TECHNICAL PAPER 56

Mlinga Forest Reserve

A biodiversity survey

Frontier Tanzania
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East Usambara Conservation Area Management Programme

Technical Paper 56

Mlinga Forest Reserve

A biodiversity survey

Hall, S.M., Fanning, E., Howell, K. M., and Pohjonen, V. (eds.)

Ministry of Natural Resources and Tourism, Tanzania
Forestry and Beekeeping Division

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East Usambara Conservation Area Management Programme (EUCAMP)
The East Usambara rain forests are one of the most valuable conservation areas in Africa. Several plant and animal species 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 Conservation Area Management Programme has established the Amani Nature Reserve and aims; at protecting water sources; establishing and protecting forest reserves while sustaining villager's benefits from the forest. The programme 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 Indufor / Metsähallitus Group. 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 Frontier Tanzania, of which one component is 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 Conservation Area Management Programme (EUCAMP). This survey of selected forests collects baseline biodiversity data and assists the EUCAMP in the management of the East Usambara forests.

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EXECUTIVE SUMMARY

Mlinga Forest Reserve, located to the east of the main East Usambara Mountain range of northeast Tanzania, covers an area of 8.9 km^2 (890ha), situated in Muheza District, Tanga Region. Its steep rocky slopes and peak area characterise the Reserve. Altitudes range from 220m to 1069m above sea level (asl). The Forest Reserve contains submontane, lowland forest, open wooded grassland and montane peak. Mlinga Forest Reserve was gazetted as a Catchment Forest Reserve in 1996 primarily to protect the headwaters of Mruka (a tributary of the Sigi) and Mkulumzi Rivers and to conserve the interesting forest and rocky summit surrounding Mlinga peak (Hamilton, 1989). Mlinga is surrounded by Misozwe, Magula and Mwembeni villages.

As part of the East Usambara Conservation Area Management Programme, (EUCAMP), (formerly the East Usambara Catchment Forest Project), Frontier-Tanzania conducted a biological survey of Mlinga Forest Reserve between October and December 2001 for a total of 10 research weeks. The systematic vegetation survey covered all parts of the reserve with a sampling intensity of 0.5%, the zoological survey was focussed on 5 trapping sites. This report provides an inventory of the trees, shrubs, herbs, mammals, reptiles, amphibians, birds and butterflies recorded during the survey. The report also describes patterns of human disturbance within the reserve. The species richness, endemism and ecological affinities of the taxa recorded are summarised in Table 1.

Table 1 Summary of biodiversity of taxa surveyed.

Taxon	Total no. of species	% forest dependent	No. of non-forest species	No. of endemic species	No. of near-endemic species	No. of forest dependent endemics and near-endemics
Trees and shrubs	135* 11** 123***	23%	10* 23***	5* 4***	12* 14***	13* 8***
Mammals	32	29%	10	0	5	2
Birds	47	17%	18	1	6	5
Reptiles	25	36%	6	0	8	8
Amphibians	21	49%	4	0	11	10
Butterflies	103	34%	34	0	2	1
Total	**497**	**n/a**	**103**	**10**	**58**	**47**

* Species recorded in vegetation plots ** Species recorded in the regeneration plots only,
*** Species recorded opportunistically

Relative to other reserves surveyed by Frontier-Tanzania, Mlinga Forest Reserve has average floral and faunal diversity. Of most interest are the species that are restricted to the unique rocky ridge and peak habitats.

In terms of flora, Mlinga FR is made up of a mosaic of different habitats. A large proportion of species recorded within Mlinga FR were categorised as non-forest dwelling (Table 1). Submontane and lowland riverine forests, unaffected by fire, were the most important habitats for endemic, near-endemic and forest dependent plant species. A total of 9 endemic plants were recorded within Mlinga Forest Reserve. Mlinga peak area supported the only population of the tree *Podocarpus latifolius* (Gymnospermae) occurring naturally in the East Usambara mountains. Also of interest, was the sighting of one *Sanraffaelia ruffonammari* tree specimen, a species only previously recorded in Kwamgumi Forest Reserve, and the tree *Cola luckei* previously only recorded in Bamba, Kwamgumi and Segoma forest reserves. Rocky areas within Submontane Forest are also important habitats for the following African violet species: *Saintpaulia magungensis* and *S. diplotricha.* These species are of utmost conservation concern.

Despite its small size, Mlinga Forest Reserve supports a high diversity of mammal and butterfly species and a high number of near-endemic amphibian and reptile species. The reserve is home to 4 endangered and 23 vulnerable species according to the National Biodiversity Database (UDSM, 1997) and IUCN categories (Hamilton-Taylor, 2000).

Mlinga Forest Reserve produced the first records of the toad *Schismaderma carens* in the East Usambara mountains. These records are believed to represent the most northerly record of this species to date.

Mlinga Forest Reserve continues to be of spiritual value to local Washambaa communities. The forest serves as a source of medicinal plants and non-timber forest products. Ritual areas were witnessed to still be in use today.

The greatest threat to Mlinga Forest Reserve, is fire disturbance that has threatened the forest annually and extensively in recent years. Pole cutting and animal hunting continue illegally on a small scale within the forest reserve. Local concern for the future of the forest reserve is apparent amongst elders in village communities.

The information collected by this survey will be used for management planning by the EUCAMP. The survey results are also available as a baseline for monitoring. The data are stored on a Microsoft Access (version Windows 2000) database in the EUCAMP library in Tanga, and parts of it will be available on the Internet at the following address: www.usambara.com

Animal specimens have been deposited at: the Department of Zoology and Marine Biology, University of Dar es Salaam; Natural History Museum, London; Zoological Museum of Copenhagen, Denmark; Frankfurt Zoological Museum, Germany and The Natural History Museum of Zimbabwe, Bulawayo. Contact names and addresses are listed in Appendix 2.

Botanical specimens are held at the National Herbarium of Tanzania (NHT) in Arusha, Missouri Botanical Gardens, USA and Kew Royal Botanical Gardens, UK.

FOREWORD

The East Usambara forests in northeastern Tanzania are part of the Eastern Arc mountains. More than one hundred years of biological interest and research have shown that these forests have a unique diversity of flora and fauna, and an exceptionally high degree of endemism. They have gained global recognition as being part of a Biodiversity Hotspot (Conservation International), an Endemic Bird Area (BirdLife), a Centre of Plant Diversity (WWF and IUCN) and a Globally Important Ecoregion (WWF). Since 1990, the East Usambara Conservation Area Management Programme (EUCAMP) (formerly known as the East Usambara Catchment Forest Project (EUCFP)) has worked in the East Usambara 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 technical support from Indufor / Metsähallitus Group.

Although a considerable amount of biological information exists from the East Usambara Mountains much of this is restricted to the Amani area and systematic surveys elsewhere are few. In order to get more comprehensive information on the forests, biodiversity surveys were initiated and contracted 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 EUCAMP. 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 priorities in the conservation of this valuable area.

The programme involves locally employed field assistants, permanent EUCAMP, Frontier-Tanzania, 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 Usambara Mountains. EUCAMP has also commissioned the development of a biodiversity database, a work which also contributed the maps to these reports. All data collected during the surveys is entered into this database, which is linked to the Tanzanian national biodiversity database held at the Department of Zoology and Marine Biology, University of Dar es Salaam.

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 better management and conservation of the East Usambara Mountains 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.

Mathias Lema	Veli Pohjonen
Project Manager	Chief Technical Adviser

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1.0 INTRODUCTION

1.1 The East Usambara Mountains and forest diversity

The East Usambara Mountains are situated in northeastern Tanzania within 40 km of 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 that 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 uprising (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. The dry seasons are from June to August and January to March. However precipitation occurs in all months. Rainfall is greatest at higher altitudes and in the southeast of the mountains, increasing from 1,200 mm annually in the foothills to over 2,200 mm at higher altitudes. Due to topographic and climatic interactions, the west-facing slopes of the mountains are drier compared to the east-facing slopes. Due to their age, isolation and their role as condensers of the moisture from the Indian Ocean, the East Usambara Mountains support ancient and unique forests, rich in endemic species (Hamilton, 1989).

Research in the East Usambara Mountains began in the late 1890s with substantial botanical collections being undertaken. Later, in 1928, surveys were undertaken on amphibians and by the 1930s detailed ornithological work had begun. Since these early studies biological research in the mountains has steadily increased. 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 (Rodgers and Homewood, 1982; Howell, 1989). They are considered to be one of the most important forest blocks in Africa (Tye, 1994). In 1991, Iversen documented at least 3450 species of vascular plants that had been recorded in the Usambara Mountains, of which it was suggested that over one quarter were endemic or near-endemic (Iversen, 1991a). Many of these species were recorded as threatened (Rodgers, 1996). Recent botanical research such as Beharrell *et al.* (2002) has shown that plant species are still being discovered, some of which are more threatened than ever before.

The forests of the East Usambara Mountains are not only important for their biodiversity, they also play an important role in maintaining the hydrological cycle that feeds the Sigi River. This 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 a more irregular run off and deterioration in water quality due to siltation.

The latest survey of the East Usambara Mountains, conducted by Johansson and Sandy (1996) shows that approximately 45,137 ha of the East Usambara Mountains 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 850m. The area recorded as forest in the East Usambara Mountains according to these categories is described in Table 2.

Table 2 Forest area in the East Usambara Mountains (based on Johansson and Sandy, 1996).

Forest type	Area	% of area
Lowland forest	29497.4	62.9
Submontane forest	12916.6	30.6
Forest plantation	2723.6	6.5
TOTAL	**45137.6**	

The mammals of the East Usambara Mountains show limited endemism (Kingdon and Howell 1993). However, there are several species of special interest. These include: the restricted Zanj elephant shrew, *Rhynchocyon petersi*, which is common in the Usambara Mountains (Collar and Stuart, 1987) yet listed as globally 'Endangered' by IUCN due to a decline in habitat extent and quality; Eastern tree hyrax, *Dendrohyrax validus*, listed as 'Vulnerable' by IUCN (Hilton-Taylor, 2000), and the Lesser pouched rat, *Beamys hindei* which is also considered 'Vulnerable' by IUCN (Hilton-Taylor, 2000).

There are at least 11 species of reptiles and amphibians endemic to the East and West Usambara Mountains (Howell, 1993). The East Usambara Biodiversity Surveys provide further information on new species and species' range extensions. A new species of snake, *Prosymna semifasciata*, was recently found in Kwamgumi and Segoma Forest Reserves (Broadley, 1995) and a recently described amphibian species; *Stephopaedes usambarae* (Poynton and Clarke, 1999) has been recorded by the surveys in Mtai and Kwamgumi Forest Reserves.

The forest avifauna of the East Usambara Mountains has a high diversity with at least 110 species (Stuart, 1989). The total number of observed bird species in the mountain range is 350 (Pohjonen, V. pers.comm.). Six species occurring in lowland forests such as Mlinga, are considered 'vulnerable' to 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* (IUCN, 1996).

The East Usambara Mountains are essentially forest 'islands' (Lovett, 1989). There has been natural forest in the area for several million years. The Usambara Mountains harbour many species that 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, 1991a).

These forests have been under continuous exploitative human pressure for at least 2,000 years (Schmidt, 1989). Until recently, especially before the past 50 years, (Kikula, 1989), this pressure was 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.

1.2 Report structure

This report provides a floral and faunal inventory of Mlinga Forest Reserve (Mlinga FR). Each species is described in terms of its ecological requirements and its endemic status.

Ecological requirements are defined as:

- **Forest dependent species (F)**: Species dependent on primary forest only. This category does not include forest edge or secondary forest species;
- **Forest non-dependent species (f)**: Forest dwelling but not dependent on primary forest: species occurring in primary forest as defined above as well as other vegetation types. It should be emphasised that many of these species are still dependent on a forest habitat albeit forest edge or disturbed forest. Most species in this category will still be adversely affected by forest destruction.
- **Non-forest species (O)**: These are species that do not normally occur in primary or secondary forest or forest edge.

Levels of endemism are defined as:

- **Usambara Endemic (E):** Occurring only in the Usambara Mountains;
- **Near-endemic (N):** Species with ranges restricted to the Eastern Arc Mountains and the adjacent coastal forests (occurring only in the East African biodiversity hotspot);
- **Widespread (W):** Species with ranges extending beyond the Eastern Arc and adjacent coastal forests.

The typical habitat association of plant species is categorised as either:

- **Lowland (L):** Species occurring at altitudes of <850m.
- **Submontane (S):** Species occurring at altitudes of >850m but <1250m.
- **Montane (M):** Species occurring at altitudes of >1250m.

This refers to the habitat(s) in which they are typically found in East Africa, rather than to where they have been recorded in the reserve.

These three criteria are used to analyse the uniqueness of the biodiversity of the reserve and its vulnerability to disturbance. The categories are based on information from various sources.

1.2.1 Flora

Floral nomeclature generally follows the following databases located on the internet:
www.mobot.org (TROPICOS database in University of Missouri, Botanical Garden)
www.ipni.org (International Plant Names Index)
Family organisation follows Iversen (1991b).

For plants, the ecological type and endemic status are primarily based on Iversen (1991b). Forest dependent species refers to those species listed as being exclusively associated with Iversen's categories 1a (wet evergreen forest), 1b (dry evergreen forest) and / or 1c (riverine forest). Species defined as forest dwelling also occur in other habitats.

Definitions of habitat type are based on Hamilton (1989). For those species not listed by Iversen (1991b) or Hamilton (1989), the information is taken from the Flora of Tropical East Africa and from the List of East African Plants (LEAP), Knox (2000).

Endemic and near-endemic status for plants was taken from Iversen (1991b) and FTEA categories Tanzania T3, T6, T8 and Kenya K7.

1.2.2 Fauna

For fauna, the following references were used:

Mammals:	Kingdon (1997), Kingdon (1974), Walker (1998).
Birds:	Zimmerman *et al.* (1996), Stattersfield *et al* (1998), Mlingwa *et al.* (2000), Stuart (1989).
Reptiles:	Spawls *et al.* (2002).
Amphibians:	Passmore and Carruthers (1995).
Butterflies:	Kielland (1990) and Larsen (1996).

For animals, the endemic and near-endemic status was gleaned from the Tanzanian National Biodiversity Database (NBD) (UDSM, 1997).

1.2.2.1 Birds

Ecological type of bird species recorded were based on, Mlingwa *et al.* (2000) which in turn is based on Bennum *et al.* (in press). Those species not included in the above were categorised by Zimmerman *et al.* (1996) and Stuart (1989).

