The Uluguru Mountains of eastern Tanzania: are we loosing their globally significant biodiversity values?

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Abstract The Uluguru Mountains in eastern Tanzania contain at least 15 vertebrate and 100 plant species as strict endemics, and hundreds more which are shared only with other Eastern Arc Mountains in eastern Tanzania. The high numbers of restricted range taxa in a small area is exceptional in tropical Africa and the area is one of the 10 most important tropical forest sites for conservation on the continent. Recent surveys in the Ulugurus have tried to establish the area of habitat remaining, the number of the endemics that can be confirmed to still exist, and the number of the endemics that might be in danger of extinction given current deforestation patterns. The forest area between 500 m and 2600 m altitude has declined from around 300 sq km in 1955, to 220 sq km today. Almost all the forest now remains within Forest Reserves managed by the Tanzanian Government. The loss of forest has been greatest between 600 m and 1600 m, which is largely in the range of sub-montane forest on the Ulugurus. These sub-montane forests contain a number of strict endemics, and species shared only with other Eastern Arc Mountains. Recent biological surveys have located most of the endemic and near-endemic vertebrate species in the Ulugurus, but have failed to locate three strict endemic vertebrate species, and two near-endemic bird species that have been recorded as occurring in the Ulugurus. Nearly all of the species which have not been found prefer a forest habitat at the elevation where deforestation has been greatest. It is likely that deforestation is the cause of the loss of these species.

Keywords Uluguru Mountains, Tanzania, endemics, forest loss, extinction risk

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Introduction

The Uluguru Mountains in eastern Tanzania (0651–0712S 3736–3745E) form one of the component blocks of the Eastern Arc Mountains of Kenya and Tanzania (Lovett, 1988, Lovett 1990). The Eastern Arc stretches from the Taita Hills in southern Kenya to the Udzungwa Mountains in south-central Tanzania (Figure 1). The Eastern Arc has long been known as a centre of both botanical (Polhill, 1968) and faunal (Moreau 1966; Allen and Loveridge 1927; Loveridge, 1942) diversity and endemism.

The unique nature of the mountains was recognised at national level in the Tanzania Forest Action Plan (Bensted-Smith & Msangi, 1989), a Tanzanian government supported planning process, which proposed conservation projects for the Eastern Arc. The Eastern Arc Mountains have also been recognised by three different international organisations as an area of global importance for the conservation of biodiversity (ICBP, 1992; Stattersfield *et al*., 1998; Mittermeier *et al*., 1998; 1999; Myers *et al*., 2000; Olson and Dinerstein, 1998). Moreover, the importance of the Eastern Arc and adjacent lowland coastal forests has been highlighted in the Country Study on Biodiversity (GOT, 1998) and the forthcoming

Tanzanian Forest Programme (GOT, in prep). All these analyses have been based on a compilation of all available biological data, some of which is decades old. They may therefore not reflect the actual situation at the sites if the forests have been removed and their species have already become extinct.

The Uluguru Mountains are one of the mountain blocks in the Eastern Arc Mountain Range. In a national survey of Catchment Forest Reserves, which are administered by central government, the Uluguru mountains were ranked has having the greatest importance (Lovett and Pócs, 1993), more recently these Mountains have been assessed as the third most important mountain block in the Eastern Arc for their fauna (Burgess *et al*., 1998c) and plants (Lovett, 1998; Pócs, 1998). The Ulugurus range from around 150 m altitude on their south-eastern margin, and extend to over 2600 m altitude at their highest point. In total they cover around 1500 sq km of highlands, mainly in a ridge running almost north-south, but with a few outlying hills around the main ridge. The natural vegetation is moist forest, with the eastern slope of the mountains receiving in excess of 3000 mm of rain a year with every 100 mm of rain in every month. The forests are thus per-humid, which is unusual in Africa. At high elevations in the southern Uluguru mountains the forest gives way to grassland above the frost line. The mountains are very steep and there are extensive cliffs and rock outcrops. Endemic plants and animals occur throughout the elevational range of the mountains, in both forest and non-forest habitats that have not been extensively disturbed.

In this paper we use new data from the Uluguru Mountains to summarise changes in forest area, the total number of endemic species and their altitudinal preferences. Results of field surveys aiming to locate the strict endemic species of the Uluguru Mountains provide a further opportunity to assess whether any species have been lost from the Ulugurus, and whether clear reasons can be determined for any such losses.

The Uluguru Mountains Biodiversity Conservation Project (UMBCP)

This project is a collaboration between the Danish Ornithological Society (BirdLife Denmark), the Wildlife Conservation Society of Tanzania (BirdLife Tanzania), the Morogoro Regional Catchment Forest Project Office, the Morogoro Natural Resources Office and the University of Sokoine in Morogoro. The funding for the project comes from the Danish Development Agency, DANIDA. One of the aims of the project is to collect and distribute data on the status and condition of the Uluguru forests, and their biodiversity. The project has pursed this aim since 1999, but it builds upon two decades of previous field work and data compilation efforts (Lovett & Pócs, 1993, Lovett and Wasser, 1993; Svendsen & Hansen, 1995; Burgess & Clarke, 2000; Burgess *et al.,* 1998a, b).

