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BIOLOGICAL VALUES AND CONSERVATION PROSPECTS FOR THE FORESTS AND PRIMATE POPULATIONS OF THE UZUNGWA MOUNTAINS, TANZANIA

W. A. RODGERS

Department of Zoology, University of Dar es Salaam, PO Box 35064, Dar es Salaam, Tanzania

&

K. M. HOMEWOOD

Department of Anthropology, University College London, Gower Street, London WC1E 6BT, Great Britain

ABSTRACT

Recent investigations in the Uzungwa Mountains of Tanzania reveal a continuous forest sequence from 300 m altitude to 2600 m (unique in tropical Africa) together with unexpected richness and endemism in plant and animal species.

Brief descriptions of climate and physical features are given and field surveys of all major forest areas in the Uzungwas are summarised. Vegetation structure and species composition at different altitudes are described in detail for each of three forests of particular biological interest and conservation importance. Population densities for four forest primate species are estimated from repeated censuses. Special emphasis is given to the endemic primate subspecies of the red colobus Colobus badius gordonorum, *which is used as an indicator of forest values. Conservation status of habitat and of primate populations in each area is discussed and specific recommendations are made for future conservation and management. Some of these recommendations have already been implemented by the Tanzanian government.*

INTRODUCTION

The Uzungwa Mountains are part of the Tanganyika–Nyassa block montane forest chain of East Africa, well known for its high diversity and endemism (Moreau, 1966; Kingdon, 1971; Schiotz, 1981; Rodgers & Homewood, in press). Collections of plant and animal species in the Uzungwas have been less intensive than for other

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block mountains (e.g. Ulugurus, Usambaras) but they are perhaps the richest in all the chain for mammals (Rodgers *et al.*, 1982; Homewood & Rodgers, 1981).

Botanically the Uzungwa forests are extremely rich in terms of numbers of communities as well as of species. Several endemic plant species have now been found and further collecting will undoubtedly reveal more. The affinities with other East African forests and the disjunct distributions with West Africa are of major biogeographical interest. The eastern scarp of the Uzungwas is the only area in East Africa where it is possible to find continuous forest cover from lowland forests at 300 m through intermediate *Parinari* rain forest to montane *Podocarpus* forest at 2600 m. This vertical zonation sequence of 2300 m is found within a 20 km transect and offers unrivalled opportunities for ecological study of tropical forest communities, especially as regards the controversial question of the distinctness of lowland and montane communities (e.g. Diamond & Hamilton, 1980).

The Uzungwas contain five species of forest antelope (red, blue and Abbott's duikers, suni and bushbuck), making it the richest site in all Tanzania for this group. Larger mammals—elephant, buffalo and bushpig—can be found, and smaller mammals—squirrels, hyrax and anomalures—are common. Leopard and otters still occur at the low densities characteristic of these species.

Within the primates, six species of Anthropoidea occur (two colobus, mangabey, Sykes, vervet and baboon, of which two are forms endemic to the Uzungwas. This is comparable with the Mahari Mountains and Gombe Stream National Parks, which have seven and six species respectively, none of which is endemic.

This paper reports a survey undertaken to establish past and present distribution, abundance and habitat status of forest primates in general and for the Iringa red colobus in particular. From the many forests investigated three areas have been selected as particularly suitable for conservation. A detailed description of conservation plans, including the practical problems of compromise and compensation for local people, is presented. These plans are in the process of implementation by the Tanzania Government.

STUDY AREA

The Uzungwas form the central area in a chain of isolated block mountains which run from southern Malawi to northeast Tanzania, the Tanganyika–Nyassa montane chain of Moreau (1966) (Fig. 1). They were formed by fusion of the ancient Mozambique shield of Usagaran biotite gneiss to the southeast and Archaean granites to the northwest, followed by uplift and faulting. The present geological boundary roughly follows the central watershed (indicated in Fig. 2).

The Uzungwas cover some 10,000 km^2. They rise from a level of 300 m at the valley of the Great Ruaha River in the north as a series of rolling hills and dissected plateaux to a gently undulating upland (1200 m) with peaks reaching 2800 m, and end as a steep southeast-facing scarp (formed by the asymmetric Pliocene rifting

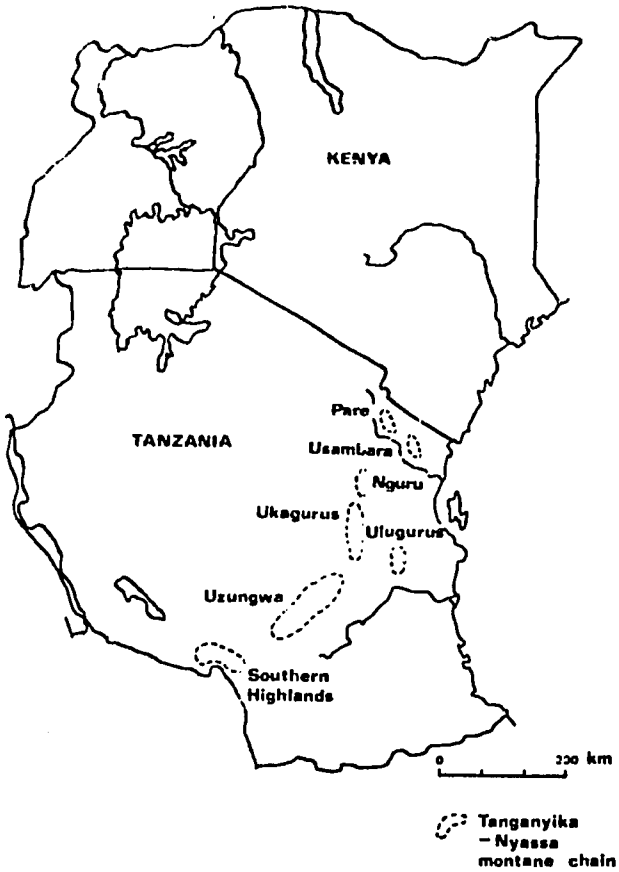

Fig. 1. Tanganyika–Nyassa montane chain.

which produced the Kilombero valley system). A northwest–southeast profile across the Uzungwas is shown in Fig. 2. Climate, soil and vegetation vary with topography, altitude and location along this profile.

The Uzungwas fall within the single rainy season of southern Tanzania, with the bulk of the precipitation due to the November–May southeast monsoons. Rainfall is high (1800–2000 mm year^{-1}) along the southeast scarp but decreases rapidly down the northwestern rain shadow slopes towards Iringa (660 mm year^{-1}). The wet southeast slopes receive some rain throughout the year (only three months with less than 50 mm) while the dry northern areas suffer a six months' drought.