Forest dependence Mlingwa *et al.* (2000):

- **Forest specialist (FF):** Species that are typical of forest interior and likely to disappear when the forest is modified to any extent.
- **Forest generalist (F):** Species that can occur in undisturbed forest but which are able to exist (and may even be numerous) at the forest edge or in modified and fragmented forests. However, these generalists continue to depend upon forests for some of their resources, such as nesting sites.
- **Forest visitors (f):** Species that occur outside forest areas but which might visit forest.

Stuart (1989) categorises species by adaptability:

1. those which live in forest but are not dependent upon it for their survival
2. those which live in forest and 'overspill' into adjacent habitats, but are dependent upon forest for their continued survival
3. those that can only survive in forest and hardly 'overspill' into adjacent habitats.

The NBD (UDSM, 1997) and IUCN 2000 were used to categorise threat status of the animals listed. The NBD lists were compiled with regard to status and threat within Tanzania and East Africa. *The status of most species are currently undergoing national and international evaluation.* IUCN categorises species in terms of global threat and produces Red data books, available from 1996 and earlier. However, a new IUCN 2000 CD-Rom has been released. Many Tanzanian species are not included in the 2000 IUCN Red data CD-Rom. IUCN 2000 status is given, where available, in addition to NBD for all taxa groups and is the main source of threat status for bird species.

1.3 Maps

The distribution of plant species within the reserve is presented as a series of maps. These are thematic maps where the size of each spot is directly proportional to the value that they represent. In the plots where no spot is shown, the relevant taxa were either not found or not surveyed. Only one map summarises animal data. Not enough capture data was available to produce useful thematic maps for each animal taxa.

1.4 Data and monitoring

Data are stored in a Microsoft Access (version Windows 2000) database currently stored at the East Usambara Conservation Area Management Programme and Frontier-Tanzania. Parts of it are now available on the Internet. Zoological data are also stored on the National Biodiversity Database at the Department of Zoology and Marine Biology, University of Dar es Salaam. This is also a Microsoft Access database. The data are geographically referenced and so can be used as a baseline for biodiversity monitoring.

1.5 Survey period and personnel

The survey of Mlinga Forest Reserve was conducted between 8th October and 12th December 2001 for a total of 10 research weeks. Frontier-Tanzania staff, EUCAMP Forest Officers, and locally employed field assistants from Maramba, Tanga, Amani and Misozwe conducted the survey.

2.0 AIMS OF THE SURVEY

The specific aims of the biodiversity survey as outlined in the Terms of Reference between the Frontier Tanzania Forest Research Programme and the East Usambara Conservation Area Management Programme (EUCAMP) are:

- to conduct biological baseline surveys in selected forests as a baseline against which to monitor future changes in biodiversity status;
- 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 provide information on human disturbance and levels of resource use in different areas of the forest;
- to develop specific, quantitative methods of monitoring key biodiveristy indicators, and assist in establishing long term monitoring procedures to address specific aspects of the forest ecology and management such as regeneration and hunting;
- to train Tanzanian personnel from EUCAMP and the Forestry and Bee Keeping Division in forest survey work;
- to contribute to global biodiversity assessment and conservation efforts through collaboration with specialists elsewhere, and the sharing of information, data and material collected during surveys.

Furthermore, the aims of the survey methods applied are:

- to sample the vegetation and tree species composition of selected forests of the East Usambara Mountains using systematic sampling techniques along systematically located vegetation transects, which sample 0.25% or 0.5% of the 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 standardised and repeatable methods to record biodiversity values of the forest in terms of small mammal, reptile, amphibian, and invertebrate species;
- to collect opportunistic data on all other groups of vertebrate and invertebrates. Species lists resulting from this will be compared against IUCN categories of threat and other conservation criteria in order to assess the overall biodiversity values of each forest.

By using standardised and repeatable methods these surveys provide an assessment of the biodiversity value of the forests, enabling their importance to be determined and their biodiversity value to be monitored in future.

An additional aim of the project that is covered in a separate report includes:

- to provide small scale feedback with regard to the survey findings through environmental education activities within school and village committee networks, in co-operation with the EUCAMP Farm Forestry Activities.

3.0 DESCRIPTION OF THE FOREST

3.1 General description

3.1.1 Description

Name: Mlinga Forest Reserve
Muheza District, Tanga Region, Tanzania.

Area: 890 ha

Status: Catchment Forest Reserve
Chain and Compass Survey 5th December 1992
Gazetted 5th October, 1996 Gazettement notice GN 443.
Central Authority Status

Maps: Ordnance Survey topographic maps 1: 50 000 Series Y742 (DOS 422)
Sheet 130/1 'Mnyuzi' of 1989 and Sheet 130/2 'Muheza' of 1989
Forest and Bee Keeping Division maps:
Jb 2213 1994 'Mlinga Forest Reserve' 1:10,000

3.1.2 Location

Lat/Long: S 05°04'00'' – S 5°05'00'' E 38°44'30'' - 38°46'00'' E

UTM/UPS: 94 4200 - 94 3800 S 04 6900 - 47 4000 E

Elevation: 220m – 1069 m above sea level

Mlinga Forest Reserve (Mlinga FR) is located in the east of the main East Usambara mountain range (Figure 1), approximately 20 km directly west from Tanga. The forest reserve is one of the smallest and most isolated blocks of forest reserve in the East Usambara Mountains. Public forest and farms surround the reserve. Mlinga FR is surrounded by Misozwe, Magula and Mwembeni villages and associated sub-villages.

3.1.3 Topography

The reserve encompasses Mlinga peak at 1069m above sea level, and the surrounding rocky ridge and outcrops (Figure 2). Much of the reserve is inaccessible by foot. The forest reserve protects headwaters of Mruka (a tributary of the Sigi) and Mkulumzi Rivers.

Flat lowland valleys surround Mlinga FR on all sides. Manga FR rises to the north, Kwamarimba to the north west, Magoroto FR to the south.

3.1.4 Land use

The latest survey of the area was carried out by Hyytiäinen (1995), and updated by Johansson and Sandy (1996). The most common habitat within Mlinga FR was recorded as dense Lowland forest (Table 3).

Table 3 Land use distribution (Johansson and Sandy, 1996).

Mlinga Forest Reserve	**Area (hectares)**	**% of area**
Dense Lowland forest	419.0	49.9
Poorly Stocked Lowland forest	198.5	23.6
Cultivation under Lowland forest	4.8	0.6
Dense Submontane forest	47.4	5.6
Barren land	77.0	9.2
Peasant cultivation	92.7	11.0
Total	**839.4**	**100**

3.1.5 History and Status

There has been human pressure in the East Usambara Mountains for at least 2000 years. In the 19th Century it appears populations were markedly lower in the East Usambara Mountains relative to the West Usambara Mountains with much of the area remaining forested.

Mlinga FR is one of the most recently gazetted forest reserves within the East Usambara mountains. Mlinga FR was gazetted in 1996 primarily to protect the headwaters of Mruka (a tributary of the Sigi) and Mkulumuzi Rivers and to conserve the interesting forest and rocky summit surrounding Mlinga peak (Hamilton, 1989).

Before Tanzanian independence (1961), the forest surrounding Mlinga peak was successfully protected traditionally. Large animals such as lion, leopard, Colobus monkey, bush pig and duiker once roamed the hillsides of Mlinga. Primarily a famous mkilindi (special elder) looked after the forest, with the aim of worshipping, extracting medicine, water and for other cultural beliefs. Cutting trees, setting fires, hunting, cultivation and grazing were restricted within the forest. People believed that the forest would punish anyone harming it. People were scared to harvest trees and hunt animals for fear of their life. Myth said that they would lose their path out of the forest if they were to cut a tree or kill an animal (pers. comm. Mzee Semwaza, Mwembene village and Woodcock, 1995).

Mlinga forest quality and expanse began to decline following independence, as a consequence of population growth and immigration. Cardamom (*Illeteria cadamon*) cultivation, extraction of valuable timber such as *Milicia excelsa* (Moraceae), *Afzelia quanzensis* (Caesalpinoideae) and *Albizia* species (Mimosoideae) and fire were the most serious threats.

The inaccessible nature of Mlinga FR meant that mechanical logging was limited to lowland areas. No logging roads were visible within the forest reserve. Pitsawing, and the extraction of non-timber forest products such as poles, medicines, fibres and honey were commonplace, particularly before gazettment.

Since gazettment, the forest has continued to be used for the collection of cultural resources and worshipping. Regular and extensive fires in recent years have occurred within the Forest Reserve and have significantly reduced the quality and expanse of closed forest habitat.

In comparison with other Forest Reserves in the East Usambara mountains, little research has been conducted within Mlinga FR. This survey is the first comprehensive, systematic and comparable survey of all accessible parts of the forest reserve.

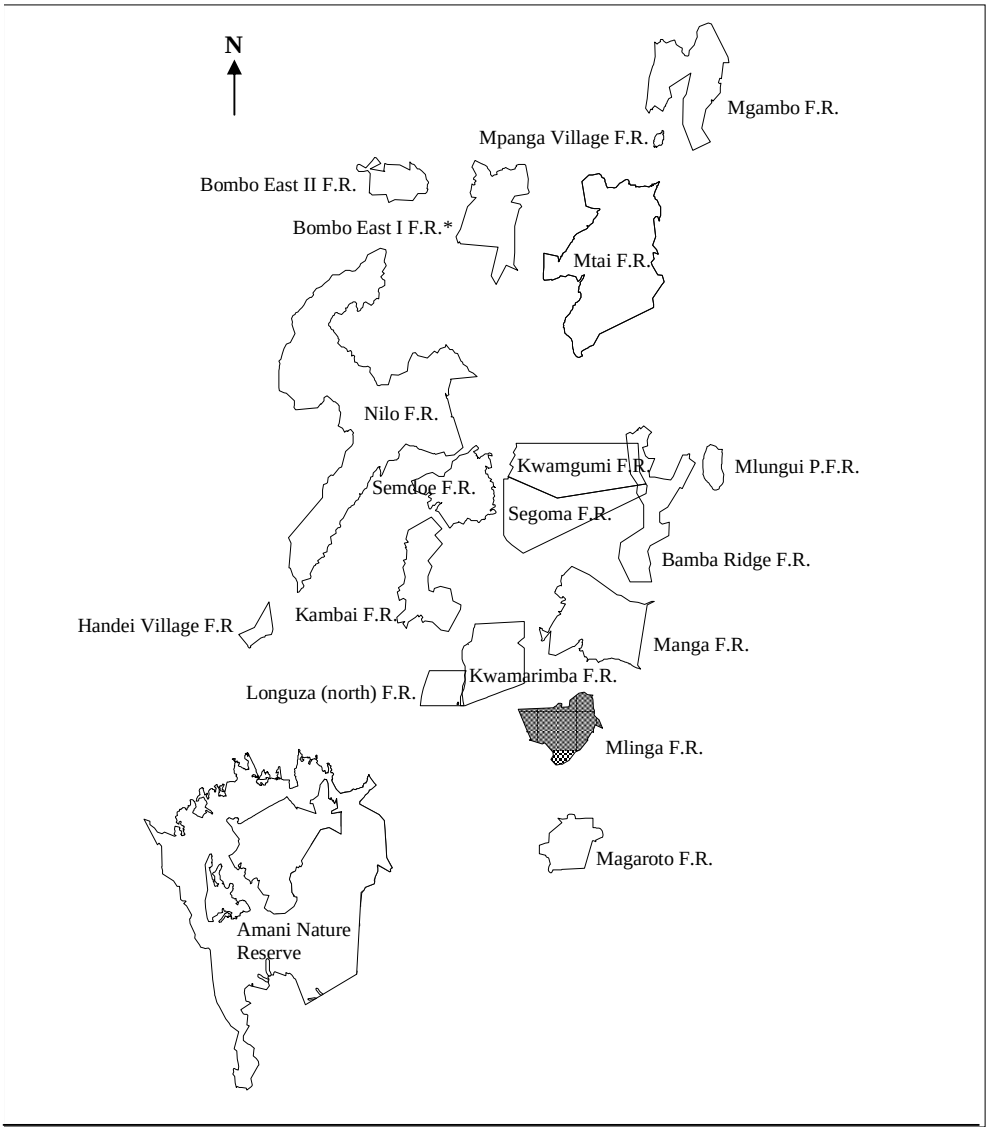

Figure 1 The location of Mlinga FR in relation to other East Usambara forests.

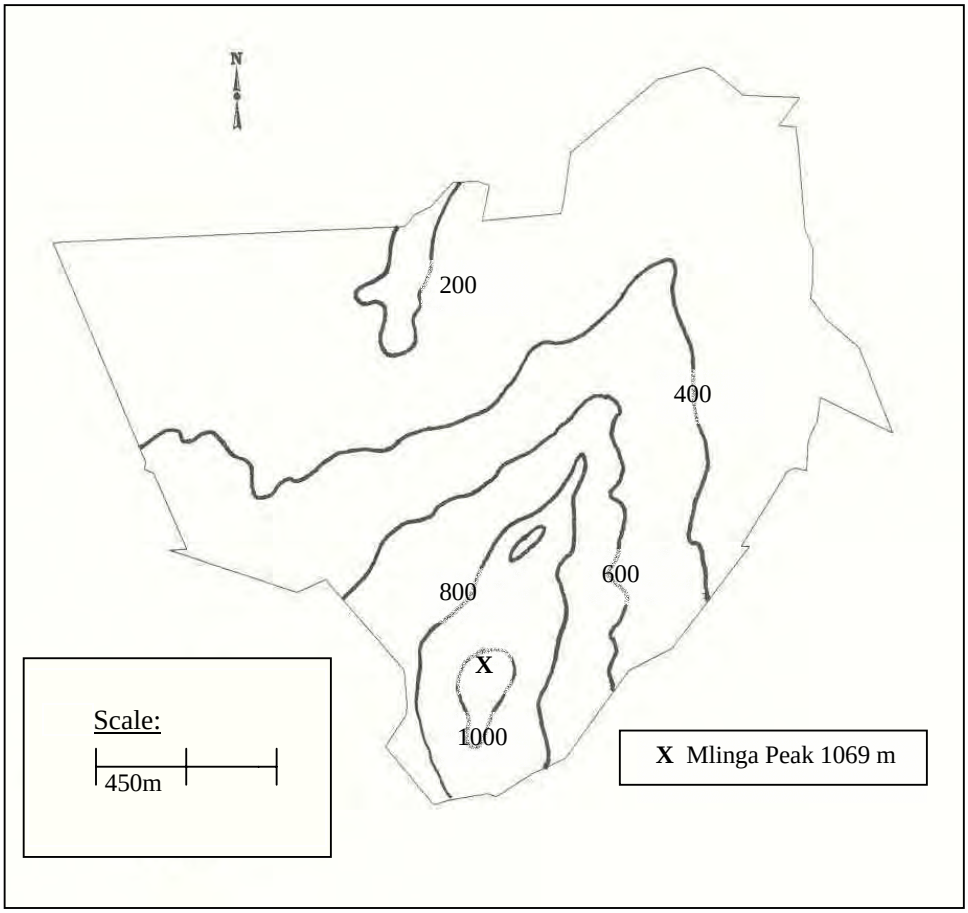

Figure 2 Topographical sketch map of Mlinga FR.