Data on the Uluguru forests and their biodiversity

Forest status data. Forest status data have been obtained by digitising forest cover information from aerial photographs taken in 1955 and 1977/82. The current (2000) forest cover has been extrapolated from the original boundary maps of the existing Forest Reserves on the Ulugurus, with the positions of the forest borders checked through field surveys in and around all of the Uluguru Forest Reserves. Remaining forest patches on the farmed lands outside the Forest Reserves have also been mapped through field surveys during 2000. A topographical model of the Ulugurus has been built in Arc View GIS and this has allowed the forest cover within 100 m altitude bands to be assessed for 1955 and 1977/82. This analysis provides a means to assess differential loss of forest at various altitudinal bands that can then be related to the available biodiversity data to see whether the biodiversity values are particularly threatened at different altitudes on the mountain.

Biological data. Existing animal data for the Uluguru Mountains have been summarised from the literature (Rodgers *et al*. 1983; Lovett & Wasser, 1993; Svendsen and Hansen, 1995; Burgess *et al*. 1998a,b; Stanley *et al*. 1998, Channing, 2000; Doggart *et al*. in prep). This compilation includes an assessment of when the species was first found in the Ulugurus, what its altitudinal preferences are thought to be, and whether the endemic species have been recently recorded on the Uluguru Mountains. In this paper 'recently recorded' means the species has been recorded in the period between 1980 and 2000, during which time assessments have been made of the birds, mammals, reptiles and amphibians of all the Forest Reserves of the Ulugurus. Field data collected during 1999 and 2000 by the Uluguru Mountains Biodiversity Conservation Programme (UMBCP) are summarised in Doggart *et al*. (in pre), and are held at the Tanzanian Biodiversity Database at the University of Dar es Salaam and the biodiversity database of the UMBCP in Morogoro. Data on endemic plants are mainly taken from an assessment of the information in the List of East African Plants (LEAP, 1995), augmented by visits to Lushoto, Arusha and Dar es Salaam herbaria in Tanzania (Temu & Nsolomo, 2000). There have also been some recent field botanical collections by UMBCP. In the analysis here, the forests are divided up by elevation into lowland, submontane, montane and upper montane using the definitions of Lovett (1993).

Change in forest cover

Overall changes There has been a large loss of evergreen forest on the Uluguru Mountains (Figures 2, 3). Using climatic data and the presence of evergreen forest patches to define past forest limits we estimate the potential natural closed forest cover in the Ulugurus to be around 500 sq. km. In 1955 the forest cover was 300 sq km, a decline of 200 sq km from the potential cover. Between 1955 and 1977 the area of forest declined by 60 sq km. Field assessments of the current geographical extent of the remaining forest indicate that a little over 220 sq km remains. This is less than 40 % of the potential forest area. Most of the forest loss has been caused by change in land use from forest to subsistence farms with maize and various other crops. Fallow fields are often dominated by bracken (*Pteridium aquilinum*) and can only be used for farming on rotations of several years. Other areas grow bananas, oranges or other tree crops; mainly in lower elevations close to roads. Farms do not offer suitable habitat to forest-dependent endemic taxa.

Evergreen forest on the Ulugurus is now almost entirely confined to Catchment Forest Reserves, managed centrally by the Tanzanian government. Our assessment of the vegetation in the 22 Forest Reserves on the Ulugurus (Table 1) shows that 15 have predominantly natural evergreen forest cover and seven are either woodlands, plantations, or are deforested. Forest formerly existed on village lands, but this has been largely cleared. For example, in the past 10-15 years around 15 sq km of forest has been lost on the Kitundu/Kitumbaku Hills outside the Uluguru North Forest Reserve on the north-east portion of the Mountains (Figure 3). This large area of forest was formerly under the authority of the traditional Chief, but political changes since 1964 have meant that his authority has been lost. In consequence they have been cleared or badly degraded by the local villagers. Other patches of forest remain in the farmlands around the Ulugurus, but these are small and are still being rapidly cleared for small-holder cultivation, except where they have traditional religious significance or are found on rocky outcrops.

Altitudinal loss An analysis of the forest loss data shows that the principal change in forest cover between 1955 and 1977/82 occurred at the lower to medium altitudes (i.e. between 500 and 1600 m altitude) (Figure 4). This loss has occurred almost entirely outside the Forest Reserves, especially those of Uluguru South, Uluguru North and Bunduki which have remained quite intact. Field surveys over the past year show that further forest loss at lower altitudes has occurred since 1977. Today only a few square kilometres of forest with an intact

canopy remains outside of the Forest Reserves, with some altitude bands now containing almost no forest at all.