Water runoff and stream density reflect this rainfall pattern, the southeastern slopes having permanent fast-flowing streams which run off into alluvial fans at the scarp foot. Permanent streams are much fewer to the northwest. Soils of the higher areas are lateritic, slightly acid red earths of medium fertility; physical soil classes are indicated in Fig. 2.

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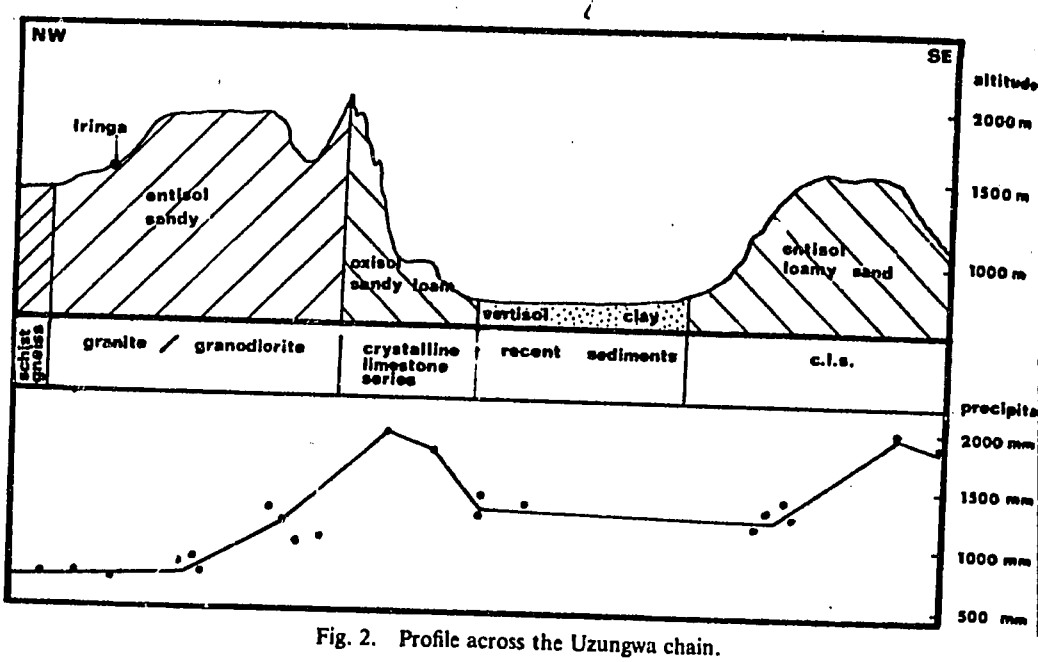

Fig. 2. Profile across the Uzungwa chain.

In the past the bulk of the mountain block would have been forest-covered: lowland and montane rain forest along the wetter slopes; dry evergreen forest on the plateau and deciduous forest grading to woodland and thicket on the drier northern slopes. Although there is virtually no sign of settlement over the last 80 years the appearance of the country indicates that fire and perhaps agriculture have reduced forest cover: the greater part of the central plateau is a *Hyparrhenia/Pteridium-Parinari/Protea* wooded grassland. Vegetation communities are described by Gilchrist (1952) and summarised by Lind & Morrison (1974). Details for individual forest areas are given below.

Difficulties of access, flooding and excessively steep slopes have prevented extensive exploitation along the southern margin. The highest human densities are to the north (Dabaga and Iringa) and west (Mufindi). The central plateau east of Dabaga is still devoid of human settlement, although seemingly suitable for peasant and intensive agriculture and livestock husbandry.

METHODS

Existing maps (1:125,000 and 1:50,000—1950s air photography) were used to determine the extent of surviving forests: further details were taken from the 1:25,000 forest inventory maps and descriptions made by Schultz & Co. (1973).

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TABLE 1

SUMMARY OF CONSERVATION STATUS AND PROSPECTS FOR UZUNGWA MOUNTAIN FORESTS

Forest	*Area natural forest (ha)*	*Altitude*	*Legal status*	*Present conservation status*[a]					*Primates present*[b]				*Future prospects*
				Poles + lianes	*Logging*	*Hunting*	*Encroachment*	*Overall*	*Cbg*	*Cap*	*Cmm*	*Cg*	
Magombera	600	L	FR (1500 ha)	+ + +	+ + + (pre 1975)	+	+ + +	Threatened	P	P	P	A	1980: north half lost to rubber planting; south half upgraded to GR
Nyange	100	L	O	+ + +	+ +	+	+ + +	Threatened	A	P	P	A	Clearing for sugar
Lolando (Mufindi Scarp)	25	M	FR	+ + +	+ + +	+	+ + +	Threatened	A	P	P	A	Deterioration
Image	8000	M	FR	+	+	+	–	Good	A	P	P	A	Stable
Mbongolo	50	M	O	+	+	+ +	+ +	Threatened	P	P	P	A	Needs protection
Kilanze	1100	M	FR	+ +	+	+	pre-1975	OK	A	P	P	A	Stable
New Dabaga	3700	M	FR	+	+	+	–	OK	A	P	P	A	Stable
Muhanga/Bomalamzinga	400	M	FR	+ +	+	+ + +	+	Threatened	P	P	P	A	Deterioration
Uzungwa Scarp	14000	L/T/M	FR (20500 ha)	+	+	+	+	OK	P	P	P	P	Proposed NP
Mwanihana	5900	L/T/M	FR (48500 ha)	+	+ +	+	–	OK	P	P	P	P	Proposed NP
West Kilombero Scarp	2500	M	FR (100000 ha)	–	–	+	–	OK	P	P	P	?	Proposed NP

FR, forest reserve; GR, game reserve; NP, national park; O, no status; L, lowland; T, transitional; M, montane.
[a] Conservation status categories: +, some utilisation; + +, steady exploitation; + + +, heavy exploitation.
[b] *Cbg*, red colobus; *Cap*, black-and-white colobus; *Cmm*, Sykes' monkey; *Cg*, Mangabey; P, present; A, absent.

Unfortunately it was not possible to examine originals and the only (small-scale) photographs available have a high degree of cloud cover, precluding accurate estimates of the extent of forest loss from 1955–1973.

