TECHNICAL PAPER 32

Mlungui Proposed Forest Reserve

A biodiversity survey

Frontier-Tanzania
University of Dar es Salaam
Society for Environmental Exploration

East Usambara Catchment Forest Project

Technical Paper 32

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A biodiversity survey

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East Usambara Catchment Forest Project (EUCFP)
The East Usambara rain forests are one of the most valuable conservation areas in Africa. Several plant and animals are found only in the East Usambara mountains. The rain forests secure the water supply of 200,000 people and the local people in the mountains depend on these forests. The East Usambara Catchment Forest Project aims at establishing the Amani Nature Reserve; protecting water sources; establishing and protecting forest reserves; sustaining villager's benefits from the forest; and rehabilitating the Amani Botanical Garden. The project is implemented by the Forestry and Beekeeping Division of the Ministry of Natural Resources and Tourism with financial support from the Government of Finland, and implementation support from the Finnish Forest and Park Service. To monitor the impact of the project, both baseline biodiversity assessments and development of a monitoring system are needed. The present activity is aimed at establishing baseline information on biological diversity in selected East Usambara forests.

The University of Dar es Salaam (UDSM)
The University of Dar es Salaam was established in July 1970 as a centre for learning and research in the arts and the physical, natural, earth, marine, medical and human sciences. The University is surveying and mapping the flora and fauna of Tanzania and is conducting research into the maintenance and improvement of the environment and the sustainable exploitation of Tanzania's natural resources.

The Society for Environmental Exploration (SEE)
The Society is a non-profit making company limited by guarantee and was formed in 1989. The Society's objectives are to advance field research into environmental issues and implement practical projects contributing to the conservation of natural resources. Projects organised by The Society are joint initiatives developed in collaboration with national research agencies in co-operating countries.

Frontier Tanzania Forest Research Programme (FT FRP)
The Society for Environmental Exploration and the University of Dar es Salaam have been conducting collaborative research into environmental issues since July 1989 under the title of the Frontier Tanzania Forest Research Programme (FT FRP). Since July 1994, the FT FRP has been working in the forests of the East Usambara mountains in collaboration with the East Usambara Catchment Forest Project (EUCFP). This survey of selected forests collects baseline biodiversity data and assists the EUCFP in the management of the East Usambara forests.

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TABLE OF CONTENTS **Page**

LIST OF TABLES

LIST OF FIGURES

FOREWORD

The East Usambara forests in north-eastern Tanzania are part of the Eastern Arc mountains. More than one hundred years of biological interest and research has shown that these forests have a unique diversity of flora and fauna, and an exceptionally high degree of endemism. They are globally listed as one of the biodiversity hotspots and centres of plant diversity, and recognized as among the most valuable conservation areas in Africa. Since 1990, the East Usambara Catchment Forest Project (EUCFP) has worked in the East Usambaras mountains with the mission to protect these natural forests. The project is implemented by the Forestry and Beekeeping Division (FBD) of the Ministry of Natural Resources and Tourism (MNRT) with financial support from the Government of Finland, and implementation support from the Finnish Forest and Park Service (FPS).

Although a considerable amount of biological information exists from the East Usambaras much of this is restricted to the Amani area and systematic surveys are few. In order to get more comprehensive information on the forests biodiversity surveys were initiated and contracted by EUCFP in July 1995. The surveys are conducted by Frontier Tanzania, a joint venture between the University of Dar es Salaam and the Society for Environmental Exploration, together with EUCFP. The aim of the surveys is to provide systematic baseline information on the biological values of different forests as a basis for management planning and long-term monitoring, as well as training forestry staff in the use of biological inventory techniques. They will also help setting of priorities in the conservation of this valuable area.

The surveys have been carried out over ten-week field phases. The programme involves short-term expatriate volunteer research assistants, permanent EUCFP, Frontier, University of Dar es Salaam, and Tanzania Forestry Research Institute staff, as well as an international network of taxonomists and other experts. The surveys have become progressively more systematic and quantitative, and have already resulted in the discovery of several previously unknown taxa. This will further raise awareness of the unique conservation values of the East Usambaras. EUCFP has also commisioned the development of a biodiversity database, a work which also contributed the maps to these reports. All data collected during the surveys will be entered in this database, which is linked to the national biodiversity database and will become operational in 1997.

The reports are the result of the work of many people – too many to be listed here. We would like to thank all of them for their invaluable effort. We hope that the surveys will make yet another contribution to the long historic chain of efforts to study and understand these unique forests. Perhaps even more than that we hope that this information will contribute to a better management and conservation of the East Usambaras so that the beauty of the area will continue to amaze coming generations and that the light in the tunnel will become the bright future.

M.I.L. Katigula
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Abstract

Mlungui proposed forest reserve is situated in the East Usambara mountains in north-east Tanzania. The East Usambaras form part of the mountain chain called the Eastern Arc which ranges from southern Kenya to southern Tanzania. These mountains are known for their high levels of species endemism and rich floral and faunal diversity (Hamilton, 1989). To investigate further this biodiversity, a biological survey of Mlungui proposed forest reserve was carried out between July and September 1995 for a total of 26 research-days.

This report summarises the findings of the survey in terms of floral and faunal inventories. Notes on ecological requirements and degree of endemism for each species is presented to provide an indication of the number of (a) forest dependent species as opposed to forest non-dependent and non-forest species; (b) threatened and rare species (based on IUCN 1994 criteria[1]) and (c) endemics and near-endemics[2] to the Usambara mountains. These are presented to highlight the importance of Mlungui proposed forest reserve in a national and international context. These two categories are then combined to assess which species are considered at high risk of becoming locally extinct if the forest continues to be further degraded and fragmented.

The survey of Mlungui identified 56 species of tree and shrub, five species of mammal, nine species of reptile and three species of amphibian.

Flora

No tree or shrub species were recorded which are endemic to the Usambara mountains but 16 were recorded that have restricted ranges limited to the Eastern Arc and/or East African lowland forests. Thirteen species are dependent on primary forest, and of these species, five are also near endemic to the Usambara mountains. Seven non-forest tree and shrub species are established within the reserve boundaries.

Species of particular interest encountered during this survey include:

- The record of *Dichapetalum stuhlmannii* in Mlungui proposed forest reserve represents a range extension (Flora of Tropical East Africa, FTEA). This species is known from the West but not the East Usambaras (FTEA);

1 All IUCN notes are based on IUCN 1994 criteria for species as compiled by the National Biodiversity Database in the Department of Zoology and Marine Biology, UDSM, Dar es Salaam. Definitions are as follows:
Endangered - a species facing a very high risk of extinction in the wild in the near future.
Vulnerable - a species facing a high risk of extinction in the wild in the medium-term future.
Near threatened - species which are close to qualifying for the status 'Vulnerable.'

2 Endemic - Species occurring only in the Usambara mountains
Near-endemic - Species with limited ranges in the Eastern Arc mountains and/or the East African lowlands between Somalia and Mozambique (Iversen, 1991b).

- *Dichapetalum macrocarpum* is a shrub of southern Tanzania and of the Mozambique, Niassa Province (FTEA). This is a new record in NE Tanzania. This species is typical of *Brachystegia* woodland, bushland and thicket;

- *Olax gambecola*, a shrub typical of rain and riverine forest in Uganda and of the Pwani and Morogoro Regions. Its occurrence in the Usambara mountains is a range extension;

- *Tricalysia pedicellata* is a forest dependent tree previously considered restricted to Pwani and Morogoro Regions (FTEA).

Fauna

One vertebrate species was recorded which is endemic to the Usambara mountains and three near-endemic vertebrate species were recorded whose ranges are restricted to the Eastern Arc and/or East African lowland forests. Four species are dependent on primary forest, and of these species, three are also endemic or near endemic to the Usambara mountains. One non-forest species is established in the reserve.

The butterfly survey recorded four near-endemic species of which all are forest dependent species.

Species of particular interest encountered during this survey include:

- *Prosymna semifasciata* sp. nov. was recorded. This is the second specimen recorded. Previously only known from Kwamgumi forest reserve. This species is considered 'Critically Endangered' by IUCN;

- *Philothamnus macrops* and *Agama montana* are listed as 'Vulnerable' by IUCN.

Soils

Three broad soil types were identified. These are largely correlated with catenary position: summit and steep upper slope, mid-slope and lower slope. These three soil types largely overlay the three corresponding vegetation types of mature mixed forest, poorly stocked forest and highly disturbed and cultivated areas.