Change in biodiversity values

Overall values Recent surveys of birds (Svendsen & Hansen 1995; Doggart *et al.,* in prep.), mammals (Stanley *et al.,* 1998; Perkin, 2000; Doggart *et al.,* in prep.), reptiles (Doggart *et al.,* in prep.) and amphibians (Channing, 2000; Doggart *et al.,* in prep.) have recorded 12 of the 15 known Uluguru endemic animals. All of the strict endemics that have not been located are snakes. In terms of the near-endemic species shared only with other Eastern Arc Mountains, we have managed to locate all the relevant mammal, reptile and amphibian species. The recent surveys have also discovered rare species on the Ulugurus that were previously only known from other Eastern Arc Mountains. The discovery of species not previously located on the Ulugurus suggests that other undiscovered species may still exist, and also that additional species may have existed in deforested areas. Surveys of birds in the Ulugurus from the 1970s through to the current date have failed to locate two species of birds which have been previously recorded; the Tanzanian Mountain Weaver *Ploceus nicolli* which was found in montane forest and the Banded Green Sunbird *Anthreptes rubritorques* which was found in sub-montane forest.

Altitudinal loss Analysis of the altitudinal distribution of the strict endemic species in the Ulugurus shows that one of these species is found in the lowland forests, six in the sub-montane, 12 in the montane and five in the upper montane forest (Table 2; Figure 5). Deforestation has been focused in the lowland and sub-montane bands, especially the sub-montane areas of unreserved forests that were formerly found on the Public Lands of the Ulugurus (see Figure 2).

Analyses of ornithological/habitat data collected on the globally threatened Uluguru Bush Shrike (Romdal *et al*. in prep), indicates that this species prefers lower altitude forests with good canopy cover. The loss of forest at lower altitudes may have already had a detrimental effect on the population of this species. For example there are records of the bird at 2100 m in Uluguru South above Tchenzema from 1981 (Collar & Stuart, 1985, Stuart & Jensen, 1985), but surveys in early 2000 at the same site failed to locate the species, and it may now be extinct in this reserve, perhaps due to the loss of all lower altitude forests in the immediate vicinity. This possibility is heightened by the fact that the recent surveys were undertaken in December-January which is the hottest season and the birds (which may undertake seasonal migrations) would be expected to occur at their maximum altitude (see Burgess and Mlingwa, 2000). The continuing removal of the lower altitude forests in Uluguru North (outside the Catchment Reserves) causes concern for the future of this species. Other animals which were originally recorded at lower altitudes in areas which have now been deforested in the Ulugurus and which have not been recorded in the recent biological surveys are the snakes *Prosymna ornatissima, Typhlops uluguruensis* and *Typhlops* sp. nov. As these species were only known from areas which have been seriously deforested there must be a chance that they are now extinct, unless they are able to survive in non-forest habitats, or are found at higher altitudes than is currently known. As mentioned above two species of birds found in the sub-montane and montane forests have not been recorded for decades. These may now be extinct in the Ulugurus.

A similar picture emerges from the compiled plant data (Figure 5) where a considerable number of the narrowly endemic species are known from the lowland and sub-montane forests and which might therefore either be extinct or threatened by extinction in the Ulugurus. At least two Uluguru endemic species are known only from the Kitundu/Kitumbaku Hills, the area of highest recent deforestation. In general plants endemic to eastern Tanzanian forests occur throughout the elevational range of the forests, but many

are confined to narrow altitudinal bands within these forests (Lovett *et al*. in press). Hence the loss of forest in a particular altitudinal band will lead to species loss. Detailed botanical surveys would be required to determine if all the plants recorded previously from the Uluguru still survive.

Future needs

Preliminary results of ongoing forest status and biodiversity surveys in the Uluguru Mountains indicate that despite the huge loss of forest in the area, many of the endemic animal species still survive. Of those strict endemics which have not been located, most are snakes (even burrowing snakes) and hence difficult to find. They may still survive and some targeted intensive surveys close to their known localities would be an important way to assess this. However, the fact that the majority of the species that have not been found are known from the altitudes that have been most intensively deforested is a cause of great concern.

For the plants no recent surveys have been undertaken aiming to relocate the more than 100 strictly endemic species. This would be required to confirm they still survive in the Ulugurus. The fact that some species are only known from areas that have been deforested indicates that some of the endemic plants are threatened with extinction, or might be already extinct. Moreover, the fact that Eastern Arc endemic forest plants are known to have a narrow elevational range further suggests that the deforestation on the Ulugurus has probably driven some plants close to extinction, or even made them extinct. Given the patchy nature of botanical exploration in the area, some species of plants with small distributional ranges may have been made extinct through deforestation before they were known to science.