Separate field trips were made to: the forests of the western and northern Uzungwas: Mufindi, Image, Dabaga; the forests of the southern escarpment: Mgeta and Chita; the forests of the eastern escarpment: Mwanihana and West Kilombero Scarp; and the low-lying forests of Magombera, Msolwa and Ruaha.

On each field trip, villagers were consulted about the distribution and numbers of primates: red colobus *Colobus badius gordonorum*, black-and-white colobus *Colobus angolensis palliatus*, Sykes' monkey *Cercopithecus mitis monoides* and, following its discovery in November 1979, a new form of the mangabey *Cercocebus galeritus* (described in Homewood & Rodgers, 1981). Guides were used to explore areas where colobus were believed to exist; primates heard and/or seen were recorded.

Conservation status for forests visited was assessed during the general survey of the basis of surrounding land pressure, and current use of the forest resource: logging, pole cutting, hunting and footpaths. Future status was predicted from current legal status (catchment reserve, exploitation forest reserve, open forest), accessibility, exploitation plans and settlement plans. Brief details for these characteristics are given in Table 1 for each reserve visited. Vegetation samples were collected and identified and forest structure was assessed in terms of species composition, canopy height and damage class. Existing maps, air photographs and ERTS satellite imagery were used to map size and gross canopy structure of selected forests. In Mwanihana, staff of the wildlife division helped to survey each valley system for primate populations. Discussion with villagers and district and national forestry and wildlife officials allowed the planning of long-term conservation measures for each forest locality.

On the basis of these preliminary observations three forest localities were selected, in terms of primate populations and forest status, as being suitable for increased conservation effort. These forests, Mwanihana, Magombera and Uzungwa Scarp, were then revisited and populations and vegetation investigated in greater detail, spending 35, 14 and 5 days in each forest respectively.

RESULTS

General

The extent of forest cover in the Uzungwas is shown in Fig. 3 and totals little more than 450 km^2 or 4·5% of the area of the Uzungwa Mountains above 400 m asl. Although no material is available for accurate estimation of forest decrease since 1955, ground work indicates considerable habitat destruction over the last 25 years.

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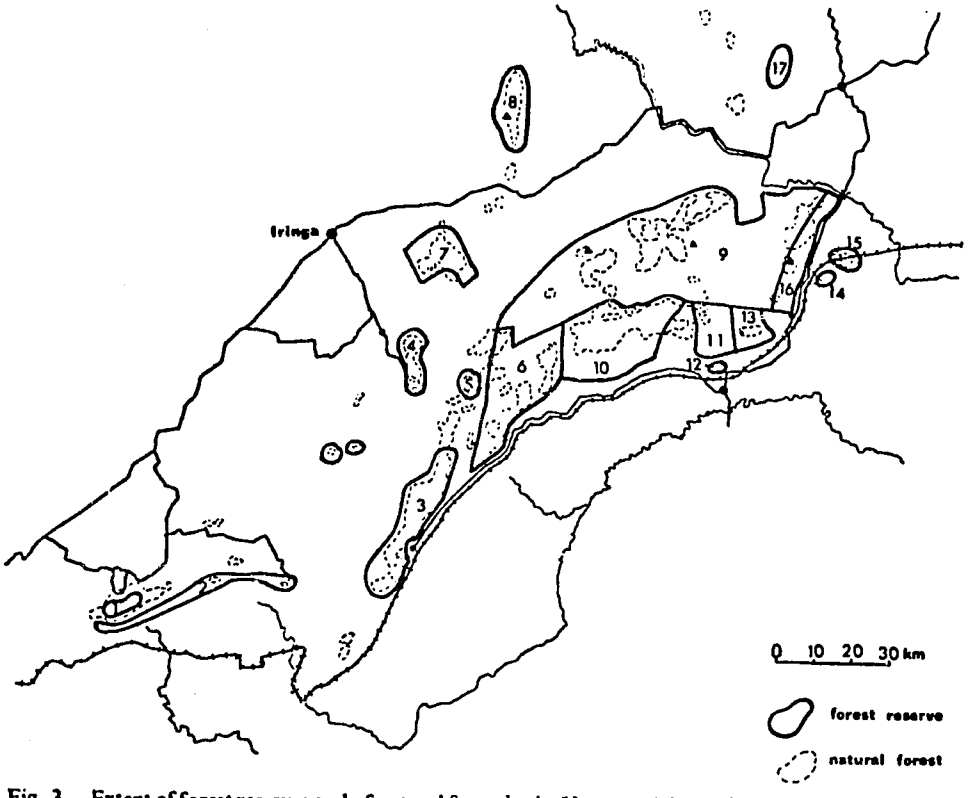

Fig. 3. Extent of forest reserves and of natural forest in the Uzungwa Mountains. 1, Kibao; 2, Mufindi Scarp; 3, Uzungwa Scarp; 4, Dabaga/Uliangambe; 5, Kilanze; 6, Iyondo; 7, Kisinga Rugaro; 8, Image; 9, West Kilombero; 10, Matundu; 11, Iwonde; 12, Ihangana; 13, Nyanganje; 14, Lukoga; 15, Magombera; 16, Mwanihana; 17, Pala Ulanga.

The location of Forest Reserves (the only category of conservation estate in the Uzungwas) is shown in Fig. 3 and details of size, condition, etc., listed in Table 1.

The probable range of the Iringa red colobus is shown in Fig. 4 and annotated presence/absence data for all anthropoid primates for each forest visited in Table 1.

Red colobus are absent from forests in the Mahenge Mountains to the south, Ruaha River forests and from Image Mountains and the Ukaguru Mountains to the north. They are rumoured to exist in the Pala Ulanga forests of south Ukaguru (Struhsaker & Leland, 1980). They are absent from Mufindi District to the west and are certainly absent from Dabaga Reserve at the present time, although they may have been present earlier this century (Swynnerton & Hayman, 1951; Kingston, 1974). Within the Uzungwas red colobus are found from 300 m (Magombera Forest Reserve) to over 2000 m (Mbongolo forests), from forest patches of less than 10 ha to large forest blocks as well as from forest currently under heavy utilisation by humans.