Disturbance

Disturbance was assessed along three transects within the reserve boundaries. Pole cutting was found at high levels in all areas: mature forest, poorly stocked forest and in previously cultivated areas. Timber extraction was found at higher rates on the lower slopes but limited timber extraction was also recorded on the upper slopes and summit at Mlungui Hill where the only remaining mature forest exists.

1.0 INTRODUCTION: EAST USAMBARA AND FOREST DIVERSITY

The East Usambara mountains are situated in north-east Tanzania, close (40 km) to the coastal town of Tanga between $4^{O}48'$-$5^{O}13'$S and $38^{O}32'$-$38^{O}48'$E. These mountains form part of a chain known as the Eastern Arc which stretches down the coast of East Africa from Southern Kenya to Southern Tanzania. This is a chain of isolated mountains composed of Precambrian rock exposed by block faulting and slow uprise (Griffiths, 1993). Being adjacent to the Indian Ocean, considerable orographic rainfall occurs in this area. The rainfall distribution is bi-modal, peaking between March and May and between September and December. Conversely, the dry seasons are from June to August and January to March. Precipitation occurs in all months. Rainfall is greatest at higher altitudes and in the south-east of the mountains, increasing from 1,200 mm annually in the foothills to over 2,200 mm at the higher altitudes. Because of the topographical and climatic interactions, the western slopes are drier compared to the eastern slopes. Due to their age, isolation and their function as condensers of the moisture from the Indian Ocean, they support ancient and unique forests, rich in endemic species (Hamilton, 1989).

Research in the East Usambara mountains began in the late 1890's with substantial botanical collections being undertaken. Later, in 1928, surveys were undertaken on amphibians and by the 1930's detailed ornithological work had begun. Biological research interest in the mountains has steadily increased over the years. More recently, work in the area has also included an attempt to understand the drainage and catchment value of the mountain's forests (Bruen, 1989; Litterick, 1989).

The East Usambara forests have been likened to the African equivalent of the Galapagos Islands in terms of their endemism and biodiversity (Rogers & Homewood, 1982; Howell, 1989). They are considered to be one of the most important forest blocks in Africa, if not the most important (Tye, 1994). Currently, around 2,800 taxa of plants have been recorded of which it is suggested that over one quarter are endemic or near-endemic (Iversen, 1991). Many are threatened (Rodgers, 1996).

In addition to the biodiversity value is the drainage and catchment value of the East Usambara forests. The forests play an important role in maintaining the hydrological cycle which feeds the Sigi river. The Sigi river is a vital water source for the local communities as well as supplying water for the large coastal town of Tanga. Deforestation in the area will lead to increased soil erosion particularly from the steeper slopes. Soil erosion is liable to result in more irregular run off and in a deterioration in water quality due to siltation.

The latest survey of the area, conducted by Johansson & Sandy (1996) shows that approximately 45,137 ha of the East Usambaras remain as natural forest. This can be divided into two types: submontane rain forest and lowland forest. Altitude is the factor differentiating these two forest types (Hamilton, 1989), with submontane forest generally occurring above 850 m.

Hyytiäinen (1995) classifies these two forest types into three categories[1]: (1) dense forest; (2) poorly stocked forest; and (3) cultivated forest, according to the density of the forest and the degree of human involvement. In the East Usambaras, submontane forest occupies 12,916.6 ha (30.7%), lowland forest occupies 29,497.4 ha (62.9%), and forest plantations occupy 2,723.6 ha (6.5%). 21,900 ha are presently gazetted forest reserves. The remainder, 35,909 ha (43%) of the East Usambaras is classified as agricultural land; woodland; grassland; ponds; rivers; barren land; and settlements (Johansson & Sandy, 1996).

The mammals of the East Usambaras show limited endemism (Collar & Stuart, 1987). However, there are several species of special interest. These include: the restricted Black and Rufous Elephant Shrew, *Rhynchocyon petersi*, which is common in the Usambaras (Collar & Stuart, 1987) yet listed as globally 'Endangered' by IUCN due to a decline in habitat extent and quality; Abbott's Duiker, *Cephalophus spadix*, listed as 'Vulnerable' (Groombridge, 1993); and the Lesser Pouched Rat, *Beamys hindei* about which insufficient information is available to determine its status (IUCN 1996).

There are at least 24 species of reptiles and amphibians endemic to the East Usambaras (Rodgers & Homewood, 1982). This series of surveys provide further information on new species and species' range extensions. A new species of snake, *Prosymna semifasciata,* was recently found in Kwamgumi forest reserve (Broadley, 1995), and a range extension for the endemic frog, *Hoplophryne rogersi*, was recorded at Bamba Ridge forest reserve (Cunneyworth & Stubblefield, 1996b).

The forest avifauna of the East Usambaras is remarkable in its diversity with 110 species, the highest recorded in this part of Africa (Stuart, 1989). Six species occurring in the lowland forests are considered threatened with global extinction: Sokoke Scops Owl, *Otus ireneae*; the endemic Usambara Eagle Owl, *Bubo vosseleri*; Swynnerton's Robin, *Swynnertonia swynnertoni*; East Coast Akalat, *Sheppardia gunningi*; Amani Sunbird, *Anthreptes pallidigaster*; and the Banded Green Sunbird, *Anthreptes rubritorques* (Collar *et al.*, 1994).

The East Usambaras are essentially forest 'islands' (Lovett, 1989). There has been natural forest in the area for thousands, if not millions, of years. These forests have been under continuous exploitative human pressure for at least 2,000 years (Schmidt, 1989). Until recently, especially in the past 50 years, (Kikula, 1989), this pressure has been sustainable. However, the growing human population in the area is leading to increased pressure on the remaining natural forest, and represents the main threat to their survival (Collar & Stuart, 1987). The Usambaras harbour many species which

[1] 1. Dense forest: uneven-aged, more or less disturbed natural forest which has a species composition characteristic to the original forest type & has an unbroken crown cover.
2. Poorly stocked forest: a variety of primary or secondary forests which are poorly stocked because of various natural or man-made reasons. They are forests with low density, fairly open crown cover, modest volume and dominant height less than in dense forests belonging to the same forest type.
3. Cultivation under forest: encroached areas which still have at least moderate forest cover.
After Hyytiainen (1995)

have been geographically separated from their closest relatives for long periods. They also serve as a refuge for formerly widespread flora and fauna that have become extinct over much of their former area (Iversen, 1991). The conservation and preservation of this unique area of biodiversity should be given high priority.

2.0 AIMS OF THE SURVEY

The specific aims of the surveys as outlined in the Terms of Reference between Frontier Tanzania Forest Research Programme and the East Usambara Catchment Forest Project, are:

- to conduct biological baseline surveys in selected gazetted forests and in forests which are proposed for gazettement;
- to provide information on the biological value and importance of these forests in order to assist in the development of management plans and practices for these forests;
- to develop a system for monitoring aspects of forest biodiversity, both on a general as well as a forest-specific level.

Furthermore, the aims of the survey methods applied are:

- to sample the vegetation and tree species composition of six forests of the East Usambaras using systematic sampling techniques along systematically located vegetation transects, which sample approximately 0.5% in area of each forest reserve;
- to assess levels of disturbance by systematically sampling the incidence of tree cutting, animal trapping and other illegal activities along the vegetation transects;
- to use standard and repeatable methods to record biodiversity values of the forest in terms of small mammal species, reptiles, amphibians, and invertebrate species;
- to collect opportunistic data on all other groups of vertebrate and invertebrates. Species lists resulting from this will be compared against standard appraisals of species rarity and other values in order to assess the overall biodiversity values of each forest.
- to undertake a socio-economic appraisal of the impact of resource-use activities by human communities in the vicinity of each forest and produce a brief assessment of how these activities affect the integrity of the forests.

Consequently, this survey will provide standardised and repeatable methods to assess the biodiversity values of the forests to enable their importance to be determined and permit biodiversity value to be monitored through time.

3.0 DESCRIPTION OF THE FOREST

Mlungui proposed forest reserve is located in the East Usambara Mountains, Tanzania at the grid reference 38°42'E 5°00'S. Administratively, Mlungui falls under the Muheza district.

Mlungui proposed forest reserve is situated on the easterly margin of the East Usambara forests. The forest is situated on the oval shaped Mlungui Hill. The hill is oriented on a north-south axis and is approximately two kilometres long and one kilometre wide, lying within a wide valley bottom. Mlungui forest is 200 ha in size of which all is included within the proposed reserve boundaries. This area is comprised of 72 ha of dense forest, 83 ha of poorly stocked forest and 45 ha of disturbed or cultivated areas. The large forest block of Bamba Ridge, Segoma and Kwamgumi lies approximately one kilometre to the west. They are separated by a valley which is crossed by a small stream and a road. The altitude of Mlungui hill ranges from 200 m to 450 m. It is classified as lowland forest as it occurs below 850 m (Hamilton, 1989).

