodiversity remain:

Logging of specific timber trees is widespread within the Corridor and mostly illegal, including the woodland species *Afzelia quanzensis* and *Pterocarpus angolensis* and the riverine species *Breonadia salicina* and African Mahogany. All boards are hand sawn on location and transported on foot to the nearest accessible track. All over Tanzania, *Pterocarpus angolensis* is highly in demand as timber, mainly for furniture, veneer and carving (Monela et al. 1993; Rodgers 1996). Trees having a dbh >25cm become very rare due to high logging pressure in a attempt to satisfy an expanding market demand. Most of the few remaining trees of harvestable size have bent or hollow trunks such that boards could not be cut from the trunk. The natural regeneration capacity of *Pterocarpus angolensis* is low due to a low and not well understood recruitment success and slow growth rates (Schwartz et al. 2002; Schwartz & Caro 2003). The paucity of small trees (not only of *Pterocarpus angolensis*) in many mature stands is apparent. The low abundance of saplings may be due to intense late dry season fires and/or browsing pressure preventing their recruitment into the adult population (see Schwartz et al. 2002; Schwartz & Caro 2003).
Despite a very low population density, the current harvest is unsustainable raising serious concerns about the long-term viability of this important hardwood species in miombo woodland (see also Schwartz et al. 2002) and probably also for the other timber species. Due to increasing scarcity of the traditional timber species loggers may shift harvest practice to other species, such as *Albizia glaberrima*, *Burkea africana*, *Erythrophleum africanum*, *Pericopsis angolensis*, *Sterculia quinqueloba* or *Trichilia emetica*. The introduction of Participatory Forest Management (PFM), which involves the communities in management and the control of timber harvesting and benefit-sharing is highly recommended.
Fires are routinely set in the Corridor especially by poachers in order to improve the hunting conditions. Frequent hot fires keep the miombo woodlands open by suppressing the woody regeneration and thereby leading to a more uniform structure with lower species richness (Rodgers 1996). Many miombo species get a new flush of leaves well before the starting of the rainy season and are therefore particularly vulnerable towards fire at the end of the dry season. Frequent fierce late dry season fires provoke a regress of the species-rich dry evergreen patches of forest mainly composed of fire sensitive species and may badly damage the scarce and vulnerable vegetation cover on rock outcrops. Moreover, late dry season fires negatively affect the production of honey (Yves Hausser, personal communication) and the growth of mushrooms. Less intensive early dry season fires do less harm the woody plants due to lower fire temperature and more resistant woody plants at this season.
To implement a controlled fire regime, especially in a vast area like the Corridor, is a very complex task. The type of fire regime should be defined considering the condition of a particular vegetation community and the management goal. More open vegetation types with a more continuous grass layer favour herbivores while browsers would benefit from

vegetation with a denser woody cover. In order to avoid widespread late dry season fires, we suggest the method of controlled early burning in all villages of the Corridor. The fire should be set by the local population around their villages and along the main roads at the very beginning of the dry season in order to facilitate the control of the fire and avoid destructive late fires. The village games scouts under the supervision of the Village Natural Resources Committee and District Game Officer should carry out the controlled early burning in the WMAs along the edge of dry evergreen forests in order to protect their ecotone from fierce late dry season fires.

Another threat to the Corridor where WMAs have not yet been established is the paddy (rice) cultivation on alluvial soils along seasonal or intermittent streams which coincides with the destruction of the riverine forests. Furthermore, the cultivation of tobacco is increasingly having a high impact on the ecosystems due to its excessive demand for firewood. More recently, uncontrolled mining and prospecting for gemstones and minerals may damage the ecosystem by removing the vegetation and the topsoil. In addition, the camp of the minors and their need for construction material and firewood further affects the ecosystem. These reasons emphasize the urgent need for either Environmental Impact Assessments and /or proper land-use planning of the area.

Livelihood of local communities

Agricultural activities are not practised in WMAs but numerous forest products will continue to play an important role for the livelihood of the local communities either for domestic use or commercialisation such as the honey production supported by ADAP (*Association pour le Développement des Aires Protégées*) in the Mbarangandu and Nalika WMAs. We believe that other forest products like wild fruits, medicinal plants or mushrooms have a marketing potential as well which might offer further income opportunities to the local communities.

Miombo woodlands are rich in edible mushrooms because almost all of the trees are ectomycorrhizal: their roots live in symbioses with mushroom mycelia. It is a general character of mycorrhizal fungi that they are highly specific to their hosts: usually a certain tree species (or genus) co-occurs with a few mycrorrhizal mushroom species only (Härkönen et al. 2003). The mushrooms species are indigenous, although they belong to widely distributed genera, such as *Amanita*, *Boletus*, *Cantharellus*, *Lactarius* or *Russula*.

In addition, *termitomyces* living in symbiotic life together with termites are very tasty. All of them are edible and most are considered superior to all other mushrooms and also their nutritive value is very good (Härkönen et al. 2003). Mushrooms are frequently collected in Tanzania by the local population mainly for own consumption. Fresh, but also dried mushrooms are only sold at some market places and sporadically along roadsides having certainly a higher marketing potential (Härkönen et al. 2003).

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