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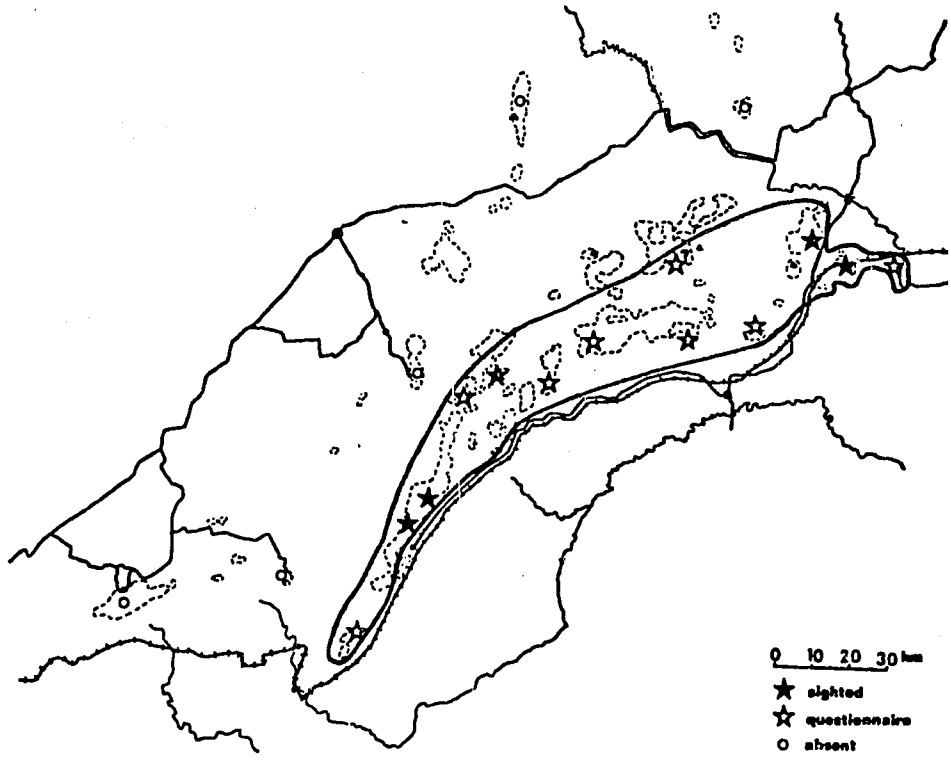

Fig. 4. Distribution of red colobus in the Uzungwa Mountains.

Localities selected for conservation effort

Mwanihana Forest Reserve and adjacent areas of West Kilombero Scarp Reserve. Mwanihana Forest Reserve was gazetted in 1959 with an area of 485 km² (flat projection only) of which 59 km² (13%) is closed catchment forest. The reserve covers the eastern scarp face of the Uzungwas, rising from 300 m at the foot to over 2000 m at Mwanihana Mountain. Rainfall is over 200 mm and permanent fast-flowing streams are numerous. West Kilombero Scarp Forest Reserve is adjacent to Mwanihana. It is officially the largest catchment forest reserve in Tanzania and extends 120 km westward, including areas of forest at 2000–2600 m, but is largely plateau grassland (Fig. 3).

The Mwanihana Forest Reserve, taken together with the West Kilombero Scarp Forest Reserve to the west, provides the only place in tropical Africa where it is possible to follow unbroken forest zonation from 400 m to 2600 m.

The altitude sequence from the lowland to the montane zone is reflected in the forest species composition. Five broad vegetation categories are recognisable:

Lower rain forest	400 m to 750 m
Intermediate rain forest	750 m to 1250 m

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Montane rain forest	1250 m +
Miombo woodland	300 m to 500 m
Upland grassland and bushed grassland on the western plateau forest edge	1000 m to 1600 m.

The lower rain forest is characterised by a high diversity of tree species with a closed canopy at 15 m to 25 m height. This forest contains a strikingly high proportion of trees whose fruits are preferred primate foods; these include several *Ficus* species, *Mimusops*, *Pachystela*, *Parinari*, *Bequartiodendron*, *Chrysophyllum* and *Afrosersalia* as well as lianes including *Saba* and *Landolphia*. Other common constituents include *Erythrophleum suaveolens*, *Dialium holstii*, *Parkia filicoidea* and *Albizia gummifera*.

Intermediate rain forest canopy is largely dominated by *Parinari* and *Newtonia* with occasional stands of *Cephalosphaeria*, *Strombosia* and *Uapaca palludosa*. The canopy may reach a height of 50 m over complex layers of underwood and shrubs (largely Rubiaceae) and a sparse herbaceous ground layer.

Only the lower levels of montane rain forest were studied; these were dominated by *Allanblackia*, *Syzygium*, *Parinari* and *Newtonia* with increasing amounts of *Olea*, *Rapania* and *Ocotea* at the higher levels. Arborescent *Erica* and *Podocarpus latifolius* were common on exposed ridges. Canopy heights varied from 15 m to 40 m.

Pericopsis, *Diplorrhynchus*, *Annona*, *Crossopteryx* and *Sclerocarya* are common woody elements in the miombo. The grasslands are dominated by *Andropogon* and *Hyparrhenia* with frequent *Pteridium* and *Dissotis* with scattered trees (principally *Agauria*, *Syzygium* and *Vitex*) common near the forest edge.

Only the eastern border of the Mwanihana Forest Reserve along the main Ifakara-Mikumi road faces agricultural development. The west and north border on the Kilombero Scarp Forest Reserve and Kidatu Hydroelectric Dam Reservoir respectively, and the southern border is in broken infertile miombo woodland. Aerial photographs (Schultz & Co., 1973) show no sign of former settlement along the existing western forest edge: German maps from 1916 show only five villages in one area of some 2500 km^2 of the eastern half of the plateau. Present government policy restricts all development to the lowland alluvium. The road acts as a physical boundary and so the reserve is considered to be immune from settlement pressure for many years to come. Commercial rubber planting on the lowlands (near to Magombera) will reinforce government policy of retaining Mwanihana as catchment forest.

Estimates of forest structure and damage were made along major trails and across ridge-slope-valley transects. The extremely steep terrain has prevented commercial exploitation although pitsawyers have removed all large *Chlorophora* and *Khaya* in the lower and intermediate altitude areas. Pitsawyers were still active at least up to the end of 1978, seven camps of less than two years of age being seen in the intensive

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study area of some 5 km². Pole cutting, fire wood and liane collecting are evident but overall forest structure is better than that of all the other forests visited in the Uzungwas.

Nine separate visits were made to the lower Mwanihana forests (400 m–1000 m altitude) between November 1979 and April 1981 and in 19 days' random census walks (ca. 115 h in the forest and 82 km total path length) red colobus were sighted 22 times, including 3 solitary individuals attached to Sykes' groups. During the same period at least 23 Sykes' groups were encountered; black-and-white colobus were sighted on 22 occasions; mangabeys were sighted 14 times (many more adult male long range calls were heard and unsuccessfully pursued).