The forest at Mlungui hill was contiguous with the Bamba Ridge, Segoma and Kwamgumi forest block up until the late 1960's. At this time, the sisal estates were established in the area and tracts of natural forest were cleared up to the present day boundarie. The estates brought an influx of people from outside the area who were employed as labourers. This influx resulted in increased pressure on the forest from people collecting firewood, cutting poles and clearing forest to create agricultural land. With the present collapse in the sisal industry and the attendant high rate of unemployment, pressure on the forest is now at its most intense.

The most recent survey of the area was carried out by Hyytiäinen (1995), and updated by Johansson & Sandy (1996). The results are summarised in Table 1 below which indicate that the majority of Mlungui proposed forest reserve can be classified as 'dense lowland forest', forest that is more or less similar to the original forest species composition with an unbroken crown cover. Lowland forest has been classified as occurring up to 850 m (Hamilton, 1989).

Table 1. Land use distribution (Johansson & Sandy, 1996).

Forest Class	Area (ha)	Percent (%)
Dense lowland forest	849.6	81.2
Poorly stocked lowland forest	78.8	7.5
Cultivation under lowland forests	40.0	3.8
Bushland	65.0	6.2
Peasant cultivation	10.4	1.0
Barren land	2.5	0.2
Total for the reserve	**1,046.3**	**100.0**

Table 2. Status of Mlungui proposed forest reserve.

Name	Status	Size (ha)	Gazettement Notice
Mlungui	Proposed Forest Reserve	200.0	Proposed 1994

No Figure / Map Currently Available in Digital Format

Figure 1. The location of Mlungui proposed forest reserve in relation to other East Usambara forests.

No Figure / Map Currently Available in Digital Format

Figure 2. Topographical map.

4.0 SOILS

4.1 Introduction

Soil analysis was conducted by the Ministry of Agriculture National Soil Survey from the Mlingano Agricultural Research Institute, Tanga (Shaka and Mwanga, 1996). The objectives of the study were to assess the nature and distribution of different soil types, and to draw up a map of the soil's of Mlungui forest.

4.2 Methods

The soils were sampled systematically as part of the integrated research methods outlined in the FT FRP methodologies report (SEE, 1996). The forest was sectioned into ten 450 m x 450 m grid squares. The soil sample was taken from the north-west corner of each of these grid squares. Using an auger, a hole was dug to a depth of 150 cm. Soil descriptions followed the FAO (1977) guidelines for soil profile descriptions. The soil colours were named according to the Munsell notation (Munsell Colour Charts Inc., 1973). Soil samples for standard fertility analysis were collected from two depths: 0-25 cm and 25-50 cm. Parameters studied include: texture; pH; total nitrogen; organic carbon; available phosphorus; and exchangeable bases. Samples were analysed according to standard soil analysis methods.

4.3 Results

Three soil types were identified within Mlungui forest. These were largely correlated with catenary position: summit and upper slopes, mid-slopes and lower slopes.

4.3.1 The soils of the summit and upper slopes

The soils typical of the summit and upper slopes were characteristically on slopes with gradients of 35 - 40%. These soils covered approximately 72 ha or 36% of the total area of the forest. The soils were deep, well drained, dark reddish-brown becoming redder with depth. The texture of these soils varied from clay loam in the topsoil, to dominantly clay in the subsoil. The soil reaction (pH) was acid (5.0 - 5.4). Total nitrogen content was low (0.19%) and decreased with depth. Organic carbon was medium (1.9%) in surface horizons though decreased to low levels in the subsoil. Available phosphorus was low, reaching a negligible level in the subsoil. Topsoils were characterised by a medium level of exchangeable calcium and magnesium, a low level of potassium, and a very low level of sodium. The level of exchangeable bases decreased with soil depth.

4.3.2 The soils of the mid-slopes

The mid-slopes were characterised by gradients of around 20%, though this increased to 38% in one area to the south-west of the hill. The soil type found in mid-slope areas covered approximately 83 ha or 41.5% of the total area of the forest. The soils were shallow to moderately deep, well drained, dark brown sandy clay loams. Rocky outcrops were common and quartz stonelines were found at variable depths. Mica flakes were found throughout the soil matrix.

In general, soil reaction was slightly acid to neutral with pH between 6.2 and 6.8. Total nitrogen was medium (0.3%) in the topsoil and decreased to low levels (0.1%)

in the subsoil. Organic carbon was high in the topsoil (3.2%), decreasing to low levels in the subsoil (1.1%). The carbon to nitrogen ratio indicated that soil organic matter was of a good quality. Available phosphorus was low. Topsoils of the mid-slopes were characterised by very high exchangeable calcium, a high level of magnesium and potassium, and a very low level of sodium. As with the soils of the summit and upper slopes, the level of exchangeable bases decreased markedly in the subsoil.

4.3.3 The soils of the lower slopes

The lower slopes had gradients between 16 - 25%. The soil type characteristic of these areas covered approximately 45 ha or 22.5% of the total forest area. In general, these soils were moderately deep to deep, well drained, clay loam to loam, dark reddish-brown soils, though in the north-east of the forest the soils were shallow due to rocky outcrops. This was the only area of rocky outcrops recorded for the lower slopes. The forests on these lower slopes were subject to high levels of human disturbance and some areas were under cultivation. As a result, the lower slope soils showed a high degree of variability depending on the nature and extent of disturbance.

Along the eastern boundary of the forest, the soils were moderately deep to deep, well drained clay loam to clay, dark reddish-brown soils. No rock outcrops occurred. The soil reaction was neutral with pH ranging from 6.6 in the topsoil to 6.8 in the subsoil. In contrast to the other soil types, in this area pH was found to increase slightly with depth. Total nitrogen was medium to high in the topsoil (0.58%) but decreased to low levels (0.2%) in the subsoil. The organic carbon level was high to very high ranging from 2.3 - 6.2%. The carbon to nitrogen ratio indicates that the soil organic matter is of good quality. Available phosphorus was low.

Exchangeable calcium was found to be very high. Although exchangeable calcium levels were found to be high throughout the reserve, in this area they were twice as high as in any other sample site whether looking at topsoil or subsoil. The topsoils of the lower slopes were characterised by very high levels of magnesium, medium levels of potassium and very low levels of sodium. As was recorded from the other soil types, the level of exchangeable bases decreased with depth.

This eastern boundary of the forest has experienced past cultivation and logging. Tree species which are common in forest gaps and indicative of disturbance, such as *Cussonia zimmermannii* and *Markhamia lutea*, were recorded on these eastern lower slopes. It appears, therefore, that soil type was a less influential factor than human disturbance on floristic composition.

The north-west boundary is situated at the lowest altitude around 220 m. The soils found in this area were very deep, well drained, dark brown or very dark brown, sandy clay loam. The soils has a slightly acid to neutral reaction with pH between 5.8 and 6.0. Total nitrogen was low and organic carbon was medium, both decreased with depth. The carbon to nitrogen ratio indicated that the soil organic matter was of a good quality. Available phosphorus was medium decreasing to low levels in the subsoil.

The topsoils of this north-west boundary area were characterised by a very high level of exchangeable calcium, a medium level of magnesium and potassium, and a very low level of sodium. The level of exchangeable bases decreased with soil depth. Charcoal was found in the soil profile between depths of 20 - 30 cm, indicating past human activity. Further evidence that this area used to be under cultivation was the presence of coconut and mango trees. Only two forest tree species with a diameter at breast height (dbh) greater than 10 cm were recorded from this sample site, indicating a high level of past agricultural encroachment.

An 8 ha pocket of lower land in the north-east of the forest was characterised by soils that were shallow, well drained, dark reddish-brown to dark red clays. This area was rocky with frequent outcrops. The soil reaction was found to be mildly alkaline (pH 7.5) in the topsoil and slightly acid (pH 6.0) in the subsoil. Total nitrogen was at a medium concentration in the topsoil decreasing with depth. Organic carbon was found to be high in the topsoil decreasing to medium levels in the subsoil. The carbon to nitrogen ratio indicated that the quality of organic matter was good. The level of available phosphorus was the lowest in all the soils sampled.