4.0 VEGETATION

Authors: Hall, S.M., Ntemi, A.S., Oliver, S., Smith, J. and Murphy, A. pp. 11-56

4.1 Introduction

A species inventory was compiled of the trees and shrubs found within the forest 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 documented. Botanical and disturbance data collected by this survey have been entered onto the EUCAMP database.

4.2 Methods

The forest reserve was divided into a grid of numbered squares marked in the field by tagged transect lines. All methods are based on this grid system and are detailed in the FT FRP methodologies report (SEE, 1998). A brief description is presented below. The location of vegetation plots and disturbance transects (Figure 3) were recorded using Global Positioning System (GPS). GPS co-ordinates are presented in Appendix 2.

4.2.1 Forest composition

Three methods were used to analyse forest composition: (1) quantitative vegetation analysis; (2) opportunistic observations and (3) disturbance transects.

4.2.1.1 Quantitative vegetation analysis

The vegetation survey was based on a 450m x 450m grid marked in the field using tagged transect lines. The small size of the forest reserve meant that intensification of the 450m x 900m grid system used, most recently, to sample Mtai FR, Segoma FR, Semdoe FR, Amani Nature Reserve and Nilo FR was necessary to document all habitats adequately. One plot 50m x 20m was sampled in each grid square, giving an approximate sampling intensity of 0.5%. The 20m x 50m vegetation plots were located in the southeast corner of each of the 450m x 450m grid rectangles. Within each sample (vegetation) plot, every tree with a diameter at breast height (dbh) of 10cm and over was recorded, marked with red paint and identified. A botanist from EUCAMP provided the field identification of plant species. Specimen collection was made of fertile individuals, and individuals that proved difficult to identify in the field.

The regeneration layer was sampled within 3m x 3m (and 6m x 6m) nested subplots at the centre of each vegetation plot. All trees and shrubs with a dbh below 10cm were counted and identified within these plots. The ground cover (of herbaceous vegetation, bare soil, leaf litter and rocks), and the dominance of other vegetation (such as grasses, forbs, mosses, lichens and ferns) were documented as percentages. Systematically sampled vegetation data is presented in the form of checklists and analytical calculations summarised in tables, graphs and maps.

4.2.1.2 Opportunistic collection and observation

Opportunistic collections and observations of ground, shrub and tree species were made throughout the survey. Fertile individuals were collected as specimens and dried in the field using a kerosene stove. Detailed field notes were made of each specimen and are stored with the specimens. All botanical specimens are held at the National Herbarium, Arusha and Missouri Botanical Gardens, USA. Some specimens are also kept at Royal Botanical Gardens Kew, UK. Opportunistic data is presented as a checklist.

4.2.1.3 Disturbance transects

Disturbance transects were used to record the intensity of pole and timber cutting and incidence of other disturbance types in the forest reserve. The disturbance transects were based on the 450m x 450m grid prepared for the vegetation plots (Figure 3). Each transect running east-west was sampled from border to border where accessible. Disturbance was recorded by 50m section along each transect.

Every self-standing tree and sapling (not lianas or creepers) above 5cm dbh was measured within 5m either side of each transect line. Each plant was recorded under one of four categories: live, old cut, new cut or naturally dead. Within these categories a distinction was made between poles and timbers. Poles were classified as having a dbh (diameter at breast height) between 5 and 15cm and a minimum of 2m relatively straight trunk. Timber was classified as having a dbh > 15cm with a minimum 3m relatively straight trunk. These divisions were based on differences in use. New cut stems were determined by cream coloured slash and classified as freshly cut within recent months (approximately within the past 6 months). Old cut stems were determined by black coloured slash and classified as old cut (approximately more than 6 months old). Timber and pole cutting data are presented as an average per hectare and summarised in graphs and maps.

The incidence of other signs of disturbance (such as fire, cultivation, animal trapping, pitsawing) were documented every 50m section and summarised in a table and maps. The most disturbed plots were calculated using pole and timber cutting counts and incidence figures for 'other signs of disturbance'. Pole and timber cutting counts were combined, summed and then ranked, with the most disturbed plot ranked 1. All incidence records of 'other signs of disturbance' were summed and ranked, with the most disturbed plot ranked 1. The top six plots in each data set were combined to give the top twelve disturbed plots. Three additional border plots were additionally considered to be worthy of consideration.

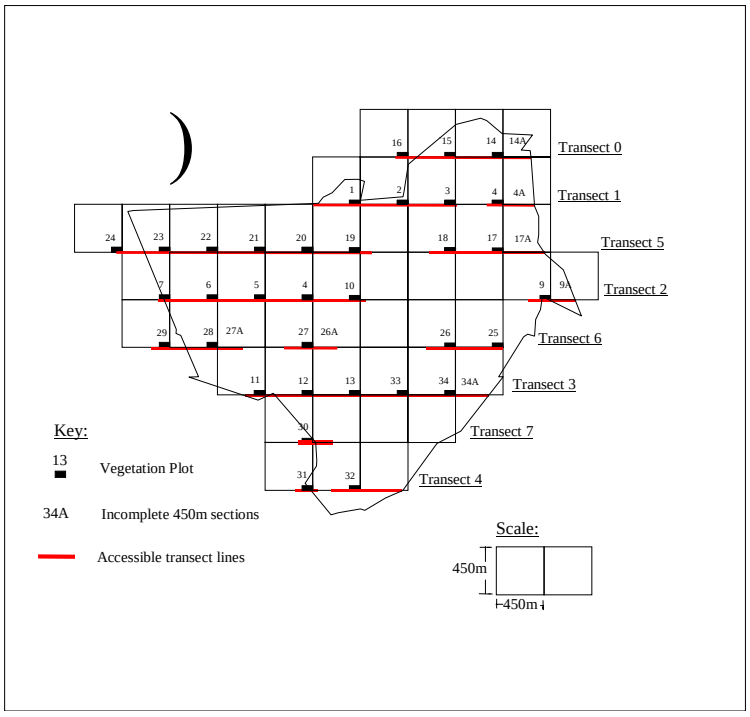

Figure 3 Location of vegetation plots and disturbance transects in Mlinga FR.
(GPS co-ordinates of vegetation plots are summarised in Appendix 2).

4.3 Results

4.3.1 Quantitative vegetation analysis

4.3.1.1 Vegetation Plots

A total of 34 20x50m vegetation plots were established. The dominant vegetation types within vegetation plots were lowland forest (35% of plots) and open woodland (29% of plots). Only three vegetation plots were classified as undisturbed submontane forest. Almost half (48%) of all vegetation plots had an average canopy height of less than 10m. Only six vegetation plots were recorded with canopy heights greater than 20m. Approximately two-thirds of vegetation plots had been affected by fire and 59% contained rock outcrops. Only four vegetation plots were positioned at submontane altitudes, greater than 850m above sea level. The average slope for all accessible vegetation plots was moderately steep at 19.5 ($\pm$10.8) degrees. Vegetation plot descriptions are summarised in Appendix 3 and a vegetation map shown in Figure 4.

A total of 780 individuals, representing 39 families and 135 species were recorded in thirty four 20m x 50m vegetation plots. Five individuals were unable to be identified. Data is presented for both 0.25% and 0.5% sampling intensities. Species are described, where adequate information exists, in terms of their ecological type, their habitat and their endemic status. Nomenclature follows Iversen (1991b), the Flora of Tropical East Africa (Polhill *et al.*, 1988) and the LEAP database (Knox, 2000). Table 4 presents a checklist of these tree and shrub species.

Table 4 Checklist of trees and shrubs recorded within the vegetation plots.

	Ecol. Type	Habitat	End. Status	Total no. of individuals	Present in n plots
Angiospermae – Dicotyledonae					
ANACARDIACEAE					
Lannea schweinfurthii (Engl.) Engl. 1897	**f**	**L&S**	**W**	**2**	**1**
Lannea schweinfurthii var. *stuhlmannii* (Engl.) Kokwaro 1980	f	L&S&M[1]	W	5	3
Rhus natalensis Bernh. 1844*	f	L&S&M[2]	W	10	3
Sorindeia madagascariensis Thouars ex DC. 1825*	**f**	**L&S**	**W**	**8**	**4**
ANNONACEAE					
Annona senegalensis Pers. 1806*	f	L&S	W	35	9
Annickia kummeriae (Engl. & Diels) Setten & Maas 1990 (basionym *Enantia kummeriae* Engl. & Diels 1900)	F	S	N	2	1
APOCYNACEAE					
Funtumia africana (Benth.) Stapf 1899*	F	L&S&M	W	20	5
Hunteria zeylanica (Retz.) Gardner ex Thwaites 1860	F	L[2]	W	2	1
Rauvolfia caffra Sonder 1850*	F	L&S&M	W	2	2
Sarcopharyngia stapfiana (Britten) P. Boiteau 1981 (basionym *Tabernaemontana stapfiana* Britten 1894)	f	L&S&M	W	6	3
Tabernamontana ventricosa Hochst. ex A. DC. 1844	F	L&S&M	W	51	6

Table 4 continued.

	Ecol. Type	Habitat	End. Status	Total no. of individuals	Present in n plots
ARALIACEAE					
Cussonia arborea Hochst. ex A. Rich. 1847	f	L&S&M	W	12	7
BIGNONIACEAE					
Markhamia lutea (Benth.) K. Schum. 1895*	f	L&S	W	12	6
Markhamia obtusifolia (Baker) Sprague 1919	**f**	**S**	**W**	**1**	**1**
Stereospermum kunthianum Cham. 1832*	f	L&S	W	83	5
BOMBACEAE					
Rhodognaphalon schumannianum A. Robyns 1963 (basionym *Bombax rhodognaphalon* K. Schum.ex Engl. 1895)	f	L[2]	W[2]	5	1
BORAGINACEAE					
Cordia africana Lam. 1792	f	L&S[2]	W[2]	1	1
Fernandoa magnifica Seem. 1870	?	L[2]	N	1	1
Gerascanthus monoicus (Roxb.) A. Borhidi 1988 (basionym *Cordia monoica* Roxb. 1796)	**f**[1]	**L&S&M**[1]	**W**[1]	**1**	**1**
CELASTRACEAE					
Maytenus undata (Thunb.) Blakelock 1956	f	L&S&M[2]	W	4	2
COMBRETACEAE					
Combretum molle R. Br. ex G. Don 1827	**O**	**L**	**W**	**1**	**1**
Combretum schumannii Engl. 1895	**f**	**L&S**[2]	**W**	**5**	**1**
Terminalia sambesiaca Engl. & Diels 1900	f	L	W	3	3
COMPOSITAE					
Solanecio mannii (Hook.f.) C.Jeffrey 1986	O	?	W[2]	1	1
EBENACEAE					
Diospyros abyssinica (Hiern) F. White 1956	f	L&S&M[2]	W	1	1
Diospyros natalensis (Harv.) Brenan 1954*	f	L&S&M	W	3	3
EUPHORBIACEAE					
Antidesma membranaceum Müll. Arg. 1866	f	L&S	W	2	2
Bridelia cathartica G. Bertol. 1854	**f**	**L&S&M**[2]	**W**	**1**	**1**
Bridelia micrantha (Hochst.) Baill 1862*	f	L&S&M	W	20	5
Croton sylvaticus Hochst. 1845	**f**	**L&S&M**[2]	**W**	**2**	**2**
Drypetes usambarica (Pax) Hutch 1912**	**f**	**L&S&M**	**N**	**3**	**1**
Macaranga capensis (Baill.) Benth. ex Sim 1907	F	L&S&M	W	14	4
Mildbraedia sp.*	**?**	**?**	**?**	**1**	**1**
Phyllanthus sp.	**?**	**?**	**?**	**1**	**1**
Pycnocoma littoralis Pax 1894	**f**[1]	**L**[1]	**W**[1]	**1**	**1**
Ricinodendron heudelotii (Baill.) Pierre ex Pax 1911	**f**	**L&S**	**W**	**6**	**4**

Table 4 continued.

	Ecol. Type	Habitat	End. Status	Total no. of individuals	Present in n plots
EUPHORBIACEAE continued.					
Shirakia elliptica (Hochst.) Kruijt 1996 (basionym *Sclerocroton ellipticus* Hochst. 1845, syn. *Sapium ellipticum* (Hochst.) Pax 1912)	f	L&S&M	W	11	4
FLACOURTIACEAE					
Caloncoba welwitschii (Oliv.) Gilg 1908 (basionym *Oncoba welwitschii* Oliv. 1868)	f[1]	S&M[2]	W[2]	1	1
GUTTIFERAE					
Allanblackia stuhlmannii (Engl.) Engl. 1897**	F	L&S&M	N	3	3
Haronga madagascariensis (Lam. ex Poir.) Choisy 1821 (basionym *Harungana madagascariensis* Lam. ex Poir. 1804)	F	S	W	2	2
LEGUMINOSAE subfamily: CAESALPINOIDEAE					
Afzelia quanzensis Welw. 1858	**f**	**L&S&M**[2]	**W**	**1**	**1**
*Cassia sp.**	?	?	?	1	1
Cynometra brachyrrhachis Harms 1915	F	L&S	E(EU)	4	1
Cynometra longipedicelata Harms	F	L&S	E(EU)	1	1
***Cynometra sp. A* (of FTEA)**	**F**	**S**	**E(EU)**	**1**	**1**
Dialium holtzii Harms 1913	**F**	**L**[2]	**W**	**1**	**1**
Scorodophloeus fischeri (Taub.) J. Léonard 1951*	F	L&S&M[2]	N	5	3
LEGUMINOSAE subfamily: MIMOSOIDEAE					
Albizia adianthifolia (Schumach.) W.F. Wight 1909*	f	L&S	W	1	1
Albizia chinensis (Osbeck) Merr. 1917 (exotic, naturalized)	O	L&S	W	2	1
Albizia gummifera (J.F. Gmel.) C.A. Sm. 1930*	f	L&S&M	W	17	7
***Dichrostachys cinerea* (L.)** Wight & Arn. 1834	**f**	**L&S&M**[2]	**W**	**1**	**1**
Feuilleea versicolor (Welw.ex Oliv.) Kuntze 1891 ***Albizia versicolor*** (Welw.ex) Oliv. 1871	**O**	**L&S&M**	**W**	**1**	**1**
Inga glaberrima (Schumach. & Thonn.) Roberty 1954 (basionym *Albizia glaberrima* (Schumach. & Thonn.) Benth. 1844)**	f	L&S	W	2	1
Newtonia buchananii (Baker) Gilb. & Bout. 1952**	F	L&S&M	W	1	1
Newtonia paucijuga (Harms) Brenan 1955**	F	L[2]	N	3	2
Parkia filicoidea (Welw.ex) Oliv. 1871	F	L&S&M	W	1	1
LEGUMINOSAE subfamily: PAPILIONOIDEAE					
Angylocalyx braunii Harms 1810*	F	L	N	12	3
Cordyla africana Lour. 1790	F	L&S	W	1	1
Craibia brevicaudata (Vatke) Dunn 1911	F	S[2]	W	3	2

Table 4 continued.