The approximate routes covered on each visit and the approximate locations of primate sightings were plotted on maps from 1:25,000 aerial photographs with the aid of a stereoscope. From this we calculated our main study area to be a rough trapezoid of total flat projection area 4·5 km² between 400 m and 1000 m altitude. Within this the sightings for each species fell into clusters which could be confirmed from simultaneous or immediately consecutive sightings to be separate groups. From this we were able to distinguish 6 separate groups of red colobus (in addition to 3 solitary individuals); 8 groups of black-and-white colobus; and 2 or 3 mangabey groups—the latter species with its tendency to dissociation and association within and between groups (Homewood, 1978; Quris, 1975, 1980) is most difficult to judge, and at least one of the groups sighted ranged far outside the area studied.

For the lower Mwanihana forest we estimate that for the area studied there is a minimum density of about 1·3 groups/km^{-2} of red colobus (mean group size = 25, giving 33 red colobus km^{-2}); 1·8 groups or 10–11 individuals of black and white colobus km^{-2} (mean group size = 6) and 0·6 groups km^{-2} of mangabeys (no mean group size estimates available for Mwanihana, but Tana River *C. galeritus* have a mean group size of 26: if this is assumed to hold for the Mwanihana mangabey it gives a density of 15–16 mangabeys km^{-2}).

The higher forest (over 1000 m) was investigated in a 12-day walking transect in April 1981, during which 69 h of active primate search were made over 65 km. During this time we made 2 sightings of red colobus, 2 of black-and-white colobus, 2 of Sykes and none of mangabeys. This impression of a very low primate density in the higher forest is reinforced by our recording of vocalisations: 17 Sykes, 4 black-and-white colobus and 2 mangabeys were heard calling. These three species have loud calls easily carrying 1000 m distance, whereas red colobus vocalisations can only be heard at close range. These data confirm our finding of very low primate densities in the higher forests of the Uzungwa plateau.

Of this 12-day survey, half of the time was spent on the western side of the watershed, concentrating on a 3 km² study area ranging in altitude from 1650 m to 1100 m at the forest edge. No mangabey or colobus sightings were made or calls recorded for any forest primate species other than Sykes, and baboons and vervets were completely absent from the forest, forest edge and the adjoining grasslands.

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Several of these sightings (at all altitudes) were of polyspecific associations: in 12 cases red colobus were in association with black-and-whites, which is worthy of note as elsewhere when these species occur sympatrically they are very rarely if ever found together (Struhsaker & Leland, 1980).

Magombera Forest Reserve. Magombera Forest Reserve was gazetted in 1955. Air photographs from 1955, 1962, 1965, and low-level oblique aerial photographs taken during the present survey showed a decrease from 15·1 km^2 closed forest in 1955 to ca. 10–11 km^2 in 1979. The reserve has suffered severe and repeated encroachment with extensive clearing for rice farming and intense selective felling with removal of all *Chlorophora excelsa* and *Khaya nyassica* timber during the 1972 construction of the Tazara railway, which bisects the long axis of the forest. There is current heavy utilisation in terms of pole cutting and other forest product collection. The reserve comprises a lowland groundwater forest on alluvial soils fed by braided streams draining from the escarpment into the Kilombero system. Rainfall is estimated at 1500 mm (as for the adjacent Kilombero Sugar Estate) as Magombera lies away from the zone of orographic rainfall associated with the scarp.

Plant collection yielded a preliminary list of 250 species. Canopy height, dominant species and damage values were assessed for the forest edges exposed along the railway cutting (which provides a 6 km transect through the long axis of the forest). The canopy is dominated by *Erythrophleum suaveolens*, *Xylopia parviflora* and *Isoberlinia scheffleri* with a typical canopy height of 10 m and emergents to 40 m. *Parkia* and *Albizia* are common; the frequency of cut stumps of *Chlorophora* indicates the former abundance of this species. *Anthocleiste grandiflora* is a common regenerant along cleared edges and *Vitex doniana* dominates the western end of the forest. Stream banks and swampy areas are characterised by *Syzygium* spp. There are a number of tree species of considerable floristic interest (Vollesen, 1980) such as the provisional endemics *Polyalthia* sp., *Ixora* sp. nov. and *Memecylon magnifoliatum* as well as the near endemics *Isolona* and *Isoberlinia*. Species richness, assessed from total enumeration of two 1/16 ha plots, was found to be high for eastern Africa with close to 150 species being recorded from a single plot (Rodgers *et al.* 1980). Biological values are not restricted to plant species, as is evidenced by an endemic tree frog (A. Schiotz, pers. comm.) and the primate populations described here.

The railway was used as a measured transect for primate censuses and to provide marker points for less rigidly controlled north–south traverses. All primates seen were recorded, mapped as to location within the forest, group counts made and age/sex classes noted where possible. As actual sighting distance from the railway was affected by the variable width of the cutting at any point an average visibility of 50 m into the forest on either side of the line was used to derive primate group density estimates.

Magombera contains three species of forest monkey: red colobus, black-and-white colobus and Sykes. Local inhabitants say mangabeys were originally (but no

longer) found in Magombera. Census operations described in detail in Rodgers *et al.* (1980) allow minimum estimates of 1·4–1·7 groups km^{-2} of red colobus (mean group size 25; total population of 385–470); 3·4–5·7 groups km^{-2} for black-and-whites and at least 9 groups km^{-2} for Sykes.

Uzungwa Scarp Forest Reserve. This reserve was gazetted in 1979 with an area of 205 km^2 of which about two-thirds is estimated as closed forest. Rainfall is high (1870 mm) and, as for Mwanihana, there are numerous fast-flowing streams draining the scarp. One day spent near Muhanga Village at the top of the scarp at 1800 m asl and four days at Chita at the foot of the scarp (400 asl) permitted some assessment of vegetation composition, structure and damage, as well as a relative estimate of primate populations.

The forest along the base of the Chita scarp is dominated by *Brachystegia microphylla* and *Lettowianthus stellatus* with *Vitex doniana* in the wetter areas. Other common species include *Erythrophleum suaveolens*, *Tabernaemontana* sp., *Pachystela brevipes*, *Ficus* spp., *Parinari excelsa*, *Chlorophora excelsa*, *Khaya nyassica* and *Chrysophyllum* sp. There was no trace of recent pitsawing in the forest nor of recent timber stacks in the village. Only one well-marked path was seen, this being a track leading to villages at the top of the escarpment and thence to Iringa. A single abandoned pitsawyers' camp was found along this path. Although other such paths leading to the top of the scarp exist, the lower Chita forest appears under little or no pressure at the present time compared with Mwanihana (with paths and logging camps in recent use on every ridge investigated) and Magombera (with current intense use of forest products and widespread encroachment). This conclusion was supported by the fairly frequent occurrence of timber-size *Khaya*, *Chlorophora* and *Chrysophyllum* in Chita forest. Despite its better current conservation status, the general impression is of rather poorer forest with a low tree density and less impressive canopy structure than Mwanihana.