The fact that almost all the forest on the Ulugurus is now found within the boundaries of the Catchment Forest Reserves managed by the Tanzanian Government is a strong vindication of the value of these reserves for the conservation of biodiversity. This was not their original aim as most of the forests were reserved for their water catchment functions and to prevent landslides and flooding downstream. The Ulugurus have some of the highest rainfall in Tanzania and are the most important water catchment forest in the country (Jackson, 1970; Temple, 1972a,b; Bensted-Smith and Msangi, 1989), the areas outside the forest are also highly landslide prone (Temple and Rapp, 1972).

The Forest Reserves of the Ulugurus now contain forests as isolated units. In particular the Uluguru North and Uluguru South forests were in 1955 (from aerial photographs) connected across the Bunduki Depression. This connection was severed shortly after that time and now the area is farmland with a dense human population. Most of the forest species of Uluguru South and North will now be confined to their reserves because forest specialists will generally not venture across large gaps (e.g. Fjeldså, 1999). Ideally these reserves should be reconnected through the establishment of forest corridors, but this will not be easy in such a densely populated area where farmland is already scarce.

The importance of these forests as a catchment area for millions of people in Tanzania is poorly described. Previous studies by Pócs (1974, 1976a,b) described how the forests assist in trapping water which then flows to Morogoro and Dar es Salaam towns, but there seems to be only preliminary data on the water flow from the mountains (Jackson, 1970; Temple, 1972a,b) and there is no information of how water flows might have changed over time. Critically, it is now known whether the current deforestation in the Kitundu/Kitumbaku Hills is affecting the water catchment potential of the Ulugurus and hence the water flow to Morogoro and the commercial capital, Dar es Salaam, where 2-3 million people live and where access to water is already a major problem for many.

It is hoped that future links can be made between the water values of the forest, their global biodiversity importance and the needs of the managers of the Catchment Forest Reserves for moderate funds to continue their work to conserve these forests for the benefit of Tanzania and the global community. In addition to this aim, it is also of importance that the approximately 200,000 people living on the slopes of the Ulugurus also perceive the benefit of the Catchment Forest Reserves. This is especially important to prevent future conflicts between the human populations need for additional farmland areas and the conservation of the forest resource. Population growth in the Ulugurus is generally 2.5-3% per annum with a population doubling time of around 20 years. Supporting twice as many people on the same area of farmland, using the current agricultural methods, without encroachment into the reserves will be a major challenge. However, it is believed that models could be applied from other parts of Africa - where mechanisms have been developed which assist local development whilst also keeping the forests intact. Perhaps the most appropriate models are provided by the development of conservation trust funds where donor funds have been used to create a sustainable financial mechanism for the conservation of an area. One example that seems to be working is in the Bwindi forest in Uganda. Full local involvement means that local priorities can also be financed making a direct link between development and the conservation of the forest. Trust funds are also being explored for the Uluguru Mountains. Sources of financing for this fund could come from aid donors, but there are also local Tanzanian sources of funds that could contribute significantly to such a fund. For example, the water supply from the Ulugurus contributes to much of the industrial production of the country and a system which linked economic production to financing of the Uluguru water supply trust fund would make long term economic sense to Tanzania. Suitably managed, such a fund would be able to manage the forests AND to provide assist the agricultural and social development of the Waluguru people.

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Table 1. Forest Reserves of the Ulugurus, with notes on their current status (from Lovett and Pócs, 1993 updated from field surveys in 1999 and 2000).