	Ecol. Type	Habitat	End. Status	Total no. of individuals	Present in n plots
LEGUMINOSAE subfamily: PAPILIONOIDEAE continued.					
Craibia brownii Dunn 1911	F	S&M	W	4	2
Diphaca kirkiii (S. Moore) Taub. 1894 (basionym ***Ormocarpum kirkii*** S. Moore 1877)	**O**[1]	**L&S**[1]	**W**[1]	**2**	**1**
Lonchocarpus bussei Harms 1902	O	L&S&M	W	14	6
Millettia oblata Gillet 1911	F	S&M	N	1	1
Millettia usaramensis Taub. 1895*	f	L[2]	W	4	3
Pterocarpus angolensis DC. 1825	f	L&S&M[2]	W	2	1
LOGANIACEAE					
Anthocleista grandiflora Gilg.1893 **	f	S	W	1	1
Strychnos innocua Delile 1826	O[1]	M[2]	W[2]	4	2
Strychnos spinosa Lam 1794	**f**	**L**[1]	**W**	**2**	**1**
Strychnos sp.	?	?	?	1	1
MELASTOMATACEAE					
Memecylon amaniense (Gilg.) A.Fern. & R.Fern 1960	F	L[2]	N	1	1
Warneckea schliebenii (Markgr.) Jacq.-Fél. 1978 (basionym ***Memecylon schliebenii*** Markgr. 1932)	**F**	**S**[2]	**N**	**2**	**1**
MELIACEAE					
Entandrophragma excelsum (Dawe & Sprague) Sprague 1910	**F**	**S&M**	**W**	**13**	**4**
Trichilia dregeana Sond. 1860*	**F**	**L&S&M**	**W**	**1**	**1**
Turraea floribunda Hochst. 1844	**f**	**L&S&M**[2]	**W**	**1**	**1**
MELIANTHACEAE					
Bersama abyssinica Fresen 1837*	f	S	W	2	2
MORACEAE					
Antiaris toxicaria Leschen. 1810*	f	L&S	W	15	10
Artocarpus heterophyllus Lam. 1789 (exotic)	O	?	W	1	1
Ficus exasperata Vahl 1805**	f	L&S&M	W	10	6
Ficus holstii Warb. 1894 (basionym *Ficus lutea* Vahl 1805)	f[1]	L&S&M[1]	W[1]	1	2
Ficus natalensis Hochst. 1845	f	L&S&M	W	3	3
Ficus sur Forssk 1775	f	L&S&M	W	11	3
Ficus vallis-choudae Delile 1843	**f**	**L&S**	**W**	**1**	**1**
Mesogyne insignis Engl. 1894*	F	L&S	W	16	3
Milicia excelsa (Welw.) C.C. Berg 1982	f	L&S	W	10	6
Trilepisium madagascariense Thouars ex DC. 1825*	F	S&M	W	10	5

Table 4 continued.

	Ecol. Type	Habitat	End. Status	Total no. of individuals	Present in n plots
MYRSINACEAE					
Baeobotrys lanceolata (Forssk.) Vahl 1790 (basionym *Maesa lanceolata* Forssk 1775)*	f	L&S&M	W	8	2
MYRTACEAE					
Eugenia guineensis (Willd.) Baill. ex Laness. 1886 (basionym *Calyptranthes guineense* Willd. 1800, syn. Syzygium guineense (Willd.) DC. 1828)	f	S&M[1]	W	1	1
OLACACEAE					
Strombosia scheffleri Engl. 1909*	F	L&S&M	W	15	2
OLEACEAE					
Olea sp.	?	?	?	2	1
RHAMNACEAE					
Maesopsis eminii Engl. 1895 (introduced, naturalized)	F	L&S	W	1	1
Ziziphus mucronata Willd. 1809	**f**	**L&S&M**[2]	**W**	**1**	**1**
Ziziphus pubescens Oliv. 1887	**f**	**L&S**[2]	**W**	**5**	**1**
RUBIACEAE					
Canthium sp.	**?**	**?**	**?**	**2**	**2**
Oxyanthus speciosus DC. 1807	F	S&M	W	6	4
Polysphaeria sp.	**?**	**?**	**?**	**2**	**1**
Rothmannia manganjae (Hiern) Keay 1958*	F	L&S&M	W	13	4
Tarenna pavettoides (Harv.) Sim 1907	F	L&S&M	W	9	2
Tricalysia sp.*	?	?	?	7	5
Vangueria infausta Burchell 1824	**f**	**L&S&M**	**W**	**3**	**2**
RUTACEAE					
Vepris amaniensis (Engl.) Mziray 1992**	**?**	**?**	**?**	4	1
Vepris simplicifolia (Engl.) Mziray 1992	?	?	W	1	1
Zanthoxylum holtzianum (Engl.) P.G. Waterman 1975	**f**[1]	**L**[1]	**W**	**1**	**1**
SAPINDACEAE					
Allophylus melliodorus Gilg ex Radlk. 1909*	f	S&M	N	2	2
Lecaniodiscus fraxinifolius Baker*	**f**	**L&S&M**	**W**	**4**	**1**
Phialodiscus unijugatus (Baker) Radlk. 1879 (basionym *Blighia unijugata* Baker 1868)*	f	L&S&M	W	4	3
Zanha golungensis Hiern 1896*	**O**[1]	**L&S**[2]	**W**[2]	**1**	**1**
SAPOTACEAE					
Synsepalum cerasiferum (Welw.) T.D. Penn. 1991 (basionym *Sapota cerasifera* Welw. 1858, syn. *Afrosersalisia cerasifera* (Welw.) Aubrév. 1957)	f	L&S&M[2]	W	4	1

Table 4 continued.

	Ecol. Type	Habitat	End. Status	Total no. of individuals	Present in n plots
SAPOTACEAE continued.					
Englerophytum natalense (Sond.) T.D. Penn. 1991 (basionym *Chrysophyllum natalense* Sond. 1850, syn. *Bequaertiodendron natalense* (Sond.) Heine & J.H. Hemsl. 1960)*	f	L&S&M	W	10	4
Manilkara sulcata (Engl.) Dubard 1915*	f	L[2]	W	11	4
Pouteria adolfi-friedericii (Engl.) A. Meeuse 1960 (basionym *Sideroxylon adolfi-friedericii* Engl. 1913, syn. *Aningeria adolfi-friedericii* (Engl.) Robyns & G.C.C. Gilbert 1947)	f	L	W	2	2
Synsepalum cerasiferum (Welw.) T.D. Penn. 1991 (basionym *Sapota cerasifera* Welw. 1858, syn. Afrosersalisia cerasifera (Welw.) Aubrév. 1957)	?	?	?	1	2
Synsepalum msolo (Engl.) T.D. Penn. 1991 (basionym ***Pachystela msolo*** (Engl.) Engl. 1904)*	**F**	**L&S&M**	**W**	**9**	**3**
STERCULIACEAE					
Cola clavata Mast. 1868 *	**F**	**L**[2]	**W**[2]	**2**	**2**
Cola scheffleri K.Schum. 1903**	F	L&S	E(EU)	3	2
Dombeya shupangae K. Schum. 1900*	O	L[2]	N	10	5
Leptonychia usambarensis K. Schum	F	?	W	4	3
Sterculia appendiculata K. Schum. 1895	**F**	**L**[2]	**W**	**1**	**1**
Sterculia rogersii N.E.Br. 1921	?	?	W[2]	2	2
TILIACEAE					
Grewia goetzeana K. Schum	**f**	**L&S**[1]	**N**	**2**	**2**
Grewia holstii Burrett 1910	f	L&S[1]	W	2	2
ULMACEAE					
Celtis africana Burm. F. 1768*	F	L&S&M	W	15	7
Celtis gomphophylla Baker 1886	**F**	**L&S&M**	**W**	**11**	**2**
Celtis mildbraedii Engl. 1909	**F**	**L&S&M**	**W**	**4**	**3**
Sponia orientalis (L.) Decne. 1934 (basionym *Celtis orientalis* L. 1753, syn. *Trema orientalis* (L.) Blume 1852)*	F	L&S&M	W	31	10
UMBELLIFERAE					
Peucedanum araliaceum (Hochst.) Hiern 1877 (basionym *Steganotaenia araliacea* Hochst. 1844)	f	L&S&M	W	4	3
VERBENACEAE					
Premna chrysoclada (Bojer) Gürke 1903	**f**	**L**[1]	**N**	**2**	**2**
Vitex ferruginea Schumach. & Thonn. 1827	F	L&S[1]	E(EU)	2	1
VIOLACEAE					
Rinorea ferruginea Engl. 1902	**F**	**L&S&M**	**W**	**1**	**2**

Table 4 continued.

	Ecol. Type	Habitat	End. Status	Total no. of individuals	Present in n plots
Angiospermae – Monocotyledonae					
DRACAENACEAE					
Dracaena sp.	**?**	**?**	**?**	**1**	**1**

KEY TO ABBREVIATIONS FOR TABLE 4 (also refer to section 1.2.1)

Ecological type: (based on Iversen, 1991b)
- F - Forest dependent species: Species previously recorded as restricted to primary or closed canopy forest only, e.g. wet evergreen forest, dry evergreen forest and/or riverine forest;
- f - Forest dwelling but not forest dependent: Species previously recorded in primary or closed canopy forest as defined above and/or in forest edge, clearings, secondary forest, deciduous forest and woodland, and
- O - Non-forest species: These are species that do not occur in primary or secondary forest or forest edge (e.g. species that have been recorded in bushland, heathland, thicket, secondary scrub, grassland, rocky outcrops, swamps, wastelands and cultivation.

Habitat: (based on Hamilton, 1989)
- L - Lowland: Species occurring at altitudes less than 850m above sea level;
- S - Submontane: Species occurring at altitudes greater than 850m above sea level (masl) and below 1,250 masl.
- M – Montane Species occurring at altitudes greater than 1,250m above sea level.

If species occur in more than one habitat range, this has been recorded (e.g. L&S – this species has been recorded at altitudes between 0m and 1,250m above sea level).

Endemic status: (based on Iversen, 1991b)
- E – Usambara endemic: Occurring only in the Usambara mountains, EU - Range limited to the East Usambara Mountains, WU - Range limited to the West Usambara Mountains;
- N – Near-endemic: Species with limited ranges in the Eastern Arc mountains and the adjacent coastal forests (occurring only in the East African biodiversity hotpot);
- W - Widespread distribution.

Regeneration Layer:
Celtis africana Burm. F. 1768*: species recorded in the regeneration sample plots 3m x 3m are marked with one asterisk.
Cola scheffleri K.Schum. 1900**: additional species recorded in the regeneration sample plots 6m x 6m are marked with two asterisks.

[1] Information based on FTEA.
[2] Information based on LEAP (Knox, 2000)

Bold type – Additional species found as a consequence of intensifying vegetation plot sampling from 450m x 900m to 450m x 450m.

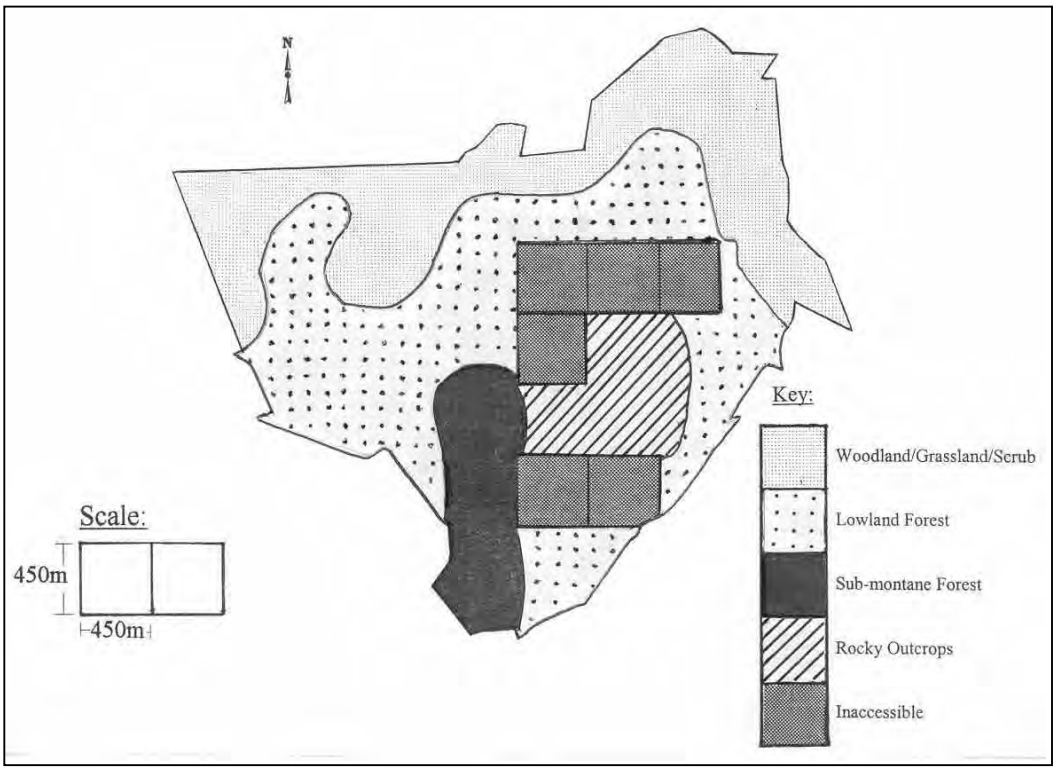

Figure 4 Sketch map of vegetation types in Mlinga FR.