As with the other soil types recorded for Mlungui forest, exchangeable bases were high in the topsoil and decreased to medium and low levels in the sub-soil. However, as noted for the other soil types, the level of exchangeable sodium was very low. This area of the forest showed signs of abandoned cultivation and a few small pioneer forest tree species were recorded. These included *Cussonia zimmermannii* which is a typical East African coastal forest species (Ruffo *et al.*, 1989). It is indicative of dry evergreen lowland forest and, since it is commonly associated with forest gaps, is common in disturbed areas (White, 1983). Other indicators of disturbance and burning were present on the easterly lower slopes, including *Panicum maximum* and *Solanum incanum.*

4.4 Discussion

Three broad soil types were identified which were associated with catenary position. The characteristics of the soils sampled from the hill summit and upper slopes were very similar to other soil types encountered in the East Usambara forests, such as Magoroto and Bamba Ridge (Cunneyworth & Stubblefield, 1996a,b). All were deep, well drained, strongly acid, red clays which can be classified as 'ferralsols' (FAO, 1988). These characteristics are typical of soils developed on weathered granitoid gneiss (Holmes, 1995). Furthermore, as would be expected, the soil surface horizons were loamy with a higher silt content and were darker in colour from the higher organic matter content. The organic matter is important in maintaining both the soil structure and nutrient levels, since these ferralsols have an inherently low nutrient status due to heavy weathering. Milne (1937) noted that, for the East Usambaras, most of the soil nutrients were associated with organic matter.

The results of the soil sampling indicates that the organic matter quality of the upper slope soils was good. However, Hamilton (1989b) states that this apparently high soil fertility is misleading since it is sustained by a very fragile cycling of nutrients between soils and vegetation. Any disruption to this cycle, therefore, will result in the rapid loss of nutrients and lead to soil impoverishment. The soils in this topographic unit supported dense forest which had experienced minimal levels of

human disturbance. It was seen that soil type was not as important an influence as altitude and aspect on the floristic composition of the forest found on the summit and upper slopes. However, any change in soil type is likely to influence the vegetation it supports and this should be considered when monitoring Mlungui forest.

The soils of the mid-slopes can also be classified as Ferralsols (FAO, 1988) in terms of colour, texture and depth. However, the level of exchangeable bases was higher in these soils than those in the upper catenary position. Milne (1937) suggested that the higher nutrient status of soils on the escarpments in the East Usambaras was due to the lower amount of weathering and the rejuvenation by material incorporated from decomposing rock faces. In the mid-slope areas of Mlungui hill rocky outcrops were common and this is one possible explanation for the higher nutrient status of these soils. Furthermore, soil displacement from the upper slopes may also lead to enrichment of the mid and lower slopes.

Due to human disturbance, the mid-slope areas support poorly stocked forest. No soil erosion was noted during the survey and the relatively high nutrient status of the soils appears to be sustained under the current level of disturbance. However, continued thinning of the forest has implications for maintaining the tight nutrient cycle necessary for maintaining soil fertility under forests and this impact should be monitored.

The impact of human disturbance on the soils of the lower slopes was marked. This disturbance has altered the floristic composition in these areas, such that much of the natural forest has been removed and on the eastern slopes in particular a different forest type, scrub forest, with associated bushland elements appears to be regenerating. This vegetation type is characteristic of lower rainfall areas and often forms a buffer between coastal forest and bushland (White, 1983). Its occurrence at this site should be monitored as it could be a successional stage before the indigenous dry evergreen forest regenerates, or it could be that the human disturbance has altered the environment such that natural forest regeneration may not be possible.

The past cultivation and burning in these disturbed lower slope areas has affected the soil characteristics. The organic matter quality appears to be good as indicated by the carbon to nitrogen ratio. However, the low phosphorus levels indicate that burning has altered the nature of the soil and that the current level of soil fertility may only be a short-term measure.

Thus, it can be seen that the broad soil types of Mlungui forest are similar to other soils surveyed in East Usambara forests. The main influences on soil characteristics were slope, aspect, and human disturbance. Several tree species recorded within the forest have disjunct distributions suggesting that they have very particular ecological requirements. More focused research would be required to determine the reasons behind these distributions although soil composition is likely to be a key factor.

5.0 BOTANY

5.1 Introduction

A survey of the major vegetation types within the forest reserve was undertaken. In terms of extent, distribution and species composition to determine the botanical diversity of the reserve. Simple, quantitative and repeatable methods were employed and the results are comparable with other forest surveys undertaken by FT FRP. Human disturbance within the forest was also studied. Data collected for this survey will be entered onto the EUCFP data base in Tanga.

5.2 Methods

The forest block is divided into grid squares which are measured and marked in the field. The methods used during this survey are detailed in the FT FRP methodologies report (SEE, 1996). A brief description is presented below. The location of vegetation plots and disturbance transects are illustrated in Figure 3.

5.2.1 Forest structure

Two methods were used to analyse forest structure: (1) quantitative vegetation analysis and (2) disturbance transects.

5.2.1.1 Quantitative vegetation analysis

A 450 m grid system was constructed throughout the forest on transect lines using boundary tape to mark the lines. A sample plot size of 50 m x 20 m was sampled in each grid square, giving an approximate sampling intensity of 0.5%. Within the sample plot, every tree with a dbh (diameter at breast height) of 10 cm and over was recorded, tagged and identified. Botanists from the Tanzanian Forestry Research Institute (TAFORI) and from the University of Dar es Salaam (UDSM) provided the field identification of plant species.

5.2.1.2 Disturbance transects

Disturbance transects provide a statistical estimate of pole cutting and logging in a forest block. Each transect consisted of three parallel sub-transects, 250 m long and at least 30 m apart, within a recognised forest type. Every self-standing tree and sapling (i.e. not lianas or creepers) above 1cm dbh was measured within an area 2.5 m either side of each transect line. Each plant was recorded under one of two categories: 'cut' or 'naturally fallen'.

Due to limitations of this method, one number representing the average cut and naturally fallen poles and timber per 100 m is given for the entire transect. The data are unable to be broken down into more meaningful units.

No Figure / Map Currently Available in Digital Format

Figure 3. Location of vegetation plots and disturbance transects.

5.3 Results

5.3.1 Quantitative vegetation analysis

Table 3 presents a checklist of the tree and shrub species recorded in the 20 m x 50 m vegetation plots. Species are described, where adequate information exists, in terms of their ecological type, their habitat and their endemic status.

Table 3. Checklist of trees and shrubs.

Species	Ecological type	Habitat[2]	Endemic status
Anacardiaceae			
Lannea schweinfurthii stuhlmannii	f		W
Sorindeia madagascariensis	f	S	W
Annonaceae			
Lettowianthus stellatus	f	L & S	N
Xylopia parviflora	f	L	W
Apocynaceae			
Pleiocarpa pycnantha	F		W
Araliaceae			
Cussonia zimmermannii	f	L (forest gaps)	N
Bignoniaceae			
Fernandoa magnifica	f	L	W
Markhamia lutea	f	L & S (forest gaps)	W
Markhamia zanzibarica	f		W
Bombacaceae			
Bombax rhodognaphalon	f	L	N
Combretaceae			
Combretum schumannii	f	L	W
Terminalia sambesiaca	f	L	N
Dichapetalaceae			
Dichapetalum macrocarpum[1]	O		W
Dichapetalum stuhlmannii[1]	f		W
Dracaenaceae			
Dracaena deremensis	f		W
Ebenaceae			
Diospyros kabuyeana	f		N
Erythroxylaceae			
Nectaropetalum acuminatum[1]	F		N?
Nectaropetalum kaessneri[1]	f		W
Euphorbiaceae			
Alchornea hirtella spp. *glabrata*	f	S (forest gaps)	W
Drypetes usambarica	f	S	N
Euphorbia nyikae	O		N
Pycnocoma sp. cf. *littoralis*[1]	?		?
Ricinodendron heudelotii ssp. *africanum*	f	L	N
Flacourtiaceae			
Ludia mauritiana	f		W
Leguminosae subfamily: Caesalpiniaceae			
Afzelia quanzensis	f		W
Julbernardia magnistipulata	f	L	N
Scorodophloeus fischeri	f	L	N

Table 3 (*cont.*)