Name of Forest Reserve	Owner-ship	Govt. Declaration Number	Area in hectares	Brief description of the vegetation and status of the reserve
BUNDUKI I-III	CFR	Cap. 132 1950	111.0	Plantation and natural forest. Plantation is being logged on licence. Fuel and pole gathering
BUNDUKI IV	CFR	Cap. 132 1950	6.1	Plantation and natural forest. Plantation is being logged on licence. Fuel and pole gathering
BUNDUKI V	CFR	Cap. 132 1950	3.7	Plantation and natural forest. Plantation is being logged on licence. Fuel and pole gathering
BUNDUKI VI	CFR	Cap. 132 1950	2.6	Plantation and natural forest. Plantation is being logged on licence. Fuel and pole gathering
CHAMANYANI	CFR	Cap. 132 1950	796.0	Mainly woodland with a few riverine forest strips. A little logging. Fuel and pole gathering
KASANGA	CFR	1907	70.0	Mainly a plantation, but with some natural forest regrowth. Being logged and farmed. Fuel and pole gathering
KIMBOZA	CFR	1907	385.9	Some natural forest and some plantation. Joint Forest Management experiments here. Fuel and pole gathering
MINDU	CFR	CFR	2285.0	Outlying Hill west of Ulugurus. Mainly woodland with a little forest on the top. Some damage from logging. Fuel and pole gathering
MKUNGWE	CFR	1954	1966.8	Outlying Hill east of Ulugurus. Lowland to sub-montane forest in good condition. Some new pitsawing. Fuel and pole gathering
MVUHA	CFR	Cap 132 1950	851.6	Mainly woodland with a few riverine forest strips. A little logging. Fuel and pole gathering
NYANDIDUMA	CFR	Cap. 132 1950	47.8	A plantation of *Eucalyptus* which is being cut. Fuel and pole gathering
NYANDIRA	CFR	German	194.8	A plantation of *Eucalyptus* which is being cut. Fuel and pole gathering
PALANGWE EAST	CFR	1963	768.5	Woodland which burns ever year. Not valuable for water catchment. Fuel wood gathering
PALANGWE WEST	CFR	1963	184.0	Woodland which burns ever year. Not valuable for water catchment Fuel wood gathering
RUVU	CFR	1955	3093.5	Woodland and lowland forest. A lot of mining damage and some logging. Fuel and pole gathering
SHIKURUFUMI	CFR	1948	260.0	Plantation and secondary forest. Fuel and pole gathering
ULUGURU NORTH	CFR	German and 1961	8356.7	Large area of submontane to upper montane forest. Farmland encroachment and illegal hunting, pitsawing and fuel and pole gathering.
ULUGURU SOUTH	CFR	German	17292.7	Large area of montane to upper montane forest with some grasslands. Farmland encroachment and illegal hunting, pitsawing and fuel and pole gathering.
VIGOZA	CFR	Cap. 132 1950	9.3	Former plantation, now cleared and farmed. Fuel and pole gathering
MANGALA	DFR	?1968	34.8	Local authority reserve largely managed by the village with lowland forest under threat from conversion to farmland. Fuel and pole gathering
MILAWILILA	DFR	?1968		Local authority reserve largely managed by the village with lowland forest under threat from conversion to farmland. Fuel and pole gathering
NGAMBAULA	DFR	?1968		Local authority reserve largely managed by the village with lowland forest under threat from conversion to farmland. Fuel and pole gathering
NGURU YA NDEGE	DFR	1962	38190.3	Outlying Hill west of Ulugurus. Mainly woodland with a little forest on the top. Lots of damage from timber, charcoal, fuelwood and pole cutting.
KONGA	Village	1910	5.3	Degazetted and now managed by the village. Good lowland patch, with some tree cutting for local use.

Key. CFR = Catchment Forest Reserve managed by the central government Forest and Beekeeping Division Catchment Forestry Project. DFR = Local Authority Forest Reserve managed by the local government Morogoro Rural District. Village = a former Forest Reserve which has been degazetted, but which still contains forest.

Table 2 Strict endemic Vertebrate Species in the Uluguru Mountains and their habitat and altitudinal distributions

Species	Described	Forest	Altitudinal Distribution			
			Lowland	Sub-montane	Montane	Upper Montane
Birds						
Malaconotus alius	Friedmann, 1927	FF		x	x	
Nectarinia loveridgei	Hartert, 1922	FF		x	x	x
Mammals						
Crocidura telfordi	Hutterer, 1986	FF			x	
Myosorex geata	Allen & Loveridge, 1927	FF			x	x
Reptiles						
Lygodactlus williamsi	Loveridge, 1952	FF	x			
Prosymna ornatissima	Barbour & Loveridge, 1928	F		x		
Rhampholeon uluguruensis	Tilbury & Emmrich, 1996	FF		x	x	
Typhlops uluguruensis	Barbour & Loveridge, 1928	F		x		
Typhlops sp. nov.	Broadley *in lit.*	F		x		
Amphibians						
Hyperolius tornieri	Ahl, 1931	FF			x	
Nectophrynoides cryptus	Perret, 1971	FF			x	x
Nectophrynoides minutus	Perret, 1972	FF			x	x
Nectophyrnoides sp.nov.	Howell *in lit*.	FF			x	
Probreviceps uluguruensis	Loveridge, 1925	FF			x	x
Scolecomorphus uluguruensis	Barbour & Loveridge, 1928	FF			x	
	TOTALS		**1**	**6**	**12**	**5**

Key. FF= dense forest only, F=dense forest and forest edge
lowland=0-800m alt, sub-montane=800-1500 m alt, montane=1500-2100 m alt, upper montane=>2100 m altitude.