4.3.1.2 Species Abundance

The most abundant species within vegetation plots was *Stereospermum kunthianum* representing 10.6% of all individuals sampled. This species was only present within five vegetation plots where it dominated other species (Table 5). *Stereospermum kunthianum* was common at low altitudes in open woodland and lowland forest margins, usually associated with rocky outcrops. *Tabernamontana ventricosa* was ranked as the second most abundant species within vegetation plots (Table 5). This species was found in six vegetation plots, in lowland forest plots and one disturbed submontane forest plot. All of the most abundant species are widespread in their distribution and common in woodland and/or forest habitats.

Table 5 Ranked abundance of tree and shrub individuals within vegetation plots.

		Rank	Number of Individuals	% of total no. individuals	In x plots (n=34)	% of total no. plots
BIGNONIACEAE	*Stereospermum kunthianum*	1	83	10.6	6	17.6
APOCYNACEAE	*Tabernamontana ventricosa*	2	51	6.5	6	17.6
ANNONACEAE	*Annona senegalensis*	3	35	4.5	9	26.5
ULMACEAE	*Sponia orientalis*	4	31	4.0	10	29.4
APOCYNACEAE	*Funtumia africana*	5	20	2.6	5	14.7
EUPHORBIACEAE	*Bridelia micrantha*	5	20	2.6	5	14.7
LEGUMINOSAE subfamily MIMOSOIDEAE	*Albizia gummifera*	7	17	2.2	7	20.6
MORACEAE	*Mesogyne insignis*	8	16	2.1	3	8.8
MORACEAE	*Antiaris toxicaria*	9	15	1.9	10	29.4
ULMACEAE	*Celtis africana*	9	15	1.9	7	20.6
OLACACEAE	*Strombosia scheffleri*	9	15	1.9	2	5.9
LEGUMINOSAE subfamily PAPILIONIDEAE	*Lonchocarpus bussei*	12	14	1.8	6	17.6
EUPHORBIACEAE	*Macaranga capensis*	12	14	1.8	4	11.8
MELIACEAE	*Entandrophragma excelsum*	14	13	1.7	4	11.8
RUBIACEAE	*Rothmannia manganjae*	14	13	1.7	4	11.8

Sponia orientalis and *Antiaris toxicaria* were present in the greatest number of plots (29.4%) (Table 6). *Sponia orientalis* was commonly found regenerating in areas that had been disturbed by fire. *Antiaris toxicaria* were mostly recorded in lowland and submontane forest plots that had not recently been affected disturbance.

Annona senegalensis was commonly found in vegetation plots throughout the reserve and was ranked third in Table 6. This species was common in open woodland areas and often associated with fire damage.

One *Maesopsis eminii* individual was recorded within Mlinga FR in vegetation plot 12.

Table 6 Ranked abundance of tree and shrub species occurrence within vegetation plots.

		Rank	In x Plots (n=34)	% of total no. plots	Number of Individuals (n=780)	% of total no. individuals
ULMACEAE	*Sponia orientalis*	1	10	29.4	31	4.0
MORACEAE	*Antiaris toxicaria*	1	10	29.4	15	1.9
ANNONACEAE	*Annona senegalensis*	3	9	26.5	35	4.5
LEGUMINOSAE subfamily: MIMOSOIDEAE	*Albizia gummifera*	4	7	20.6	17	2.2
ULMACEAE	*Celtis africana*	4	7	20.6	15	1.9
ARALIACEAE	*Cussonia arborea*	4	7	20.6	12	1.5
BIGNONIACEAE	*Stereospermum kunthianum*	7	6	17.6	83	10.6
APOCYNACEAE	*Tabernamontana ventricosa*	7	6	17.6	51	6.5
LEGUMINOSAE subfamily: PAPILIONIDEAE	*Lonchocarpus bussei*	7	6	17.6	14	1.8
MORACEAE	*Ficus exasperata*	7	6	17.6	10	1.3
MORACEAE	*Milicia excelsa*	7	6	17.6	10	1.3
APOCYNACEAE	*Funtumia africana*	12	5	14.7	20	2.6
EUPHORBIACEAE	*Bridelia micrantha*	12	5	14.7	20	2.6
STERCULIACEAE	*Dombeya shupangae*	12	5	14.7	10	1.3
RUBIACEAE	*Tricalysia sp.*	12	5	14.7	7	0.9

4.3.1.3 Species Accumulation

The accumulation of species records throughout the systematic vegetation survey showed that an additional 45 species were recorded as a consequence of increasing the sampling intensity from 450 x 900m (0.25%) to 450 x 450m (0.5%) (Figure 5). Although the curve seems to be reaching a plateau, there is not enough evidence to suggest that the accumulation of species would not increase with even greater sampling intensity (Figure 5).

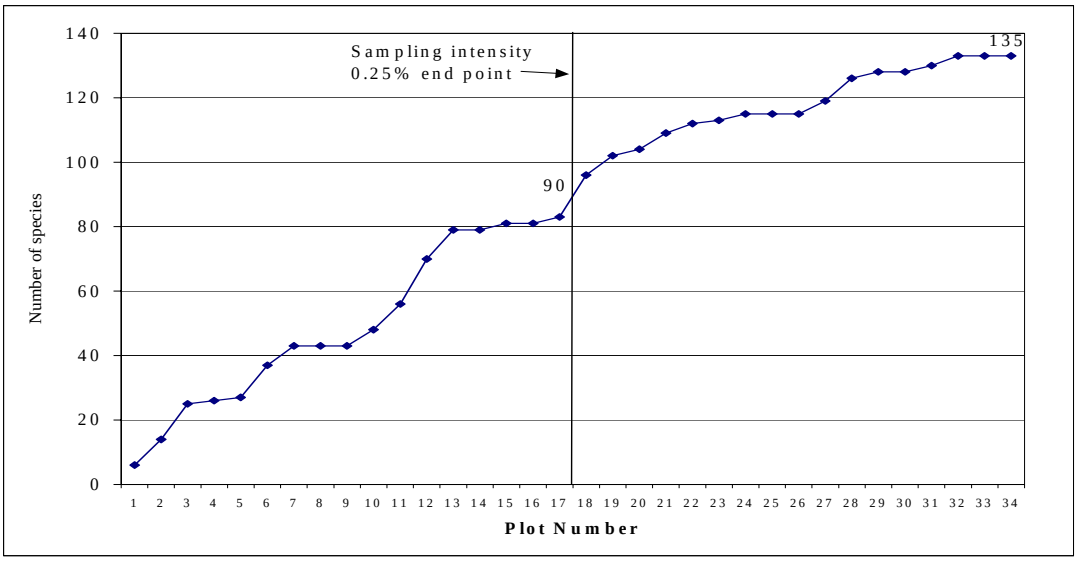

Figure 5 Species accumulation rates of trees and shrubs (10cm dbh and larger) by vegetation plot for 0.5% sampling intensity.

4.3.1.4 Endemic Status

A total of 5 species and 11 (1.4%) individuals recorded in vegetation plots were endemic to the East Usambara mountains, with 14 (10%) species and 49 individuals recorded as near-endemic. The majority of species recorded were therefore widespread in their distribution (W) (Table 4). Endemic and near-endemic species were relatively widely dispersed throughout the forest reserve (Figure 6 and 7). At both 0.5% and 0.25% sampling intensities, percentages of the total number of species and individuals were similar, although actual records were significantly lower at the lowest (0.25%) sampling intensity (Table 7).

Table 7 Summary of endemism for tree and shrub species recorded in the 50m x 20m vegetation plots.

	Number of species	**% of species**	**Number of individuals**	**% of individuals**
Endemic to the East Usambara Mountains (E(EU))	5 (4)	3.7 (4.4)	11 (10)	1.4 (3.0)
Near-endemic (N)	14 (10)	10.4 (11.1)	49 (24)	6.3 (7.1)
Widespread (W)	99 (67)	73.3 (74.5)	680 (285)	87.2 (84.3)
Unknown (?)	17 (9)	12.6 (10)	40 (19)	5.1 (5.6)
Total	**134 (90)**	**100 (100)**	**780 (338)**	**100 (100)**

Based on Table 4. Figures from 0.25% sampling intensity are shown in brackets.

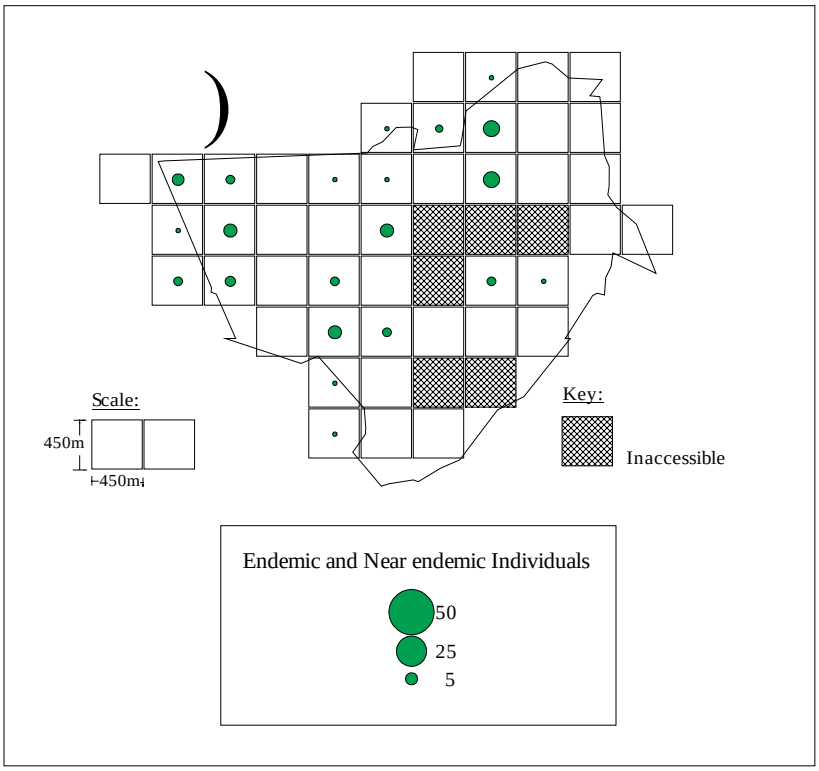

Figure 6 Distribution of endemic and near-endemic tree and shrub individuals in Mlinga FR.

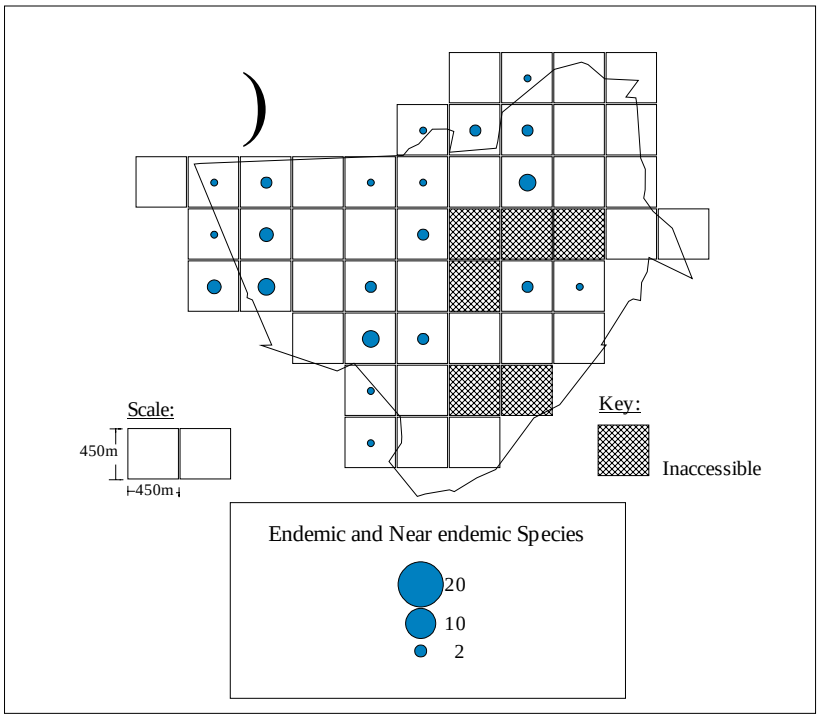

Figure 7 Distribution of endemic and near-endemic tree and shrub species in Mlinga FR.

4.3.1.5 Ecological type

A total of 41 (30%) species and 298 (38%) individuals recorded within vegetation plots were forest dependent (Table 8). The majority of species and individuals were forest dwelling (Table 8). Figures 8 and 9 show the distribution of forest dependent individuals and species, and give an indication of the distribution of tall closed canopy forest within Mlinga FR (refer to Figure 4). Forest dependent species show a similar distribution throughout Mlinga FR to the endemic and near-endemic species (Figures 6, 7, 8 and 9).

Non-forest individuals and species are concentrated in the north and north west border areas of the forest reserve (Figures 10 and 11), and give an indication of the distribution of non-forest habitats (refer to Figure 4).

At both 0.5% and 0.25% sampling intensities, percentages of the total number of tree and shrub species and individuals recorded in each ecological type were similar. Actual records were significantly lower at the lowest (0.25%) sampling intensity (Table 8).

Table 8 Summary of ecological type of tree and shrub species recorded in the 50m x 20m vegetation plots.

Ecological Type	Number of species	% of total species	Number of individuals	% of total individuals
Forest dependent (F)	41 (31)	30.4 (34.4)	298 (123)	38.2 (36.3)
Forest dwelling (f)	64 (39)	47.4 (43.3)	401 (177)	51.5 (52.5)
Other (O)	10 (6)	7.4 (6.7)	37 (14)	4.7 (4.1)
Unknown (?)	20 (14)	14.8 (12.2)	44 (24)	5.6 (7.1)
Total	**135 (90)**	**100 (100)**	**780 (338)**	**100 (100)**

Based on Table 4. Figures from 0.25% sampling intensity are shown in brackets.

4.3.1.6 Habitat

A total of 50 species (35%) and 385 individuals (50%) present within vegetation plots had previously been recorded in other areas at altitudes of between 0m and greater than 1250m above sea level and therefore were categorised as species of lowland, submontane and montane forest (L&S&M) habitats (Table 8). Plant records from Mlinga FR were most commonly categorised within this habitat type and hence showed limited elevational specialisation. A total of 22 (16%) species and 49 (6%) individuals were categorised as unknown. Only 8 (6%) species and 14 (2%) individuals were categorised soley as submontane forest species (S) and 1 species and 4 individuals as montane forest species. Figures 12 and 13 present the distribution of submontane and montane forest species throughout the FR.

Although submontane altitudes are restricted to the south of the forest reserve (refer to Figure 2) submontane and montane individuals and species were present throughout Mlinga FR (Figures 12 and 13), particularly in areas of closed canopy within lowland and riverine forest (refer to Figure 4).