Dominant tree species for the top of Uzungwa scarp (about 1600 m altitude near Muhanga) include *Parinari*, *Chrysophyllum*, *Newtonia*, *Albizia* and *Macaranga*. The subjective impression here was of a tall and beautiful montane forest, considerable human use and, as for the higher reaches of Mwanihana/West Kilombero, a low primate population.

Although no systematic census was possible in the absence of any marked paths, a relative estimate of primate densities was attempted. Thus during a total of 40 hours actively searching for primates in the lower forest (500 m–750 m), we made 7 sightings of red colobus (including 3 solitaries), 1 of black-and-white colobus, 9 of Sykes and 1 of mangabeys. Despite the low number of mangabey sightings, at least 6 separate adult male long range call sources were recorded over the approximately 5 km^2 area covered.

There is apparently a lower overall primate density in the Uzungwa forest than at Mwanihana. All primate species are hunted (colobus and Sykes with muzzle-loaders, mangabeys with dogs and nets), and are correspondingly shy. In the few

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hours we spent in the forest at the top of the scarp (Muhanga) we sighted one solitary Sykes and a small group of black-and-white colobus: both species were uncharacteristically shy.

DISCUSSION

Distribution and population size of the red colobus

East Africa has five subspecies of red colobus (Struhsaker, 1975) of which *Colobus badius gordonorum*, the Iringa or Uhehe red colobus, is the least well known. The type specimen was collected in the early part of the century from the Dabaga area of Iringa District and subsequently only brief observations were reported (Swynnerton & Hayman, 1951; Kingston, 1974; Tanganyika and Tanzania Game Division records) until a full field description was published by Struhsaker & Leland (1980). Known only from forests in and around the Uzungwa Mountains (Rodgers, 1981), the Iringa red colobus is geographically and morphologically intermediate between the red colobus of western Tanzania (*Colobus badius tephrosceles*) and that of Zanzibar (*Colobus badius kirkii*: Kingdom, 1971; Struhsaker & Leland, 1980).

Figure 4 shows *C.b. gordonorum* to be virtually confined to forest patches along the southern and eastern slopes of the Uzungwa Mountains with rare occurrences in some plateau forests. Populations in Magombera and the adjacent Ruaha and Msolwa riverine forests are the only ones not directly associated with the mountain mass. Examination of the 1951 and 1975 air photographs of the Mwanihana–Magombera area show that what are now isolated forests were continuous only a few years ago. It is probable that such a complete forest cover existed over the whole of the wetter slopes at the turn of the century. Colobus distribution could thus also have been continuous at that time, but the evidence of 1902 German maps indicates that plateau forests have been isolated for much longer time periods.

Red colobus are restricted to evergreen forests, which implies year-round moisture availability. This excludes their presence in the drier forests to the east of Magombera, and those of the rain shadow northern slopes of the Uzungwas in the vicinity of Iringa, Mafinga and the west of Mlimba.

Reasons for the absence of red colobus from the adjacent mountain masses of Mahenge, Uluguru and Ukaguru where adequate habitat is apparently available must be sought in paleoecological history. The Mahenge Mountains are separated from the Uzungwas by the 40 km + wide Kilombero swamp and floodplain. Black-and-white colobus occur but have colonised the area via the drier Njombe hills to the west. The absence of red colobus from the Ulugurus and Ukagurus is more difficult to explain, but the presence of significant speciation between these areas (Schiotz, 1981) and many faunal differences (Stuart, 1981) indicate that faunal connections have been absent for a long time.

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The present red colobus distribution is characterised by many small scattered isolated subpopulations in increasingly fragmented forest patches. Within 10 km of Magombera there are eight separate and distinct groups or subpopulations, some in forest patches of less than 10 ha in size separated by 1 km or more. Unlike black-and-white colobus, red colobus rarely travel on the ground (an exception being *C.b. kirkii* on Zanzibar), and then only for very short distances (generally less than 100 m—Marsh, 1978). There would be little or no contact and gene flow between these small groups, which would perish as forest patches decrease below minimum size.

The effective total population size for *C.b. gordonorum* is the sum of all *viable* subpopulations or groups. This figure will be very much less than for the overall total, which would include single groups and groups in forest patches below a size adequate for long-term maintenance. Attempts to derive such an effective population figure require decisions on what constitutes a viable population. A total of 200 individuals in an inter-breeding population has been suggested as a minimum for long-term viability (Soulé & Wilcox, 1980). Data on group size and group density for Magombera (Rodgers *et al.*, 1980; Struhsaker & Leland, 1980) indicate that 200 individuals would require at least eight groups in a forest area of 5 km^2 (mean group size = 25, minimum density = 1·6 groups km^{-2}).

Forest areas of at least 5 km^2 of continuous cover with red colobus populations are not frequent, and are found mainly in Mwanihana, West Kilombero (the east and south parts thereof), Matundu, Iyonde, Iwondo and Uzungwa Scarp Forest Reserves; Magombera South is an isolated 5 km^2 area. Total forest extent in these listed areas is estimated as approximately 400 km^2. Assuming a lower overall density of 1 group km^{-2} this would indicate a population of 10,000 *C.b. gordonorum*. However, the largest single interbreeding population will be very much smaller—certainly less than 2000 individuals.

These populations are considered viable now, as their forest habitat is not immediately threatened. However, little of the habitat is immune from exploitation and so permanent conservation status is not high. For example, urgent action was required in 1979 to prevent Magombera Forest Reserve being cleared for commercial rubber plantation (Rodgers *et al.*, 1980) while Matundu Forest Reserve is being exploited on an increasingly intensive scale for timber.