Species	**Ecological type**	**Habitat**[2]	**Endemic status**
Leguminosae subfamily: Mimosaceae			
Albizia schimperana amaniensis	F		N
Albizia anthelmintica	O		W
Albizia petersiana	f		W
Leguminosae subfamily: Papilionoideae			
Cordyla africana	F		W
Craibia zimmermannii	F		W
Erythrina sacleuxii[1]	f		W
Millettia usaramensis	O	L	W
Moraceae			
Trilepisium madagascariense	f	L	W
Olacaceae			
Olax gambecola[1]	F		W
Pandanaceae			
Pandanus rabaiensis	O		N
Pittosporaceae			
Pittosporum viridiflorum	f	S	W
Rhamnaceae			
Ziziphus mucronata	O	L	W
Rutaceae			
Teclea nobilis	f	S	W
Teclea simplicifolia	f	S	W
Vepris stoltzii	F		W
Sapindaceae			
Lecaniodiscus fraxinifolius	F	L	W
Haplocoelum inopleum[1]	O		W
Sapotaceae			
Afrosersalicia cerasifera	f	S	W
Bequaertiodendron natalense	f	L & S	W
Manilkara sulcata	f	L	W
Sterculiaceae			
Cola discoglypremnophylla[1]	?		?
Cola microcarpa	F		N
Dombeya torrida	F		N
Leptonychia usambarensis	F	L & S	N
Sterculia appendiculata	f	L	W
Tiliaceae			
Grewia microcarpa	f		W
Ulmaceae			
Celtis mildbraedii	F	L & S	W
Celtis wightii	f	S	W
Celtis zenkeri	F	L & S	W

[1] Species which do not appear in Iversen (1991). Summary information is based on Ruffo *et al.* (1989), Lovett (1993) or the *Flora of Tropical East Africa*.
[2] Information is based on Ruffo *et al.* (1989).

KEY TO ABBREVIATIONS FOR TABLE 3

Ecological type: (based on Iversen, 1991)

- F - Forest dependent species: This is defined as primary forest only. It does not include forest edge or secondary forest;
- f - Forest dwelling but not forest dependent: Species occurring in primary forest as defined above as well as other vegetation types. Thus these are not forest-dependent species; and
- O - Non-forest species: These are species that do not occur in primary or secondary forest or forest edge.

Habitat: (based on Hamilton, 1989)

- L - Lowland: Occurring at altitudes of <850 m;
- S - Submontane: Occurring at altitudes of >850 m.

In the case where species occur in both lowland and submontane habitats, the most common habitat will be listed first and only this habitat will be counted in the summary statistics. If a species is common in forest gaps, rather than in the forest proper, this will also be noted.

Endemic status: (based on Iversen, 1991):

- E - Endemic: Occurring only in the Usambara mountains;
- N - Near endemic: Species with limited ranges in the Eastern Arc mountains and/or the East African lowlands between Somalia and Mozambique.
- W - Widespread distribution.

? Insufficient data

Species accumulation rates:

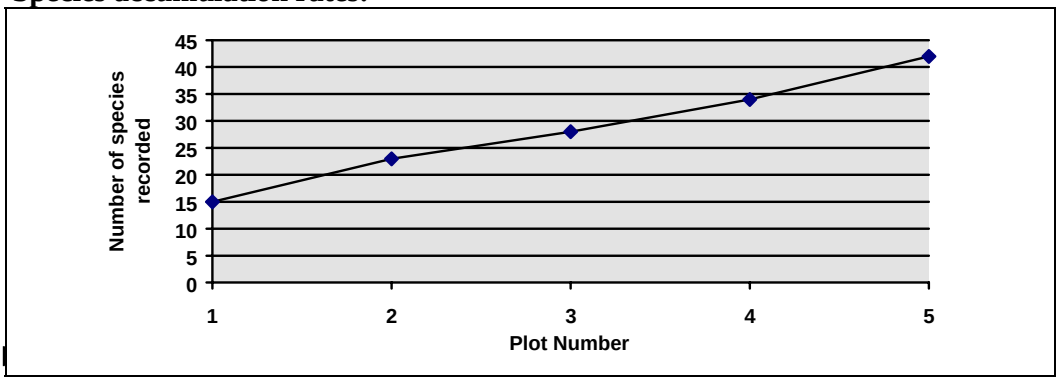

Figure 4. Species accumulation rates of trees and shrubs (10 cm dbh and larger) by vegetation plot.

Table 4 summarises information for species which were recorded in Mlungui outside the range described by Ruffo *et al.* (1989).

Table 4. Trees found outside their previously recorded range in the East Usambaras.

Species	**Location as previously recorded**[1]
Cussonia zimmermannii	Mhinduro and Mtai
Cola microcarpa	Mtai

[1] Information is based on Ruffo *et al.* (1989).

Ecological type (refer to Figures 5,6,7,8)**:**

Table 5. Summary of ecological type for tree and shrub species (based on Table 3).

Ecological type	Number of species	% of total species
(F) Forest Dependent Species	13	23.2
(f) Forest Non- Dependent Species	34	60.7
(O) Non-Forest Species	7	12.5
Unknown	2	3.6
Total:	**56**	**100.0**

Habitat (refer to Figures 9 and 10)**:**

Table 6. Summary of the habitat for tree and shrub species (based on Table 3).

Habitat	Number of species	% of total species
(L) Lowland Forest Species	21	72.4
(S) Submontane Forest Species	8	27.6
Total:	**29**	**100.0**

Table 7. Submontane species occurring in lowland plots and the altitudes where they were recorded.

Species	Altitude (meters)
Afrosersalicia cerasifera	380, 470
Alchornea hirtella spp. *glabrata*	380, 470
Celtis wightii	390, 450
Drypetes usambarica	450
Sorindeia madagascariensis	450
Teclea simplicifolia	300, 390, 470,

Endemic status (refer to Figure 11 and 12)**:**

Table 8. Summary of endemic status for tree and shrub species (based on Table 3).

Endemic status	Number of species	% of total species
(E) Endemic	0	0
(N) Near Endemic	16	28.6
(W) Widespread	38	67.9
Unknown	2	3.6
Total:	**56**	**100.1**

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Figure 5. Distribution of forest dependent tree and shrub individuals.

No Figure / Map Currently Available in Digital Format

Figure 6. Distribution of forest dependent tree and shrub species.

No Figure / Map Currently Available in Digital Format

Figure 7. Distribution of non-forest tree and shrub individuals.

No Figure / Map Currently Available in Digital Format

Figure 8. Distribution of non-forest tree and shrub species.

No Figure / Map Currently Available in Digital Format

Figure 9. Distribution of submontane tree and shrub individuals.

No Figure / Map Currently Available in Digital Format

Figure 10. Distribution of submontane tree and shrub species.

No Figure / Map Currently Available in Digital Format

Figure 11. Distribution of near-endemic tree and shrub individuals.

No Figure / Map Currently Available in Digital Format

Figure 12. Distribution of near-endemic tree and shrub species.

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Figure 13. Vegetation of Mlungui proposed forest reserve.

5.3.2 Disturbance transects

A total of three disturbance transects were recorded for pole and timber extraction during the survey. Disturbance transects are described in Table 9 and the results summarised in Table 10 for poles and Table 11 for timber. The terms pole and timber are used in this section only as this method examines the forest in terms of its extractive value. Poles are defined as <10 cm dbh and timber as >= 10 cm dbh.

Table 9. Summary description of disturbance transects.

Plot number	Topography	Altitude	Vegetation type
3	ridge top	450	mature forest
7	upper slope	380	poorly stocked forest
9	mid-slope	250	disturbed

Table 10. Disturbance transect results for pole counts.*

Plot number	Length of transect (m)	Total poles sampled	Cut poles	Average per 100 metres	Naturally fallen poles	Average per 100 metres
3	750	195	96	**25.6**	99	**26.4**
7	750	157	84	**22.4**	73	**19.5**
9	750	165	91	**24.3**	74	**19.7**

* Due to differences in methods, the results under 'Average per 100 metres' are doubled to allow direct comparisons with other forest reserves in this survey series.

Figure 14. Cut and naturally fallen poles recorded per 100 metres by transect.

Table 11. Disturbance transect results for timber counts.*

Plot number	Length of transect (m)	Total timber sampled	Cut timber	Average per 100 metres	Naturally fallen timber	Average per 100 metres
3	750	40	3	**0.8**	37	**9.9**
7	750	69	16	**4.3**	53	**14.1**
9	750	65	21	**5.6**	44	**11.7**

* Due to differences in methods, the results under 'Average per 100 metres' are doubled to allow direct comparisons with other forest reserves in this survey series.