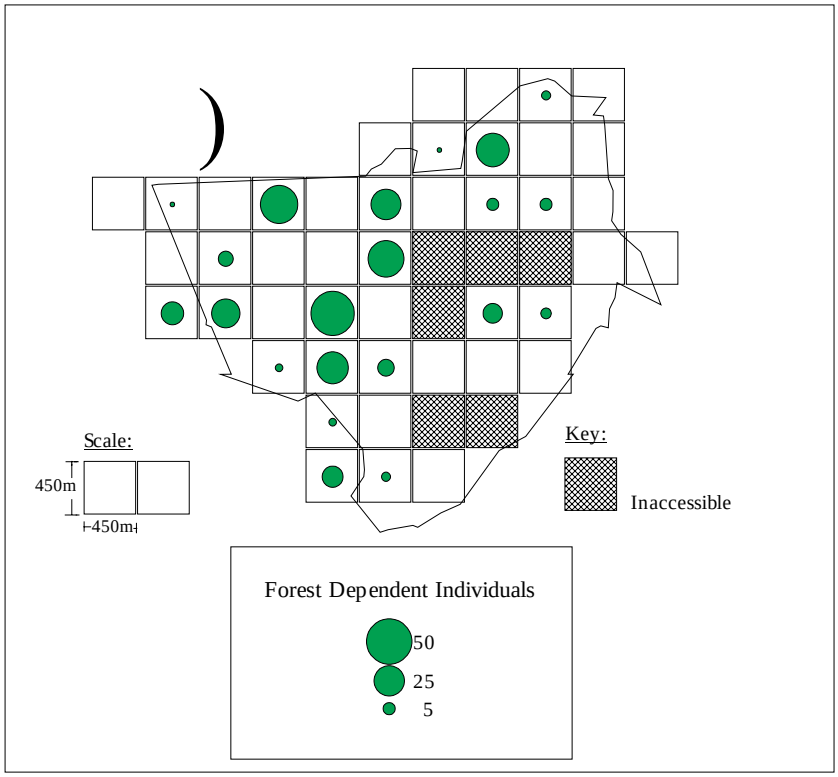

Figure 8 Distribution of forest dependent tree and shrub individuals in Mlinga FR.

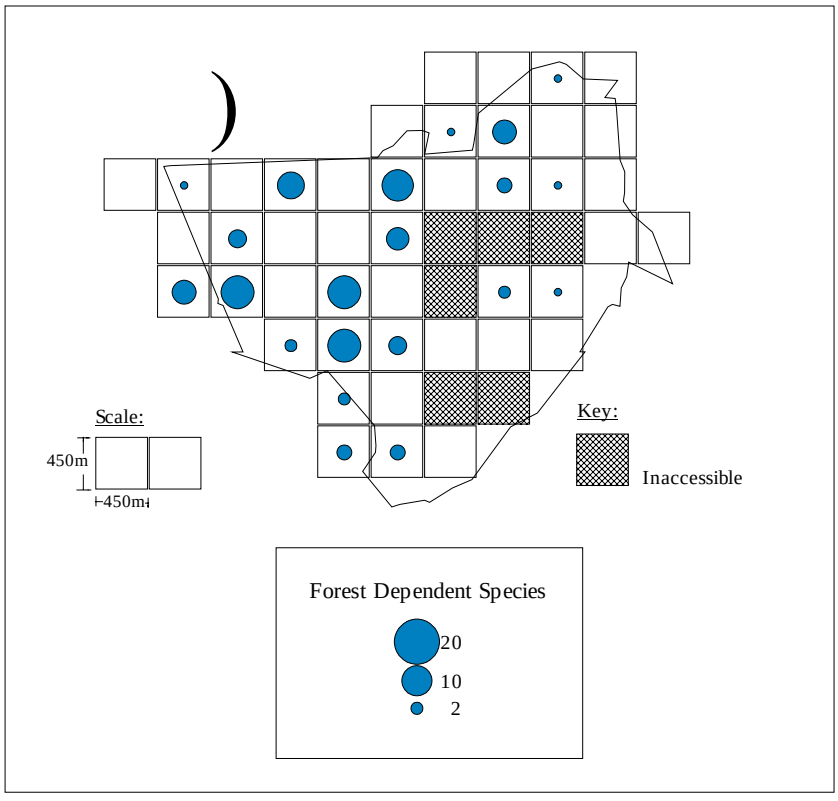

Figure 9 Distribution of forest dependent tree and shrub species in Mlinga FR.

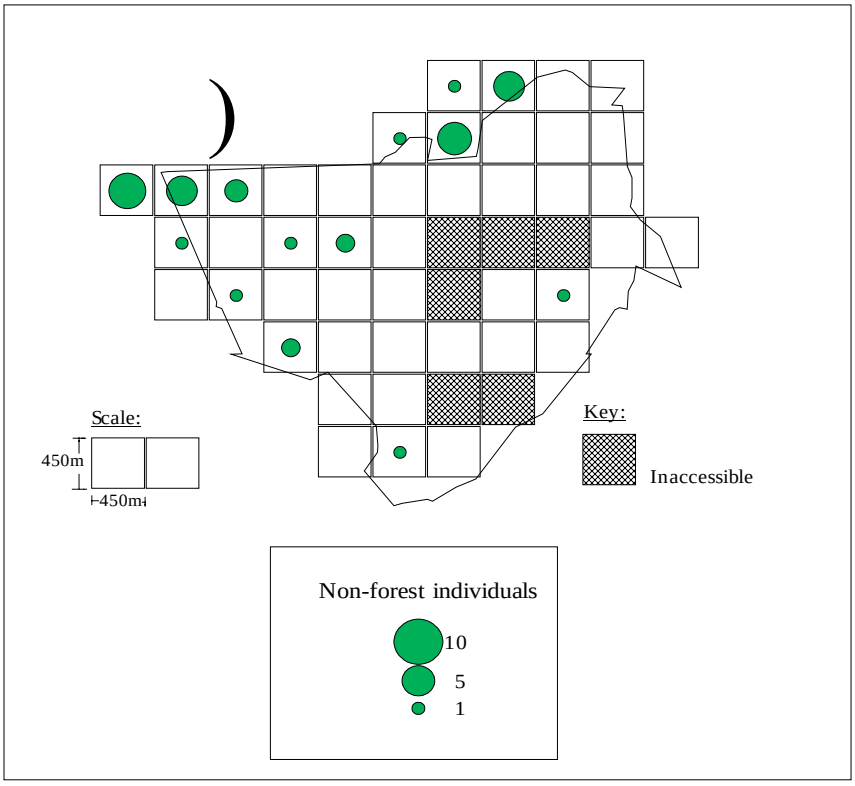

Figure 10 Distribution of non-forest tree and shrub individuals in Mlinga FR.

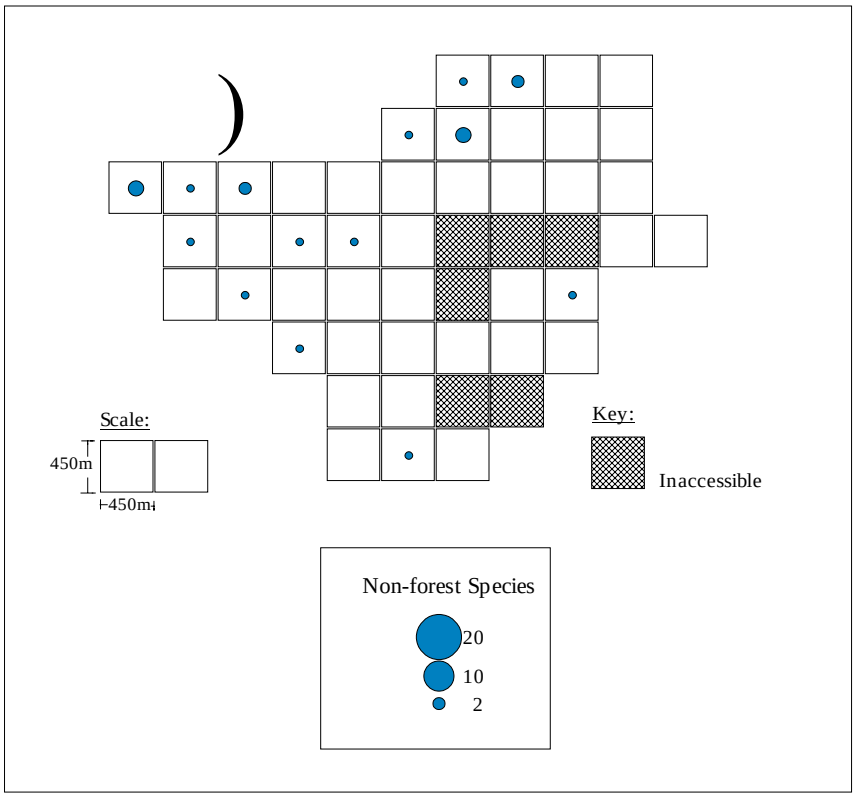

Figure 11 Distribution of non-forest tree and shrub species in Mlinga FR.

Table 9 Summary of habitat type for tree and shrub species recorded in the 50m x 20m vegetation plots.

Habitat	No. of species	% of total species	No. of individuals	% of total individuals
Montane (M)	1 (1)	0.7 (1.1)	4 (4)	0.5 (1.2)
Submontane & montane (S&M)	8 (7)	5.9 (7.8)	38 (13)	4.9 (3.8)
Submontane (S)	8 (5)	5.9 (5.6)	14 (7)	1.8 (2.1)
Lowland, submontane & montane (L&S&M)	50 (35)	37.0 (38.9)	385 (172)	49.4 (50.9)
Lowland & submontane (L&S)	27 (18)	20.0 (20.0)	225 (95)	28.8 (28.1)
Lowland (L)	19 (10)	14.1 (11.1)	65 (23)	8.3 (6.8)
Unknown (?)	22 (14)	16.4 (15.5)	49 (24)	6.3 (7.1)
Total	**135 (90)**	**100 (100)**	**780 (338)**	**100 (100)**

Based on Table 4. Figures from 0.25% sampling intensity are shown in brackets.

A total of 12 submontane forest species were found within lowland forest habitats in Mlinga FR. One species, *Strychnos innocua* was categorised as a montane forest species (M) by the literature, but was recorded in open woodland at 360m above sea level within Mlinga FR.

Table 10 Submontane and montane species sampled in lowland areas, and the altitudes at which they were recorded in Mlinga FR.

Family	Species	Altitude (masl)
Bignoniaceae	*Markhamia obtusifolia*	260
Flacourtiaceae	*Caloncoba welwitschii*	760
Guttiferae	*Haronga madagascariensis*	740, 610
Leguminosae subfamily: Papilionideae	*Cynometra sp. A* (of FTEA)	460
Leguminosae subfamily: Papilionideae	*Craibia brevicaudata*	340,460
Leguminosae subfamily: Papilionideae	*Craibia brownii*	340, 380
Leguminosae subfamily: Papilionideae	*Millettia oblata*	380
Loganiaceae	***Strychnos innocua***	**380, 360**
Melastomataceae	*Warneckea schliebenii*	330
Meliaceae	*Entandrophragma excelsum*	240, 610, 460, 440
Moraceae	*Trilepisium madagascariense*	440, 460, 440
Rubiaceae	*Oxyanthus speciosus*	460, 440, 380, 360
Sapindaceae	*Allophylus melliodorus*	460

Bold Type: Montane Forest species Altitude (masl): metres above sea level

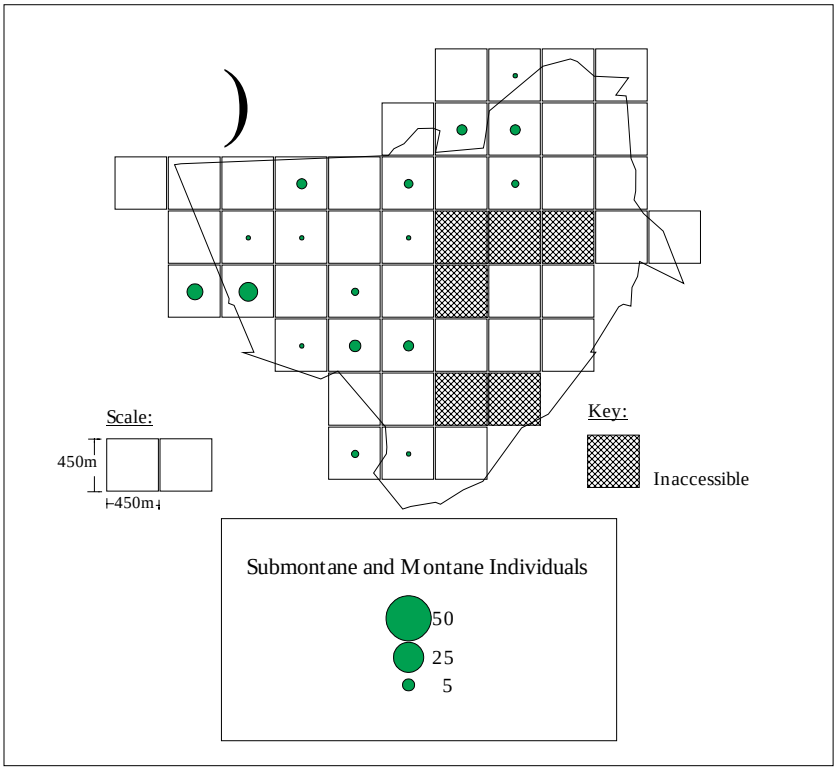

Figure 12 Distribution of submontane and montane tree and shrub individuals in Mlinga FR.