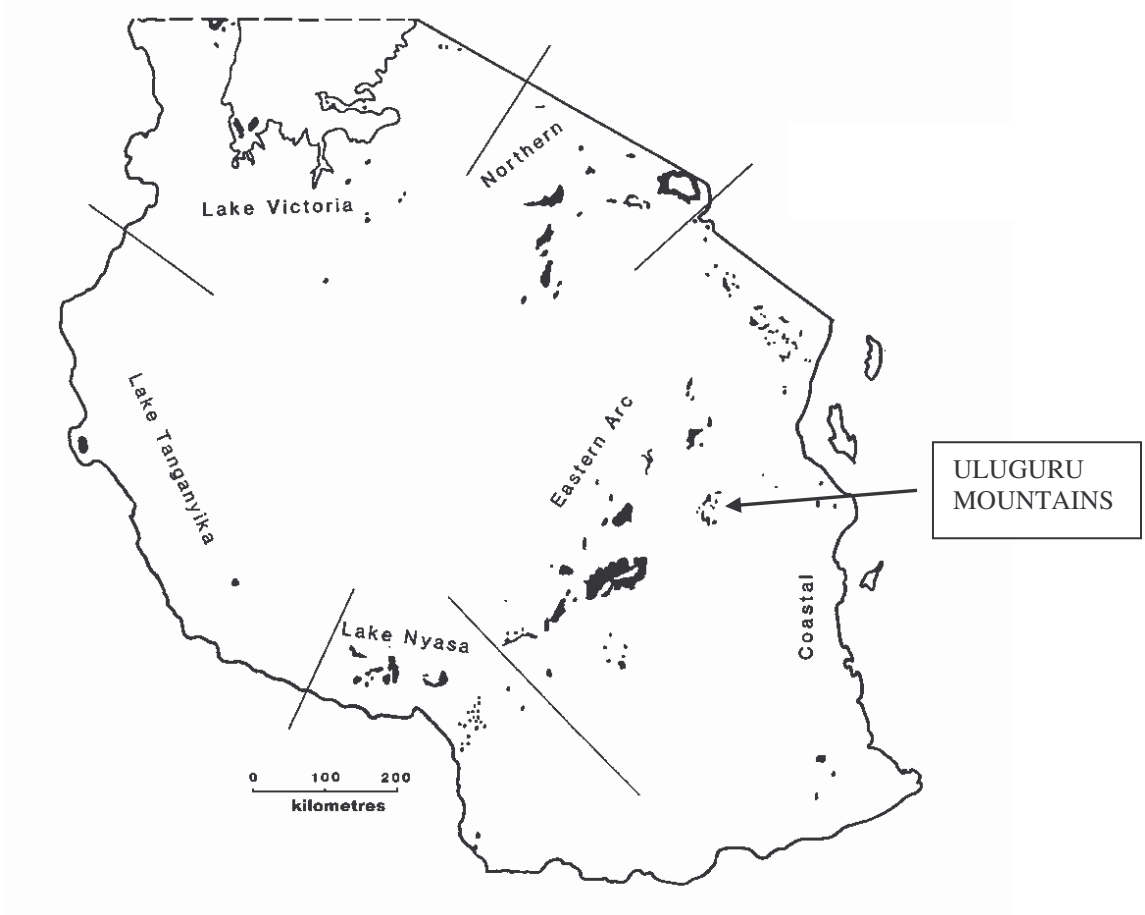

Figure 1. Division of Tanzanian forests on the basis of geology and climate (from Lovett, 1990; 1998). Forest distribution is based on forest reserves containing closed forest formations. Coastal, Eastern Arc and Northern forests are under the direct climatic influence of the Indian Ocean, but Coastal forests are predominantly on sedimentary rocks, the Eastern Arc are on igneous and metamorphic rocks, and Northern forests are predominantly on volcanic areas (with the exception of the Mbulu highlands). Forests associated with the great lakes of Victoria, Tanganyika and Nyasa are subject to environmental fluctuations associated with variation in the local climates associated with these lakes.