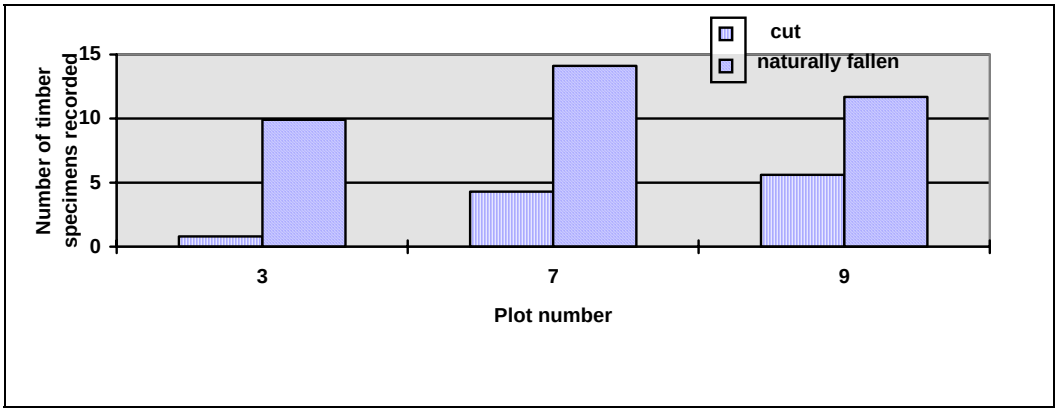

Figure 15. Cut and naturally fallen timber recorded per 100 metres by transect.

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Figure 16. Areas of highest disturbance in relation to the distribution of tree and shrub individuals that are both forest dependent and near-endemic

No Figure / Map Currently Available in Digital Format

Figure 17. Areas of highest disturbance in relation to the distribution of tree and shrub species that are both forest dependent and near-endemic.

5.4 Summary

Mlungui proposed forest reserve covers an area of 200 ha with altitudes ranging from 220 to 480 m. Fifty-six trees and shrubs species from 25 families were recorded.

From the survey, Mlungui Hill was found to have approximately 36% mature mixed forest, 50% colonising, formerly disturbed or poorly stocked forest and 14% formerly cultivated land.

Species Accumulation Rates

The species accumulation rate does not appear to be approaching a plateau indicating that further sampling is required.

Ecological Type

Forest dependent species defined as species limited to primary forest, were recorded from 13 plots. This represents 23.2% of all species recorded. The most common forest dependent tree recorded was *Lecaniodiscus fraxinifolius*. Five of the forest dependent species are also near-endemic to the Usambaras.

Seven non-forest species were recorded. All of the plots surveyed contain non-forest species. *Pandanus rubaiensis* was the most common non-forest species recorded.

Habitat

Less than one third of the species recorded are submontane species. This is expected as the highest altitude of Mlungui Hill is well below the 850 m limit considered to differentiate submontane and lowland species (White, 1983).

Endemic Status

Of the plant species recorded, 38 (67.9%) have widespread distributions. Sixteen near-endemic species (28.6%) were recorded from 13 families. These near-endemics are found in all the plots surveyed. Of the five plots surveyed, four (80%) have >10 near-endemic individuals.) The most common near-endemic in the reserve is *Scorodophloeus fischeri*. Of these 16 near-endemic species, five species are also considered to be forest dependent.

No endemic species were recorded on Mlungui Hill.

Range Extensions

The record of *Dichapetalum stuhlmannii* in Mlungui proposed forest reserve represents a range extension (Flora of Tropical East Africa, FTEA). This species is known from the West but not the East Usambaras (FTEA).

Dichapetalum macrocarpum is a shrub of southern Tanzania and of the Mozambique, Niassa Province (FTEA). This is a new record in NE Tanzania. This species is typical of *Brachystegia* woodland, bushland and thicket.

Range extensions from botanical survey outside vegetation plots:

Olax gambecola, a shrub typical of rain and riverine forest in Uganda and of the Pwani and Morogoro Regions. Its occurrence in the Usambara mountains is a range extension;

Tricalysia pedicellata is a forest dependent tree previously considered restricted to Pwani and Morogoro Regions (FTEA).

Disturbance

Disturbance from timber extraction was recorded at lower rates than naturally fallen trees whereas pole extraction was recorded at higher or similar rates to naturally fallen saplings. Other disturbances, such as cultivation, fire, charcoal, pottery remnants were observed but generally limited to the lower slopes. Rates of pole cutting occurred between 22.4 and 25.6 per 100 m and for timber cutting, 0.8 to 5.6 per 100 m.

Based on these disturbance transects, it appears that disturbance from pole-cutting is high throughout the reserve with approximately 1 pole cut every 4 m in a 10 m wide strip. This intensity appears to be the same in the poorly stocked areas as in the mature forest on the upper slopes and ridge top.

Timber extraction has been intensive as can be deduced from the many stumps of large trees still visible on the lower slopes of Mlungui Hill. The lowest rate of timber extraction occurs in the mature forest on the upper slopes and summit. On the lower slopes the rate of timber extraction is higher and is similar between disturbed forest and previously cultivated land.

From this data, it appears that all areas are under threat from pole-cutting. Timber extraction, although occurring at a lower rate in the mature forest, is considered a threat due to the small size of the forested area.

6.0 ZOOLOGY

6.1 Introduction

The faunal biodiversity of Mlungui proposed forest reserve was investigated using standard, repeatable, survey methods. Studies of small mammals, reptiles and amphibians were carried out. In line with the specific aims of the survey, an inventory of all fauna encountered was compiled. This data was analysed to assess the biodiversity value of the area.

6.2 Methods

All methods used during the expedition survey are outlined in detail in the FT FRP methodologies report (SEE, 1996). A brief description is presented below. The location of trap sites are presented in Figure 18.

6.2.1 Mammals

Three methods were used to sample the mammal community within Mlungui proposed forest reserve: (1) snap traps, (2) bucket pitfalls, (3) opportunistic observations.

6.2.1.1 Snap-trap lines

In order to sample the community of rodents, small and large break-back traps (snap-traps) were used. Typically the traps were set out in transect lines of 50, with traps positioned at least 2 m apart. However, this was not always possible due to the nature of the habitat. The traps were set each evening and checked early the following morning. A bait of fried coconut and peanut butter was used. Previous forest surveys indicate that this bait is very successful in terms of catch numbers and species diversity (Stanley, *pers. comm.*). Each mammal caught was weighed and measured. Trapping and biometric data was recorded on standardised data sheets. Unless otherwise indicated, specimens were identified by Prof. K. Howell or by Dr. D. Kock (see Appendix 2).

6.2.1.2 Bucket pitfall trapping

The bucket pitfall traps consisted of one line of 33, 20 litre plastic buckets sunk flush to ground level in a linear transect. These were positioned approximately 2.5 m apart. A continuous piece of plastic sheeting ran perpendicular to the ground across the centre of each bucket forming a "runner". A lip of plastic sheeting, a drift fence, was kept on the ground on to which soil and leaf litter was placed. An animal was, therefore, channelled along the plastic to one of the buckets. The bucket pitfalls, acting as live traps, were designed for sampling the community of shrews within the forest. Each mammal captured was weighed and measured. Trapping and biometric information was recorded on standardised data sheets. Unless otherwise indicated, taxonomic identification was made by Prof. K. Howell, Dr. D. Kock or Dr. W. Stanley (see Appendix 2).

6.2.1.3 Mammal observations

Other mammals were recorded on an opportunistic basis throughout the survey.

6.2.2 Reptiles

The aim of this study was to collect and identify a representative sample of the forest reptile community. The community of ground-dwelling reptiles was sampled using the bucket pitfall method (see 6.2.1.2 above). Opportunistic captures were also conducted by hand, and a snake stick where necessary. Unless otherwise indicated, taxonomic identifications were made by Prof. K. Howell or Prof. D. Broadley (see Appendix 2).

6.2.3 Amphibians

The aim of this study was to collect and identify a representative sample of the forest amphibian community. The community of ground-dwelling amphibians was sampled using the bucket pitfall method (see 6.2.1.2 above). Unless otherwise indicated, taxonomic identifications were made by Prof. K. Howell or by Prof. J. Poynton (see Appendix 2).

6.2.4 Butterfly netting

Butterflies were caught on an opportunistic basis with a hand-held net.

6.3 Trapping sites and sampling intensity

Three trapping sites were conducted in different habitats. Table 12 describes the sites and Table 13 summarises the sampling intensity for each site and for each trapping method.

Table 12. Summary description of trapping sites.

Plot number	Vegetation type	Altitude (metres)	Topography
3	mature lowland forest	480	ridge top
4	open forest; poorly stocked; disturbed	370	mid-slope
6	mature lowland forest	480	ridge top

Table 13. Sampling intensity by trap night (number of nights x number of traps).