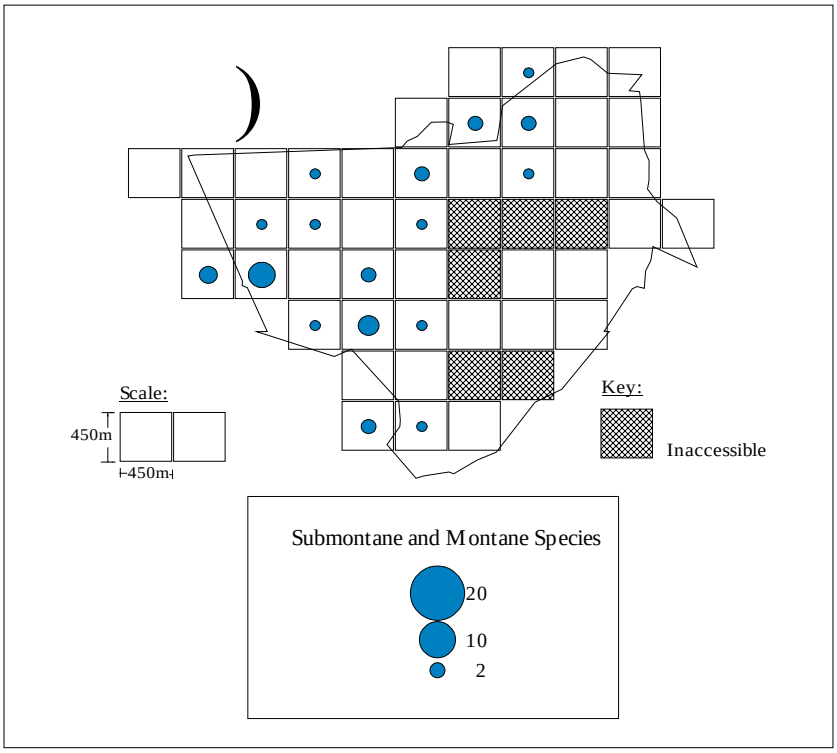

Figure 13 Distribution of submontane tree and shrub species in Mlinga FR.

4.3.1.7 Range extensions

In 1986 and 1987 a botanical survey was conducted in the East Usambara Mountains (Ruffo *et al.* 1989). 53 species recorded in vegetation plots in Mlinga FR were also recorded by Ruffo *et al.* (1989) to be present in Mlinga FR. A total of 82 additional species were recorded in Mlinga FR during the present survey, 49 of these were recorded by Ruffo *et al.* (1989) at other locations in the East Usambaras, whilst 38 species were not recorded at all by Ruffo *et al.* (1989). Table 11 lists these new records for Mlinga FR.

Despite more than seven years systematic and opportunistic vegetation survey work by the EUBS team throughout the majority of the East Usambara Forest Reserves, 4 new species were found in the vegetation plots in Mlinga FR that were new to the East Usambara Biodiversity Database. These species are listed in Appendix 4.

Table 11 Tree and shrub species found outside their previously recorded range in the East Usambara Mountains, and those species not listed by the 1986/7 survey (Ruffo *et al.*, 1989).

Species	**Range**
ANACARDIACEAE	
Lannea schweinfurthii (Engl.) Engl. 1897	Not listed
Lannea schweinfurthii var. *stuhlmannii* (Engl.) Kokwaro 1980	Not listed
Rhus natalensis Bernh. 1844	Not listed
ANNONACEAE	
Annikia kummeriace (Engl. & Diels) Setten & Maas 1990 (basionym *Enantia kummeriae* Engl. & Diels 1900)	Amani area, Kwamsambia/Kihuhwi, Lutindi, Kwamgumi/Segoma, Mtai
Annona senegalensis Pers. 1806	Not listed
APOCYNACEAE	
Hunteria zeylanica (Retz.) Gardn. Ex Thwaites 1860	Not listed
ARALIACEAE	
Cussonia arborea Hochst. Ex A. Rich. 1847	Not listed
BIGNONIACEAE	
Markhamia lutea (Benth.) K. Schum 1895	Not listed
Markhamia obtusifolia (Bak.) Spargue 1919	Not listed
Stereospermum kunthianum Cham. 1832	Not listed
BOMBACEAE	
Rhodognaphalon schumannianum A. Robyns 1963 (basionym *Bombax rhodognaphalon* K.Schum 1895)	Kwamsambia/Kihuhwi, Kilanga, Lutindi, Longuza, Kwamgumi/Segoma, Mtai
BORAGINACEAE	
Cordia africana Lam. 1792	Kwamsambia/Kihuhwi, Lutindi
Gerascanthus mooicus (Roxb.) A. Borhidi 1988 (basionym *Cordia monoica* Roxb. 1796)	Not listed
CELASTRACEAE	
Maytenus undata (Thunb.) Blakelock 1956	Lutindi, Kilanga, Kizara/Kizerui
COMBRETACEAE	
Combretum molle R. Br. Ex G. Don 1827	Not listed
Combretum schumannii Engl. 1895	Kwamsambia/Kihuhwi, Kilanga, Lutindi, Longuza, Marimba, Kwamgumi/Segoma
COMPOSITAE	
Solanecio mannii (Hook.f.) C.Jeffrey 1986	Not listed
EBENACEAE	
Diospyros abyssinica (Hiern) F. White 1956	Bulwa, Kwamkoro
Diospyros natalensis (Harv.) Brenan 1954	Kwamgumi/Segoma, Mtai

Table 11 continued.

Species	Range
EUPHORBIACEAE	
Antidesma membranaceum Müll. Arg. 1866	Kwamkoro, Kwamsambia/Kihuhwi, Lutindi, Longuza, Kwamgumi/Segoma, Mtai
Bridelia cathartica G. Bertol. 1854	Not listed
Croton sylvaticus Hochst. 1845	Kwamsambia/Kihuhwi, Longuza, Kwamgumi, Mtai
Pycnocoma littoralis Pax 1894	Not listed
Ricinodendron heudelotii (Baill.) Pierre ex Pax 1911	Kwamsambia/Kihuhwi, Kilanga, Lutindi, Longuza, Marimba, Kwamgumi/Segoma, Mtai
Shirakia elliptica (Hochst.) Kruijt 1996 (synonym *Sapium ellipticum* (Krauss) Pax 1912)	Kwamkoro, Kwamsambia/Kihuhwi, Lutindi, Longuza, Marimba, Kwamgumi/Segoma, Mtai
FLACOURTIACEAE	
Caloncoba welwitschii (Oliv.) Gilg 1908 (basionym *Oncoba welwitschii* Oliv. 1868	Bulwa, Kwamkoro, Kwamsambia/Kihuhwi
LEGUMINOSAE subfamily: CAESALPINOIDEAE	
Afzelia quanzensis Welw. 1858	Longuza
Cynometra brachyrrhachis Harms 1915	Amani (FTEA)
Cynometra longipedicelata Harms	Amani (FTEA)
Cynometra sp. A (of FTEA)	Amani, Maramba
Dialium holtzii Harms 1913	Kwamsambia/Kihuhwi, Longuza, Kwamgumi/Segoma, Mtai
Scorodophloeus fischeri (Taub.) J. Léonard 1951	Longuza, Marimba, Kwamgumi/Segoma, Mtai
LEGUMINOSAE subfamily: MIMOSOIDEAE	
Albizia adianthifolia (Schumach.) W.F. Wight 1909	Amani (FTEA)
Feuilleea versicolor (Welw. Ex Oliv) Kuntze 1891 (basionym *Albizia versicolor* (Welw.ex) Oliv. 1871)	Not listed
Dichrostachys cinerea (L.) Wight & Arn. 1834	Not listed
Parkia filicoidea (Welw.ex) Oliv. 1871	Kwamkoro, Kwasambia/Kihuhwi, Lutindi, Longuza, Marimba, Mtai
LEGUMINOSAE subfamily: PAPILIONOIDEAE	
Angylocalyx braunii Harms 1810	Kwamsambia/Kihuhwi, Kwambgumi/Segoma, Mtai
Cordyla africana Lour. 1790	Not listed
Craibia brevicaudata (Vatke) Dunn 1911	Kwamsambia/Kihuhwi, Longuza
Craibia brownii Dunn 1911	Not listed
Lonchocarpus bussei Harms 1902	Longuza
Millettia oblata Gillet 1911	Sangarawe, Monga (FTEA)
Millettia usaramensis Taub. 1895	Not listed
Diphaca kirkii (S. Moore) Taub. 1894 (basionym *Ormocarpum kirkii* S. Moore 1877)	Not listed
Pterocarpus angolensis DC. 1825	Not listed
LOGANIACEAE	
Strychnos innocua Delile 1826	Not listed
Strychnos spinosa Lam 1794	Not listed

Table 11 continued.

Species	Range
MELASTOMATACEAE	
Memecylon amaniense (Gilg.) A.Fern. & & R.Fern 1960	Kilanga, Lutindi
Warneckea schliebenii (Markgr.) Jacq.-Fél. 1978 (basionym *Memecylon schliebenii* Markgr. 1932)	Not listed
MELIACEAE	
Entandrophragma excelsum (Dawe & Sprague) Sprauge 1910	Kwamkoro, Amani area, Kwamsambia/Kihuhwi, Lutindi, Mtai
Trichilia dregeana Sond. 1860	Kwamkoro, Amani area, Kwamsambia/Kihuhwi, Lutindi, Kwamgumi
Turraea floribunda Hochst. 1844	Not listed
MELIANTHACEAE	
Bersama abyssinica Fresen 1837	Kwamkoro, Kwamsambia/Kihuhwi, Lutindi, Marimba, Mtai
MORACEAE	
Artocarpus heterophyllus Lam. (exotic) 1789	Not listed
Ficus holstii Warb. 1894 (basionym *Ficus lutea* Vahl 1805)	Bulwa, Lutindi, Longuza
Mesogyne insignis Engl. 1894	Bulwa, Kwamkoro, Amani area, Kilanga, Lutindi, Longuza, Marimba, Kwamgumi, Mtai
Trilepisium madagascariense Thouars ex DC. 1825	Kwamkoro, Kwamsambia/Kihuhwi, Kilanga, Lutindi, Longuza, Kwamgumi/Segoma, Mtai
MYRTACEAE	
Eugenia guineense (synonym *Synzigium guineense* (Willd.) DC. 1828 *afromontanum* F. White)	Kwamkoro, Kwamsambia/Kihuhwi, Lutindi, Mtai
RHAMNACEAE	
Maesopsis eminii Engl. 1895 (introduced)	Bulwa, Kwamkoro, Amani area, Kwamsambia/Kihuhwi, Longuza, Kwamgumi/Segoma
Ziziphus mucronata Willd. 1809	Mtai
Ziziphus pubescens Oliv. 1887	Mtai
RUBIACEAE	
Rothmannia manganjae (Hiern) Keay 1958	Bulwa, Kwamsambia/Kihuhwi, Kilanga, Lutindi, Longuza, Mtai
Tarenna pavettoides (Harv.) Sim 1907	Kwamsambia/Kihuhwi,Lutindi, Longuza, Longuza
Vangueria infausta Burchell 1824	Kwamsambia/Kihuhwi
RUTACEAE	
Vepris amaniensis (Engl.) Mziray 1992	Not listed
Vepris simplicifolia (Engl.) Mziray 1992	Not listed
Zanthoxylum holtzianum (Engl.) P.G. Waterman 1975	Not listed
SAPINDACEAE	
Allophylus melliodorus Gilg ex Radlk. 1909	Lutindi, Mtai
Phialodiscus unijugatus Baker 1879 (basionym *Blighia unijugata* Baker 1868)	Kwamkoro, Kwamsambia/Kihuhwi, Kilanga, Lutindi, Longuza, Kwamgumi/Segoma, Mtai
Zanha golungensis Hiern 1896	Kwamsambia/Kihuhwi, Kilanga, Lutindi, Longuza, Kwamgumi/Segoma, Mtai

Table 11 continued.

Species	Range
SAPOTACEAE	
Bequaertiodendron natalense (Sond.) Heine & J.H. Hemsl. 1960	Kwamsambia/Kihuhwi, Lutindi, Longuza, Kwamgumi/Segoma, Mtai
Manilkara sulcata (Engl.) Dubard. 1915	Lutindi, Longuza
Pouteria adolfi-friedericii (Engl.) A. Meeuse 1960 (synonym *Aningeria adolfi-friedericii* (Engl.) Robyns & G.C.C. Gilbert 1947)	Bulwa, Kwamkoro, Kwamsambia/Kihuhwi, Kilanga, Lutindi, Longuza, Mtai
Synsepalum cerasiferum (Welw.) T.D. Penn. 1991	Not listed
STERCULIACEAE	
Cola clavata Mast. 1868	Marimba, Kwamgumi/Segoma
Cola scheffleri K.Schum 1903	Kwamsambia/Kihuhwi, Lutindi, Kwamgumi/Segoma, Mtai
Dombeya shupangae K. Schum 1900	Lutindi
Sterculia rogersii N.E.Br. 1921	Not listed
ULMACEAE	
Celtis africana Burm. f. 1768	Kwamsambia/Kihuhwi, Lutindi, Longuza, Kwamgumi/Segoma, Mtai
UMBELLIFERAE	
Peucedanum araliaceum (Hochst.) Hiern 1877 (basionym *Steganotaenia araliacea* Hochst. 1844)	Not listed
VERBENACEAE	
Premna chrysoclada (Bojer) Gürke 1903	Kwamsambia/Kihuhwi, Lutindi, Longuza, Marimba, Kwamgumi/Segoma, Mtai
Vitex ferruginea Schumach. & Thonn. 1827	Not listed

4.3.1.8 Timber species

The inaccessible nature of Mlinga FR suggests that this forest block was not subjected to such extensive commercial logging as were other more accessible and resource rich areas such as Amani and Nilo FRs. However, small scale extraction of timber for local and commercial use over the years is suspected to have been significant. The most commonly extracted trees within Tanzania (Ruffo *et al.*, 1989) are listed in Table 12 to present an indication of the remaining populations of these species within Mlinga FR.

A total of fifteen tree species recorded within the vegetation plots were listed by Ruffo *et al.* (1989) as useful for timber and/or plywood use. Ten species and 73 individuals were recorded as 'Timber only' (species that are regarded by the Forestry Division as timber trees, although may not necessarily have been used in the East Usambaras) (Table 12). Two species and 2 individuals were listed as 'Plywood only' and 5 species and 31 individuals listed as 'Plywood and Timber' species (information based on Sikh Saw Mills (T) Ltd of Tanga) (Ruffo *et al.*, 1989) (Table 12).

Table 12 The abundance of selected timber and plywood species.