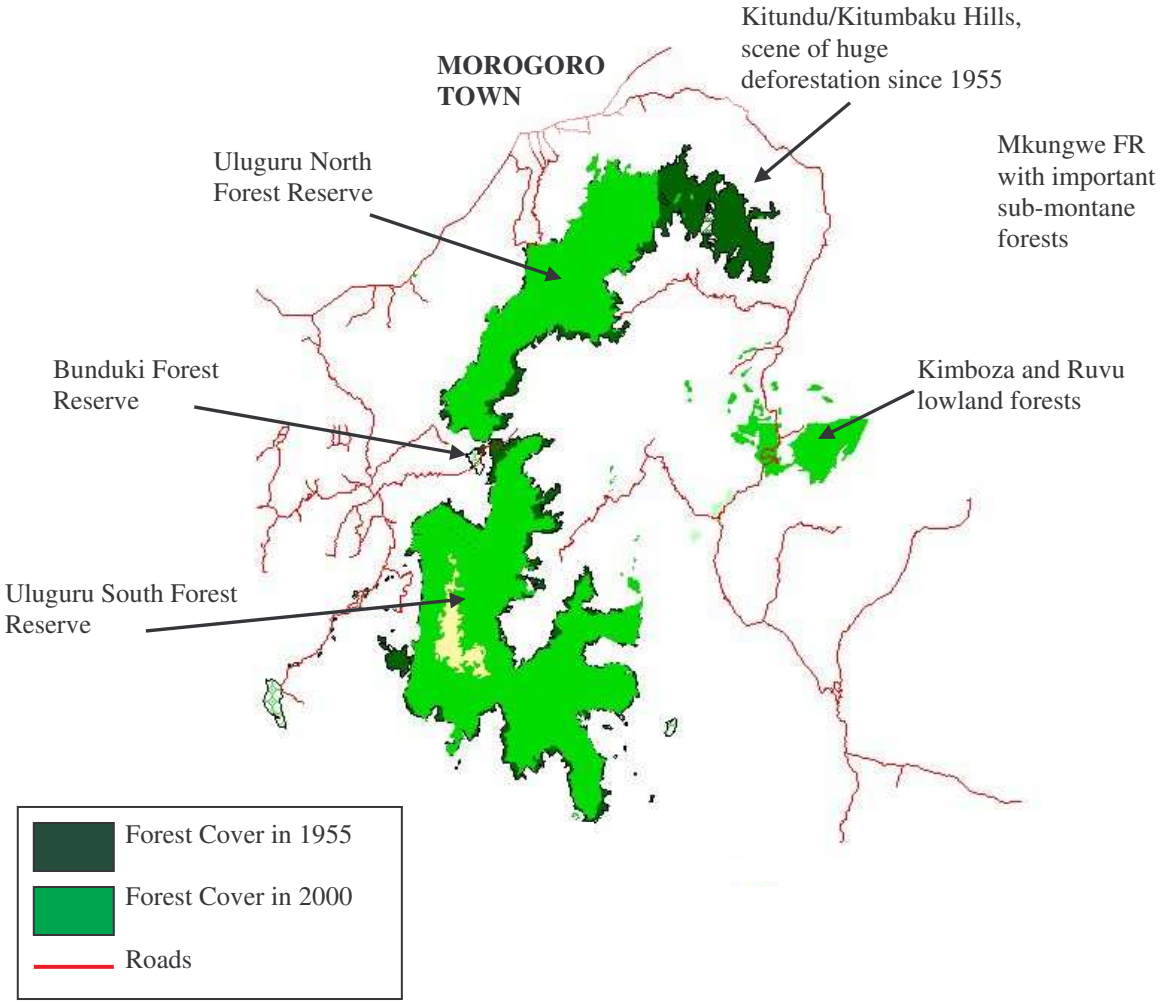

Figure 2. Forest cover in 1955 in the vicinity of Uluguru North (top), Bunduki (middle) and Uluguru South (bottom) Catchment Forest Reserves. Forest is now almost confined to the Forest Reserves, except on the southern margin of Uluguru South, and some fragments.

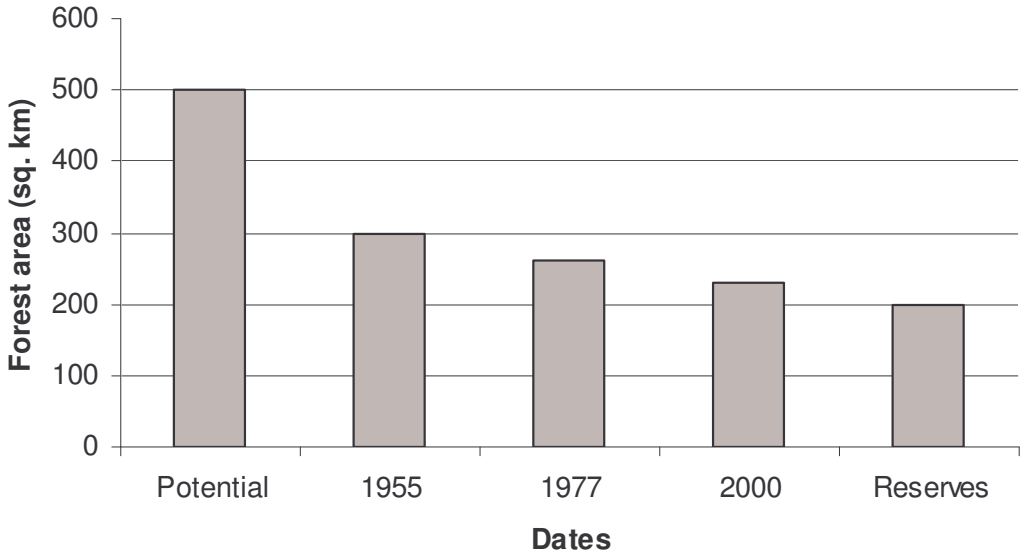

Figure 3. Changes in the area of forest on the Uluguru Mountains. Potential is estimated from climate and the extent of lowland forest patches which are assumed to have been originally joined. Estimates for 1955 and 1977 are based on aerial photographs, and for 2000 on ground surveys. 'Reserves' is an estimate of the minimum forest area if the present reserves are maintained, with little encroachment, but all forest outside is lost (around 20 sq km of the Uluguru Forest reserves is upland grassland and some is rock).