Trapping method	Plot 3	Plot 4	Plot 6
snap trap	0	480	279
bucket pitfall*	858	0	0

* Each bucket represents one trap night

No Figure / Map Currently Available in Digital Format

Figure 18. Location of trapping sites.

6.4 Results

6.4.1 Mammals

A total of eight specimens were retained for taxonomic purposes. These represent at least four species from three families. Ecological type, endemic status and IUCN status were compiled from the National Biodiversity Database (UDSM, 1997) and Kingdon (1989).

Table 14. Summary of mammals.

Species	Ecological type	Endemic status	IUCN status	Capture location by plot & number collected			
				3	**4**	**6**	**Total**
Cricetidae							
Beamys hindei	f	N	DD		1	1	**2**
Muridae							
Acomys sp.	?	?		1		1	**2**
Praomys sp.	?	?			1	1	**2**
Soricidae							
Crocidura sp.	?	?		1	1		**2**

Table 15. Summary of mammal observations.

Species	Certainty	Ecological type	Endemic status	Observation location
Viverridae				
Viverra civetta	probable	f	W	mid-slope; poorly stocked forest

KEY TO ABBREVIATIONS FOR TABLE 14 & 15 (Definitions based on those described in the botanical section of this report).

Ecological type:

- F - Forest dependent species: This is defined as primary forest only. It does not include forest edge or secondary forest;
- f - Forest dwelling but not forest dependent: Species occurring in primary forest as defined above as well as other vegetation types. Thus these are not forest-dependent species; and
- O - Non-forest species: These are species that do not occur in primary or secondary forest or forest edge.

Endemic status:

- E - Endemic: Occurring only in the Usambara mountains;
- N - Near endemic: Species with limited ranges usually only including coastal forest and/or the Eastern Arc mountains;
- W - Widespread distribution.

IUCN status:

- DD - Data deficient

? - No data available

Certainty: Indicates the probability of the correctness of the identity of the species observed;

Definite: Can be regarded as occurring in the reserve.

Probable: Identification is likely but requires confirmation before placing on the reserve's species list.

Table 16. Ranges of near-endemic mammal species recorded (National Biodiversity Database, 1997).

Near-endemic species	Range
Beamys hindei	coastal forests, Tanzania; S.E. Kenya

No Figure / Map Currently Available in Digital Format

Figure 19. Distribution of near-endemic mammal species.

6.4.2 Reptiles

A total of 11 specimens were retained for taxonomic purposes. These represent nine species from five families. Ecological type, endemic status and IUCN status were compiled from the National Biodiversity Database (UDSM, 1997); Broadley and Howell (unpubl.); Howell (1993); and Branch (1994).

Table 17. Summary of reptiles.

Species	Ecol. type	End. status	IUCN status	Capture location by plot & number collected						
				3	**4**	**6**	**OR**	**PF**	**UK**	**Total**
Colubridae										
Prosymna semifasciata sp. nov.	F?	E	CR	1						**1**
Philothamnus macrops	F	N	V	1						**1**
Crotaphopeltis hotamboeia	O	W		1						**1**
Thelotornis capensis spp. *mossambicana*	f	W					1			**1**
Viperidae										
Bitis arietans spp. *arietans*	f	W						1		**1**
*Bitis gabonica**	F	W		1	1					**2**
Cordylidae										
Cordylus t. tropidosternum	f	W		1						**1**
Agamidae										
Agama montana	F	N	V						1	**1**
Gekkonidae										
Hemidactylus sp.	?	?		1						**1**

KEY TO ABBREVIATIONS FOR TABLE 17 (Definitions based on those described in the botanical section of this report).

Ecological (Ecol.) type:
- F - Forest dependent species: This is defined as primary forest only. It does not include forest edge or secondary forest;
- f - Forest dwelling but not forest dependent: Species occurring in primary forest as defined above as well as other vegetation types. Thus these are not forest-dependent species; and
- O - Non-forest species: These are species that do not occur in primary or secondary forest or forest edge.

Endemic (End.) status:
- E - Endemic: Occurring only in the Usambara mountains;
- N - Near endemic: Species with limited ranges usually only including coastal forest and/or the Eastern Arc mountains;
- W - Widespread distribution.

IUCN status:
- CR - Critically Endangered
- V -Vulnerable

Capture locale codes:
- OR - Outside reserve
- PF -Poorly stocked forest; location unknown
- UK - Unknown location

? - Insufficient data

Table 18. Ranges of endemic and near-endemic reptile species recorded (Howell, 1993).

Endemic	**Range**
Prosymna semifasciata sp. nov.	Kwamgumi forest reserve, East Usambaras
Near-endemic species	**Range**
Philothamnus macrops	East Usambara; Zanzibar; Coastal forests
Agama montana	East Usambara; West Usambara; Uluguru; Nguru

No Figure / Map Currently Available in Digital Format

Figure 20. Distribution of forest dependent reptile species.

No Figure / Map Currently Available in Digital Format

Figure 21. Distribution of endemic reptile species.

No Figure / Map Currently Available in Digital Format

Figure 22. Distribution of near-endemic reptile species.

6.4.3 Amphibians

A total of three specimens were retained for taxonomic purposes which represent three species from two families. Ecological type and endemic status were compiled from the National Biodiversity Database (UDSM, 1997); Howell (1993); Poynton and Broadley (1991); and Poynton (unpubl.).

Table 19. Summary of amphibians.

Species	Ecological type	Endemic status	Capture location by plot & number collected	
			3	**Total**
Arthroleptidae				
Arthroleptis stenodactylus	f	W	1	**1**
Arthroleptis xenodactyloides	f	W	1	**1**
Hyperoliidae				
Hyperolius argus	f	W	1	**1**

6.4.4 Butterflies

A total of 13 specimens were retained for taxonomic purposes. These represent 13 species from four families. Ecological type and endemic status were compiled from Larsen (1996).

Table 20. Summary of butterflies.

Species	Ecological type	Endemic status
Hesperiidae		
Ceratrichia bonga	F	N
Gretna carmen spp. capra	F	W
Borbo gemella	O	W
Andronymus caesor spp. *philander*	O	W
Lycaenidae		
Baliochila latimarginata	F	N
Baliochilia hildegarda	f	W
Baliochilia amanica	F	N?
Pentila rogersi spp. *parapetreia*	F	N
Pentila tropicalis spp. *mombasae*	F	W
Cacyreus lingeus	f	W
Nymphalidae		
Acraea eponina	f	W
Pseudacraea dolomena spp. *usagarae*	F	W
Pieridae		
Leptosia alcesta spp. *inalcesta*	f	W

KEY TO ABBREVIATIONS FOR TABLE 19 & 20 (Definitions based on those described in the botanical section of this report).

Ecological type:

- F - Forest dependent species: This is defined as primary forest only. It does not include forest edge or secondary forest;
- f - Forest dwelling but not forest dependent: Species occurring in primary forest as defined above as well as other vegetation types. Thus these are not forest-dependent species; and
- O - Non-forest species: These are species that do not occur in primary or secondary forest or forest edge.

Endemic status:

- E - Endemic: Occurring only in the Usambara mountains;
- N - Near endemic: Species with limited ranges usually only including coastal forest and/or the Eastern Arc mountains;
- W - Widespread distribution.

6.5 Summary

Species Richness

In this section, species which have been captured or observed three or more times during the survey are considered locally common. Although unproven this figure is based on extensive sampling of populations in the region and seems a reasonable basis for assessing abundance.

Due to the low capture rates, species richness is difficult to assess. The following is a brief summary of the preliminary findings.

Mammals:

Five mammal species were found in Mlungui. Four rodent species were recorded, with two specimens being caught of each species. *Beamys hindei*, *Praomys* sp., and *Crocidura* sp. were found in mature and poorly stocked forest whereas *Acomys* sp. was only found in mature forest.

Reptiles:

All reptiles were recorded once except *Bitis gabonica* which was recorded twice. This species was found in mature and poorly stocked forest.

Amphibians:

Few amphibians were collected however two of the three species recorded are typical of the forest reserves of the East Usambaras (*i.e.* Cunneyworth & Stubblefield 1996a,b,c) and of the coastal forests (Howell, in prep.) These species are *Arthroleptis stenodactylus* and *A. xenodactyloides*.

Butterflies:

Among the butterflies collected, forest dependent, forest non-dependent and non-forest species were captured. In particular, it appears that there is suitable habitat remaining to maintain populations of some forest dependent species. However, these populations may be at high risk of extinction due to limited habitat and loss of habitat corridors.