Much of the 450 km^2 estimated to contain colobus is gazetted Forest Reserve but such status does not necessarily confer protection on the biological resource. Forest Reserve status implies control of the timber resources and their rate of exploitation. The Forestry Division have recently introduced a category of Catchment Reserve which is meant to exclude all exploitation. However, this category has as yet no legal status, boundaries are not mapped or described, and may be altered by successive directors, and so have little long-term value for conservation. The Uzungwas contain over 25 forest reserves ranging from one to 1800 km^2: some are of considerable value for biological conservation, others of little or none. To ensure

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long-term conservation of valuable or unique biological resources, the status of the area must be raised beyond that of adjacent timber reserves where minor cutting and encroachment is of no import.

Conservation status of the Uzungwa Mountain forests

Timber exploitation depends on the availability of marketable species, and accessibility to markets. Magombera was logged intensively, effectively removing all *Chlorophora*, as the railway made it possible to transport complete logs to areas of demand. Mwanihana has lost good-quality timber for a considerable distance up the scarp (all *Khaya* and most large *Chlorophora* up to 1200 m) as there is easy access to markets of pitsawn planks. Uzungwa Scarp lost little timber as no access routes were available until the advent of the railway, whose authorities require complete logs rather than the pitsawn planks, which is the only form in which timber can be brought down the precipitous scarp slopes. As a result there are still large *Chlorophora* within easy reach of settlement.

Pole cutting is a function of population density. Magombera is surrounded by two new ujamaa settlements and a sugar estate with a growing labour force. Pole demand for house building is high and Magombera is the only forest remaining on the floodplain. Mwanihana has a large population along its eastern edge and there is evidence that poles are exported. Uzungwa has a small population at Chita and cutting is minimal compared with the other two sites. Cutting undergrowth has two principal effects: disturbing the habitat (perhaps especially important for forest ungulates and terrestrial primates) and prevention of regeneration of canopy trees. As such, it is not compatible with the conservation of biological values.

The hunting of primates is either for skins (black-and-white colobus only) or for meat (non-Muslim people only; principally the Wahehe, who take all primate species). Magombera is surrounded by a predominantly Muslim community recently settled in the area and there is little sign of primate hunting. The higher densities of all species and their level of habituation probably reflect this lack of overt disturbance. By contrast Mwanihana and Uzungwa are hunted—skulls and skin fragments of black-and-white colobus were found in cooking fire ashes. Although we have no information on hunting it is likely to be associated with pitsawing camps, and the effective prevention of pitsawing should reduce hunting to a negligible scale.

Conservation proposals

The areas of Magombera, Uzungwa Scarp and Mwanihana/West Kilombero Scarp were selected as the optimum choice for long-term conservation on the basis of their biological values, with emphasis on size and density of red colobus and other primate populations, existing conservation status and future development plans.

Within Tanzania there are three levels of conservation status: National Park, the highest level, allowing no human rights or consumptive exploitation; Game

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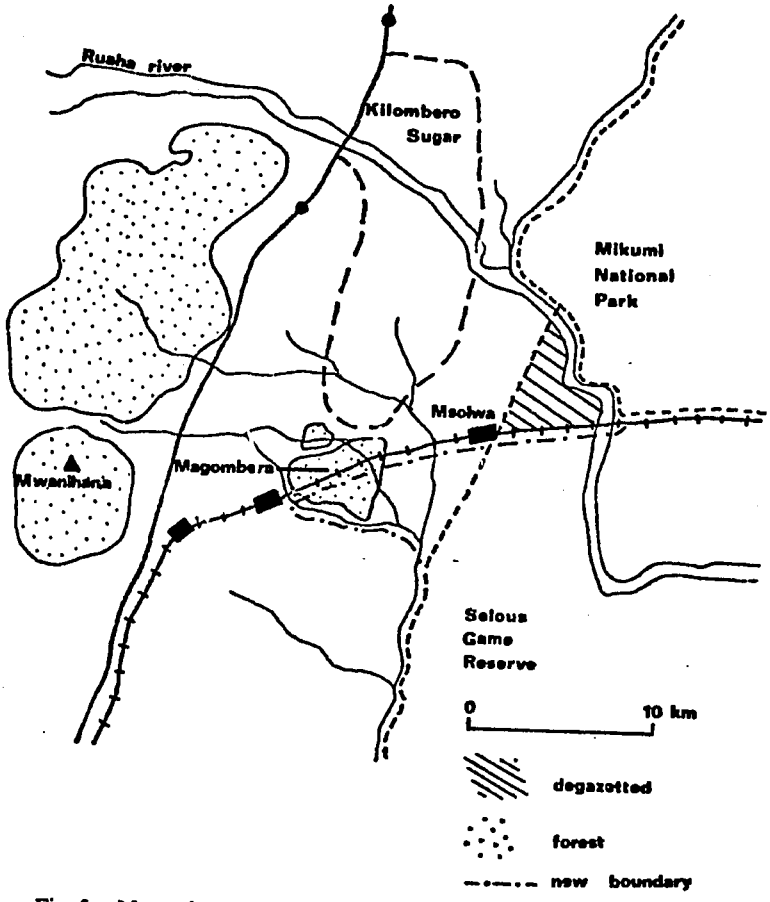

Fig. 5. Magombera forest: new conservation and management plans.

Reserves and Forest Reserves, where settlement or permanent rights are prohibited but some consumptive exploitation is allowed by order of the Director of Wildlife or Forests; Controlled Hunting Areas, which allow settlement and resource exploitation and therefore have little value in protecting forest resources. Unlike Kenya and Uganda there has never been a category of Nature Reserve in Tanzania.

The biological values of the Uzungwa forests which combine the presence of endemic species and rare species with extreme biological richness warrant the highest level of conservation status. When the other forest values are considered—water catchment, soil conservation and the great scenic beauty of the area—this level of protection becomes imperative. Much of the Mwanihana and Uzungwa Scarp slopes are dangerously steep and would pose an extreme erosion hazard under the high rainfall of the area were the forest cover to deteriorate.

Changes in the land use in Tanzania, such as a change of conservation status, as

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for example from ungazetted land to Game Reserve or from Forest Reserve to National Park, require the approval of regional and district authorities before gazetting by the national conservation body. Securing such approval requires an appreciation of local land-use pressures and traditional land-use practice. The alienation of a right or resource should be compensated. The case of Magombera illustrates this problem (Fig. 5).