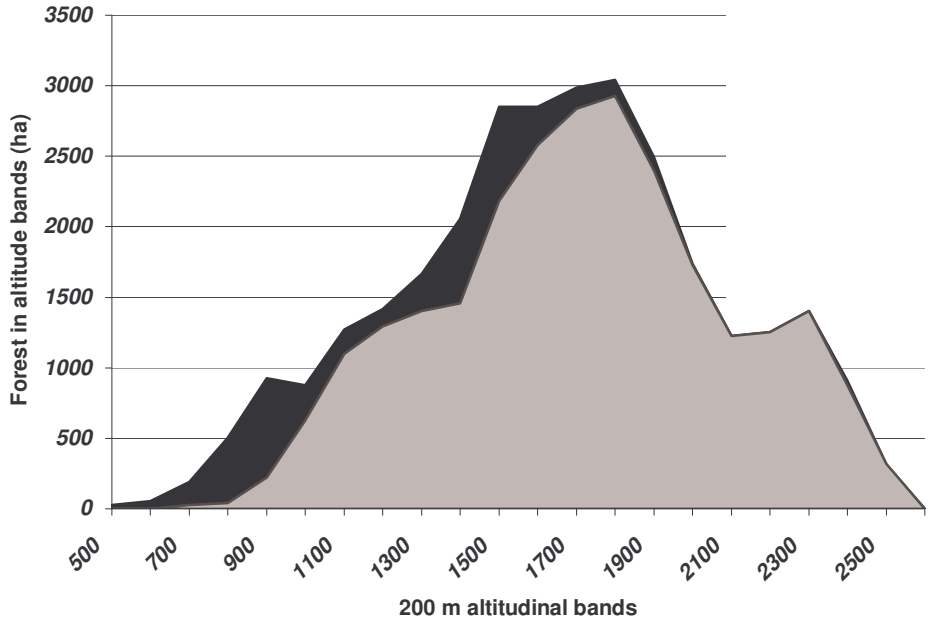

Figure 4. Altitudinal distribution of montane forests in the Uluguru Mountains, 1955 and 1977, illustrating the greatest forest loss between 700 and 1700 m, and very little forest loss above this altitude.

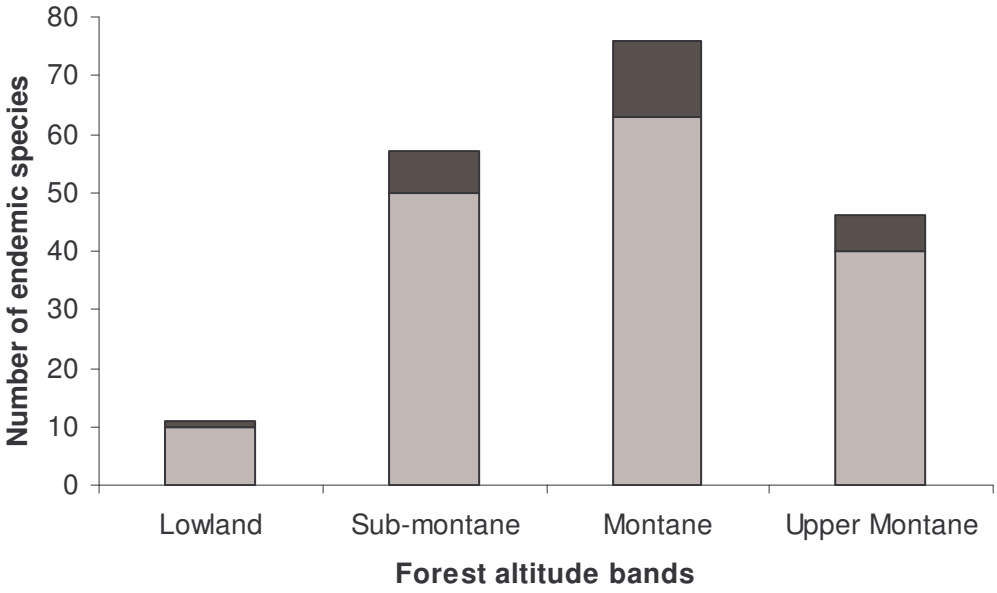

Figure 5: Altitudinal Distribution of Uluguru Mountains Strict Endemic Plants (grey) and Strict endemic Animals (black). Most of these strict endemics are forest species. Lowland forest ranges from 0-800m, sub-montane forest from 900-1500 m, montane forest from 1500-2100 m and upper montane forest above 2100 m.