Endemics and near-endemics:

Of the four vertebrate species endemic or near-endemic to the Usambaras which were recorded, none appear to be locally common as they were not recorded at least three times during the survey. However, given the low sampling intensity and low rainfall during the sampling period it is possible that this apparent scarcity is a product of the sampling strategy rather than the species' abundance.

Four near-endemic butterfly species were recorded within the proposed forest reserve.

Forest dependent species:

Of the four forest dependent vertebrate species, none appear to be locally common. Again this may be a product of the sampling strategy.

Seven forest dependent butterflies were recorded within the proposed forest reserve.

High risk species:
Assuming that the number captured reflects relative population size, those species that are locally uncommon, forest dependent and either near-endemic or endemic species are considered to be at high risk. These species are: *Agama montana, Philothamnus macrops* and *Prosymna semifasciata* sp. nov. and the butterflies *Pentila rogersi* spp. *parapetreia, Baliochilia amanica, Baliochila latimarginata* and *Ceratrichia bonga.*

Table 21. Summary of faunal families and species.

Taxon	Number of families	Number of species
mammals	4	5
reptiles	5	9
amphibians	2	3
butterflies	4	13

Table 22. Summary of capture locations of faunal species.

Taxon	Mature forest	Poorly stocked forest	Cultivated land	Unknown
mammals	4	2	0	0
reptiles	5	3	2	1
amphibians	3	0	0	0

Ecological type

Of the five forest dependent vertebrate species, all are reptiles. Seven butterflies are also forest dependent. One invasive vertebrate was recorded, this is the snake, *Crotaphopeltis hotamboeia.* The species is apparently already established in primary forest as it was captured near the summit of Mlungui Hill. Two non-forest butterfly species were also captured.

Table 23. Summary of ecological type of vertebrate faunal species.

Ecological type	No. of species	% of total species recorded
(F) Forest dependent	4	23.5
(f) Forest dwelling but not forest dependent	8	47.1
(O) Non-forest species	1	5.9
Unknown	4	23.5
Total	**17**	**100.0**

Table 24. Summary of ecological type of butterfly species.

Ecological type	No. of species	% of total species recorded
(F) Forest dependent	7	53.8
(f) Forest dwelling but not forest dependent	4	30.8
(O) Non-forest species	2	15.4
Unknown	0	0
Total	**13**	**100.0**

Endemic Status

One species recorded is endemic to the Usambara mountains. This is the snake, *Prosymna semifasciata* sp. nov., known previously only from Kwamgumi forest reserve. Specimens in both locales were found in forested areas.

Table 25. Summary of endemic status of vertebrate faunal species.

Endemic status	No. of species	% of total species recorded
(E) Endemic to the Usambara Mountains	1	5.8
(N) Near-Endemic: ranges in restricted locations	3	17.6
(W) Widespread	9	52.9
Unknown	4	23.5
Total	**17**	**100.0**

Table 26. Summary of endemic status of butterfly species.

Endemic status	No. of species	% of total species recorded
(E) Endemic to the Usambara Mountains	0	0
(N) Near-Endemic: ranges in restricted locations	4	30.8
(W) Widespread	9	69.2
Unknown	0	0
Total	**13**	**100.0**

Range Extensions

Reptiles:

The second specimen of *Prosymna semifasciata* sp. nov. was collected, the only other collecting site of this species is the overbank flood plain of the Muzi river in Kwamgumi forest reserve. Mlungui and the forest block of which Kwamgumi is a part have been isolated since the late 1960's due to the establishment of sisal estates.

IUCN Status (National Biodiversity Database, 1997)

Prosymna semifasciata sp. nov. is listed as 'Critically Endangered'

Philothamnus macrops and *Agama montana* are listed as 'Vulnerable'.

No Figure / Map Currently Available in Digital Format

Figure 23. Areas of highest disturbance in relation to the distribution of animal species that are both forest dependent and either endemic or near-endemic.

7.0 CONCLUSION

This report presents the raw data of the survey with preliminary descriptions in terms of ecological type and endemic status. These two factors provide an indication of three main aspects of biodiversity and conservation:

1. the relationship between forest dependency and endemism;
2. the extent to which non-forest species are established in the reserve; and
3. the relationship between disturbance and areas of biological value.

Mlungui forest, proposed as a forest reserve in 1994, covers an area of 200 ha on the eastern edge of the East Usambara range. With altitudes between 220 m and 480 m, it consists of approximately 36.0% mature forest, 50.0% previously disturbed, colonising or poorly stocked forest, 14.0% formerly cultivated land.

Disturbance

All areas assessed for human disturbance indicate that Mlungui Hill is under high pressure from pole cutting and on the lower slopes from timber extraction. Although timber extraction from the mature, dense forest was lower, any pressure is likely to be exacerbated by the small size of the reserve.

Species Richness

The proposed forest reserve was found to contain at least 56 species of tree and shrub; five mammal, nine reptile and three amphibian species.

Flora

No tree or shrub species were recorded which are endemic to the Usambara mountains although 16 have ranges restricted to the Eastern Arc and/or East African lowland forests. Thirteen species are dependent on primary forest, and of these species, five are also near endemic to the Usambara mountains. Seven non-forest tree and shrub species are established within the reserve boundaries.

Fauna

One vertebrate species endemic to the Usambara Mountains was recorded as well as four near-endemic species. Four species are dependent on primary forest, and of these, three are also endemic or near endemic to the Usambara mountains. One non-forest species is established in the reserve.

The butterfly survey recorded four near-endemic species all of which are forest dependent.

Table 27. Summary of biodiversity of taxa surveyed.

Taxon:	Total no. of species	% forest dependent	No. of non-forest species	No. of endemics	No. of near-endemics	No. of forest dependent endemics and near-endemics
trees and shrubs	56	23.2	7	0	16	**5**
mammals	5	0	0	0	1	**0**
reptiles	9	44.4	1	1	2	**3**
amphibians	3	0	0	0	0	**0**
butterflies	13	53.8	2	0	4	**4**
Total	**87**	--	**10**	**1**	**23**	**12**

Conservation

The East Usambara mountains are important due to their floral and faunal diversity, their high level of species endemism and their water catchment value. The forests are also an important source of fuelwood, poles, timber, food and medicinal plants for the local people. Differences in the perceived value of the forests have caused and still cause a conflict of interest between the villagers and the Catchment authorities. The remaining forests of the East Usambara mountains are now only small refuges of what was present just one hundred years ago (Hamilton, 1989). The area continues to be vulnerable because of growing pressure for agricultural land associated with a growing population.

Mlungui proposed forest reserve is a small area separated by 1 km of agricultural land from a large forest block to the west. The size of the reserve and its isolation from areas of similar habitat has implications for the reserve's biodiversity. Without natural corridors to link the reserve to the neighbouring larger forest block some populations may be nonviable as populations with few individuals and simple community structures tend to be more susceptible to the loss of genetic variability (Wilcox, 1984). The loss of genetic variability caused by inbreeding within Mlungui's small populations may affect the fecundity and fitness of its flora and fauna. The overall result may be extinction for these small populations without the genetic diversity to respond to disease and environmental stress (Ledig, 1992). Mlungui harbours some important species of flora and fauna but these are threatened from within by this erosion of genetic diversity. The reserve is also threatened by unsustainable resource use which has reduced mature forest to just over one-third of the reserve where it is restricted to the summit and upper slopes.

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Appendix 1:

General Plot Information

Plot Number	Topography	Altitude (metres)	Slope (degrees)	Vegetation Condition	Canopy Height (metres)
1	SU	450	50	M	20-30
2	SU	380	25	M	10-20
3	MS	470	31	M	20-30
4	GL	200	30	P	<10
5	GL	390	38	B	20-30
6	GL	220	25	G/P	10-20
7	GL	290	?	P	?
8	GL	300	34	M	<10

KEY TO ABBREVIATIONS

Topography

GL - gentle lower slope
SL - steep lower slope
M - mid-slope
GU - gentle upper slope
SU - steep upper slope
FV - flat valley floor
RT - ridge top
F - mature mixed forest
SG - steep gully

Vegetation Condition

M - mature mixed forest/more or less natural forest
P - disturbed primary forest or secondary forest
G - grassland
B - bushland and/or thicket
W - woodland
FC - forest edge/colonising
EC - former encroachment/colonising

* No 50m x 20m plot was surveyed in this area. This is a trapping site only.

Appendix 2:

Taxonomic Verification

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