Magombera Forest Reserve has been bisected by the Tazara Railway and red colobus cannot regularly cross the 70 m wide cutting with its embankment, flanking waterfilled ditches and perpetual through-traffic of people. As a result there are now in effect two red colobus populations, the south estimated at 285 in 7·5 km^2, the north estimated at 140 in 3·5 km^2. The forest was surrounded by newly cultivated rice fields which stretched to the boundary of the 45,000 km^2 Selous Game Reserve some 3 km to the southeast. The rice fields were cultivated by the new Msolwa Ujamaa village, developed since the railway was finished. The village, which is still actively growing, is restricted in agricultural production as it is hemmed in by a sugar estate to the north, forest reserve to the west and game reserve to the east and north. Encroachment into the forest reserve was the path of least resistance as it has no resident Forestry division employees, while the village provides a base for some 120 game reserve staff protecting the Selous from illegal use along this boundary.

Following our survey of Magombera land pressures we made the following suggestions to the Government (Rodgers *et al.*, 1980):

(1) that the southern half of the forest reserve be gazetted as part of the Selous Game Reserve;
(2) that the rice fields between the forest and the Selous become part of the reserve and the villagers be evacuated;
(3) that the northern half of the forest should remain as forest reserve but with right of access for villagers to cut poles and take firewood. (Since our report we have learned that an international rubber company plans a major rubber plantation in the area and it is possible that the northern part of the forest will be lost to this scheme.)
(4) to compensate for the loss of rice lands, an area of the Selous Game Reserve to the east of the village and cut off from the main body of the Selous by the railway should be degazetted and made available for village expansion.

This plan was accepted by all authorities in 1980 and implemented in 1981.

Enhanced conservation status for Mwanihana and Uzungwa Scarp will not deprive local people of existing resources or land use rights. Illegal resource use would be curtailed but this loss should be more than offset by increased employment opportunities with the development of more intensive conservation effort.

The planning of conservation policy for the biological resources of the Uzungwa Mountains should ideally be linked with the conservation of all natural values in Tanzania which, not being closely identified with 'large mammals or tourists', fall

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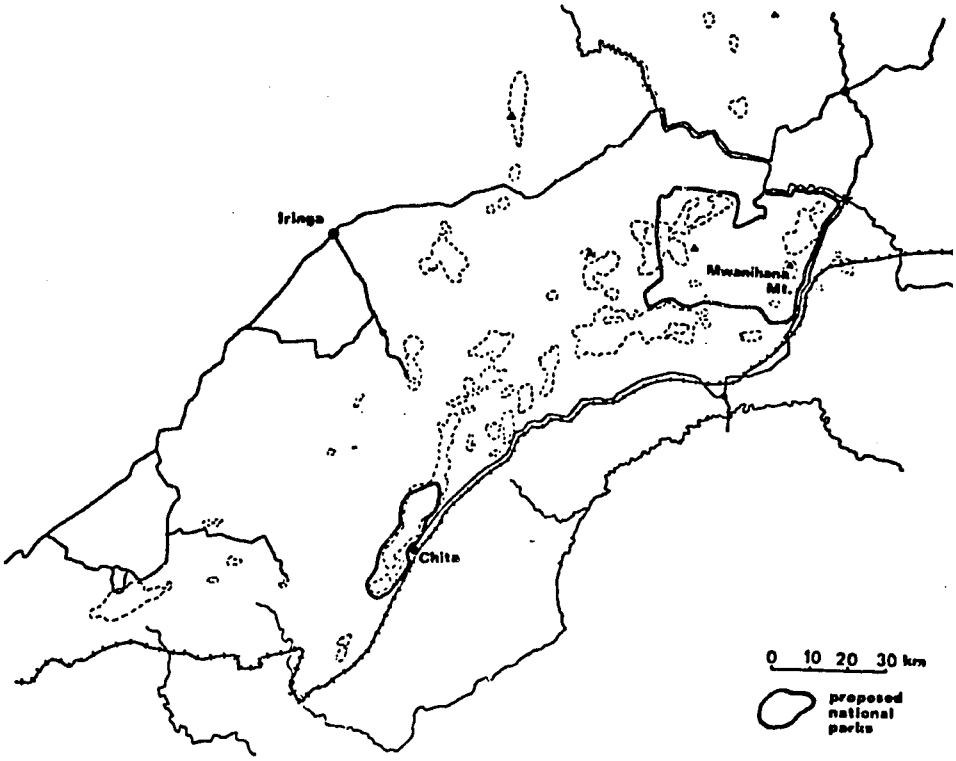

Fig. 6. Proposed national parks.

outside the present orbit of National Parks. The requirement is for the provision of status preventing all resource exploitation and limiting human rights of occupation or access. Only two categories of status approved by the African Convention on Conservation in Ethiopia in 1969 give such protection. They are 'Strict Natural Reserve' and 'National Park'. To date, the category of natural reserve does not exist in Tanzania, and it would require special legislation to introduce such a policy. National Parks do exist, and whilst they are largely concerned with administering tourist-oriented large mammal parks, their recent acquisitions, including Mahari Mountains and Rubondo Island, have been forest areas. It is conceivable therefore that the Parks would be able to administer the purely forest areas. Another possibility is the introduction of Forest National Parks within the Forestry Division, where the ideals and legal safeguards of Park status are met but the administration is undertaken by the forest experts.

How big an area should be upgraded to Park status? Ideally, as large as possible: UNESCO (1976) advocates forest reserve areas of at least 2000 ha for effective conservation. We believe that the gazetting of separate areas in Uzungwa and Mwanihana would doubly safeguard the major resources as well as conserving

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slightly different forest communities. Both are catchment reserves with no exploitation or development plans.

For Uzungwa we advocate the upgrading of the southwestern half of Uzungwa Scarp Forest Reserve, i.e. that in Kilombero District and the adjacent small Reserve up to the Kihansi River, an area of approximately 150 km^2 (Fig. 6) This excludes some of the isolated upper forest areas near Muhanga, which are close to expanding settlement with a growing fuel shortage and an area with considerable human traffic through the forest.

For Mwanihana–West Kilombero we consider the presence of virtually continuous forest cover from 300 m to 2600 m to be of paramount importance. To ensure the conservation of forest above 2200 m, it is necessary to include the eastern portion of West Kilombero Scarp Forest Reserve up to Luhombero Mountain summit. If existing forest reserve boundaries are used to the line of the Ruipa Cutundu Rivers then this whole area, Mwanihana and Eastern West Kilombero, totals about 2500 km^2 (Fig. 6). The area at present is gazetted as catchment forest, timber is totally unexploitable due to the steepness of the terrain and the area is unused by humans, legally or illegally. Elevation to park status would preserve what is one of Africa's richest biological reservoirs in the forest areas, and maintain a large area of scenically spectacular montane grassland wilderness which supports big game populations and has been unused by man for a hundred years or more.

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