Family	Species	Ruffo *et al.*, 1989 category	No. Indivs (n=780)	No. plots (n=34)
Timber only				
Boraginaceae	*Cordia africana*	Timber only	1	1
Combretaceae	*Combretum schumannii*	Timber only	5	1
Combretaceae	*Terminalia sambesiaca*	Timber only	3	3
Ebenaceae	*Diospyros abyssinica*	Timber only	1	1
Euphorbiaceae	*Macaranga capensis*	Timber only	14	4
Guttiferae	*Allanblackia stuhlmannii***	Timber only	3	3
Leguminosae subfamily: Mimosoideae	*Albizia gummifera**	Timber only	17	7
Melianthaceae	*Bersama abyssinica**	Timber only	2	2
Moraceae	***Milicia excelsa***	**Timber only**	**10**	**6**
Olacaeae	*Strombosia scheffleri **	Timber only	15	2
Sapotaceae	*Pouteria adolfi-fredericii* (syn. *Aningeria aldofi-fredericii*)	Timber only	2	2
		Total	**73**	
Plywood only				
Loganiaceae	*Anthocleista grandiflora***	Plywood only	1	1
Sterculiaceae	*Sterculia appendiculata*	Plywood only	1	1
		Total	**2**	
Plywood & Timber				
Leguminosae subfamily: Mimosoideae	***Newtonia buchananii*** **	**Plywood & Timber**	**1**	**1**
Meliaceae	*Entandrophragma excelsum*	Plywood & Timber	13	4
Moraceae	*Antiaris toxicaria**	Plywood & Timber	15	10
Myrtaceae	*Eugenia guineensis (*syn. *Synzigium guineense afromontanum*)	Plywood & Timber	1	1
Rhamnaceae	*Maesopsis eminii* (introduced, naturalized)	Plywood & Timber	1	1
		Total	**31**	

KEY TO ABBREVIATIONS FOR TABLE 12

Bold Type – species that are listed by Ruffo *et al.* (1989) as one of four species preferred by pitsawers.

Timber only: regarded as timber trees by the Forestry Division but have not necessarily been used in the East Usambaras.

Plywood only and Plywood & Timber: lists of species provided by Sikh Saw Mills (T) Ltd of Tanga (Ruffo *et al.*, 1989).

Regeneration Layer:

*Antiaris toxicaria** : species recorded in the regeneration sample plots 3m x 3m are marked with one asterisk

*Anthocleista gradiflora*** : additional species recorded in the regeneration sample plots 6m x 6m are marked with two asterisks.

Appendices 5 and 6 provide further lists of useful plant species found within Mlinga FR (including fuelwood, building poles and medicinal plants).

4.3.1.9 Sampling Intensity

The species accumulation curve (Figure 5) and the vegetation plot species list (Table 4) show that a significant number of species and individuals were recorded as a consequence of increasing the intensity of sampling from 0.25% to 0.5%. Table 13 summarises the most important differences between the two sampling intensities.

Table 13 Comparison of results obtained from vegetation sampling as a consequence of increase of sampling intensity.

	0.5% sampling intensity (450m x 450m grid system)	**0.25% sampling intensity (450m x 900m grid system)**
Number of vegetation plots sampled	34	17
Total number of individuals sampled	780	338
Total number of species sampled	135	90
Mean no. of trees per plot (Stdev.)	22.92 (16.82)	19.88 (16.24)
Mean no. of species per plot (Stdev.)	9.44 (7.13)	8.06 (6.07)
No. of endemic species (E(EU))	5	4
No. of near-endemic species (N)	15	11
No. of forest dependent species (F)	41	31

Stdev.: Standard deviation – measure of variability about the mean (the higher the number the more variability around the main value).

4.3.1.10 Regeneration

Herbaceous vegetation dominated the ground layer in regeneration plots, with grasses predominant. Soils were a mixture of loamy clay, sandy clay, sandy loam and rock. Regeneration, in general was poor with an average of 3.18 and 2.41 species regenerating per plot within 6m x 6m and 3m x 3m plots respectively. A more detailed summary of regeneration plot information is shown in Appendix 7.

An additional eleven species were recorded solely in the regeneration layer, ten within the 3m x 3m sample plots and eleven in the 6m x 6m sample plots (Table 14). Four of these species were classified as forest dependent, all with a widespread distribution. Identification of four of these species to species level was not possible (Table 14).

At least three of the species present in the regeneration layer represent range extensions for the survey performed by Ruffo *et al.* (1989), these include: *Garcinia volkensii* (Guttiferae) previously recorded in Bulwa, Lutindi FR and Mtai FR; *Khaya nyasica* (Meliaceae) previously recorded in Kwamkoro FR, Kwamsambia/Kihuhwi FRs, Kilanga FR, Lutindi FR, Longuza FR, Kwamgumi/Segoma and Mtai FR; *Rinorea ilicifolia* (Violaceae) previously recorded in Monga/Ndora.

At least two of the regenerating species are useful to humans, *Khaya nyasica* (Meliaceae) is recorded as useful for plywood or timber, whilst *Millettia dura* (Leguminosae: subfamily Papilionoideae) are used for building poles (Ruffo, 1989).

Table 14 Species recorded exclusively in the regeneration layer.

	Ecol. Type	Habitat	Endemic Status
BURSEACEAE			
Commiphora sp.	?	?	?
GUTTIFERAE			
Garcinia volkensii Engl. 1895	F	L&S&M	W
HERNANDIACEAE			
Gynocarpus americanus [1]	f	L	W
LEGUMINOSAE: subfamily CAESALPINIOIDEAE			
Senna singueana (Delile) J.M. Lock 1988 (basionym *Cassia singueana* (Delile) Lock, 1988)	O	L&S&M	W
LEGUMINOSAE: subfamily MIMOSOIDEAE			
Albizia sp.	?	?	?
LEGUMINOSAE: subfamily PAPILIONOIDEAE			
Millettia dura Dunn 1912	f	S&M	W
MELIACEAE			
Khaya nyasica stapf ex Baker f. 1911	F	?	W
Trichilia emetica Vahl (basionym *Elcaja roka* Forssk, synonym *Trichilia roka* Forssk. Chiov. 1932)	f	L&S	W
RUBIACEAE			
Pavetta sp.	?	?	?
SAPINDACEAE			
Lecaniodiscus fraxinifolia Baker 1849	F	?	W
SAPOTACEAE			
Manilkara sp.	?	?	?
VIOLACEAE			
Rinorea ilicifolia (Wlw. ex Oliv) Kuntze 1891 (basionym *Alsodeia ilicifolia* Welw. ex Oliv. 1869)	F	L&S&M	W

KEY TO ABBREVIATIONS FOR TABLE 14 (also refer to section 1.2.1)

Ecological type: (based on Iversen, 1991b)

- F - Forest dependent species: Species previously recorded as restricted to primary or closed canopy forest only, e.g. wet evergreen forest, dry evergreen forest and/or riverine forest;
- f - Forest dwelling but not forest dependent: Species previously recorded in primary or closed canopy forest as defined above and/or in forest edge, clearings, secondary forest, deciduous forest and woodland, and
- O - Non-forest species: These are species that do not occur in primary or secondary forest or forest edge (e.g. species that have been recorded in bushland, heathland, thicket, secondary scrub, grassland, rocky outcrops, swamps, wastelands and cultivation.

Habitat: (based on Hamilton, 1989)

- L - Lowland: Species occurring at altitudes less than 850m above sea level;
- S - Submontane: Species occurring at altitudes greater than 850m above sea level (masl) and below 1,250 masl.
- M – Montane Species occurring at altitudes greater than 1,250m above sea level.

If species occur in more than one habitat range, this has been recorded (e.g. L&S – this species has been recorded at altitudes between 0m and 1,250m above sea level).

Endemic status: (based on Iversen, 1991b)

- E – Usambara endemic: Occurring only in the Usambara mountains, EU - Range limited to the East Usambara Mountains, WU - Range limited to the West Usambara Mountains;
- N – Near-endemic: Species with limited ranges in the Eastern Arc mountains and the adjacent coastal forests (occurring only in the East African biodiversity hotpot);
- W - Widespread distribution.

[1] Additional species recorded as a consequence of intensitying sampling effort by increasing plots to 6m x 6m in size.

4.3.1.11 Regeneration sampling intensity

In Mlinga FR, the increase in the size of sample plot during regeneration sampling from 3m x 3m to 6m x 6m produced an additional 11 species (Table 15), although only one of these was not recorded in the vegetation plots (Table 14). An additional 200 individuals were recorded, 61 stems of dbh 1-9.5cm and 139 stems of dbh <1cm (Table 15). An increase in sampling intensity decreased the mean number of individuals per plot and the variance (standard deviation) associated with it (Table 15). Only a small increase was seen in the mean number of species per plot and its associated variance when sampling intensity was increased to 6m x 6 m plots (Table 15).

Table 15 Comparison of results obtained from regeneration sampling as a consequence of increasing the size of nested plots from 3m x 3m to 6m x 6m.

	Regeneration plot 3m x 3m	**Regeneration plot 6m x 6m**
Total number of species	49	60
Total number of individuals	227	427
Total number of stems (1-9.5cm)	33	94
Total number of stems (<1cm)	194	333
Mean number of individuals per plot	4.63	1.85
Standard Deviation (s) (degree of variance)	8.07	1.24
Mean no. sp. per plot	2.24	3.15
Standard Deviation (s) (degree of variance)	2.13	2.97

4.3.1.12 Opportunistic plant collection and observation

A total of 123 species including monocotyledons, dicotyledons, pteridophytes and gymnosperms, were opportunistically recorded within Mlinga FR (Table 14). These represented 54 families. Forty voucher specimens were collected. An additional 4 endemic, 12 near-endemic and 17 forest dependent species were recorded during opportunistic collection. Fifteen species from the opportunistic checklist (Table 16) are new species records for the East Usambara Biodiveristy Database. These species are summarised in Appendix 4.

Mlinga Peak summit area was of particular interest during opportunistic collection. Collections of gymnosperms such as *Podocarpus latifolius* (Podocarpaceae) and *Encephalartos hildebrandtii* (Zamiaceae); the dicotyledonous angiosperms *Saintpaulia diplotricha, S. magungensis* and *Streptocarpus* sp. (Gesneriaceae), and monocotyledonous angiosperms *Pandanus sp.* (Pandanaceae) and *Phoenix reclinata* (Palmae) were made here (Table 16). These species were seen nowhere else in the reserve.

Sanrafaelia ruffonammari (Annonaceae) and *Cola luckei* (Sterculiaceae) were also discovered during opportunistic botanical collection and were of particular interest.

Table 16 Checklist of opportunistic plant collection and observation within Mlinga FR.

Species	Lifeform	Ecol. Type	Habitat	Endemic Status	Location of specimen collected
Pteridophyta					
ASPLENOCEAE					
Asplenium sp.	Fern	?	?	?	
Gymnospermae					
PODOCARPACEAE					
Podocarpus latifolius (Thunb.) R. Br. Ex Mirb. 1825	Tree	F	S&M	W	E 038°44'42.2" S 05°04'42.6"
ZAMIACEAE					
Encephalartos hildebrandtii Braun & Bouché 1874	Palm	F	?	W	
Angiospermae – Dicotyledonae					
ACANTHACEAE					
Asystasia schimperi T. Anderson 1864	Herb	?	?	W[2]	
Justicia oblongifolia (Lindau) M.E. Steiner 1989.	Herb	f	?	E(EU)	
ANACARDIACEAE					
Mangifera indica L. 1753 (cultivated, exotic, naturalized)	Tree	O	L&S&M	W	
ANISOPHYLLEACEAE					
Anisophyllea stuhmanii	Tree	?	L&S	?	
ANNONACEAE					
Sanrafaelia ruffonammari Verdc. 1996	Tree	F	L	E(EU)	E 038°44'52.1" S 05°03'33.9"
Uvaria acuminata Oliv. 1868	Shrub	f	L&S	W	
APOCYNACEAE					
Cameraria obesa (Forssk.) Spreng. 1824 (basionym *Nerium obesum* Forssk. 1775, syn. *Adenium obesum* (Forssk.) Roem. & Schult. 1819)	Liana	f	L&S&M	W	
Landolphia kirkii Dyer 1881	Liana	f	L&S	W	
Rauwolfia rosea K & Schum. 1895	Shrub	?	?	?	
Saba comorensis (Bojer ex A. DC.) Pichon 1953	Liana	f	L&S&M	W	
Treculia africana Decne. 1847	Tree	?	?	?	
ARISTOLOCHIACEAE					
Aristolochia densivenia Engl.	?	?	?	?	

Table 16 continued.

Species	Lifeform	Ecol. Type	Habitat	Endemic Status	Location of specimen collected
ASCLEPIADACEAE					
Cryptolepis newii (Benth.) P. Forster 1990 (basionym *Gymnolaema newii* Benth. 1876, syn. *Sacleuxia newii* (Benth.) Bullock 1962)	Shrub	f	L&S&M	N	
BASELLACEAE					
Basella alba L. 1753	Climber	f	L&S&M	W	
BIGNONIACEAE					
Kigelia africana (Lam.) Benth. 1849	Tree	f	S&M	W	
BURSERACEAE					
Commiphora zimmermannii Engl. 1910	Tree	f[1]	L&S[1]	W[1]	
CAPPARIDACEAE					
Capparis tomentosa Lam. 1785	Shrub	f	L&S&M	W	
Ritchiea albersii Gilg 1903	Climber	f	S&M[1]	W	
CARICACEAE					
Cylicomopha parviflora Urban 1901	Tree	f	S&M	N	
CECROPIACEAE					
Myrianthus holstii Engl. 1898	Tree	f	S&M	W	
COMMELINACEAE					
Commelia sp.	Herb	?	?	?	
COMPOSITAE					
Aspilia abyssinica Vatke 1875	Herb	?	?	?	
Aspilia mossambicensis (Oliv.) Wild 1966	Shrub	f	?	W[2]	
Baccharoides lasiopus (O. Hoffm.) H. Rob. 1990 (basionym *Vernonia lasiopus* O. Hoffm. 1895)	Shrub	f	L&S&M	N	
Bidens pilosa L. 1753	Herb	O	L&S&M	W[2]	
Crassocephalum bojeri (DC.) Robyns 1947	Herb	?	?	W	
Melanthera scandens (Schumach. & Thonn.) Roberty 1954	Climber	f	?	W	
Vernonia colorata (Willd.) Drake 1899	Shrub	O	?	W	
CONNARACEAE					
Rourea coccinea (Schumach. & Thonn.) Benth. (Basionym *Byrsocarpus coccineus* Schumach. & Thonn. 1827)	Shrub	f[1]	L&S&M[1]	W[1]	
CONVOLVULACEAE					
Ipomoea obscura(L.) Ker-Gawl. 1817	Climber	f	L&S&M	W	

Table 16 continued.

Species	Lifeform	Ecol. Type	Habitat	Endemic Status	Location of specimen collected
CRASSULACEAE					
Kalanchoe sp.	Herb	?	?	?	
CUCURBITACEAE					
Momordica anigosantha Hook.f. 1871	Climber	f	L&S	W	
EUPHORBIACEAE					
Acalypha forbesii S. Moore 1914	Shrub	O	L&S	W	
Acalypha racemosa Wall. ex Baill. 1858	Shrub	f	L&S&M	W	
Acalypha volkensii Pax 1895	Shrub	f	L&S&M	W[2]	
Erythrococca fischeri Pax 1894	Shrub	f[1]	S&M	W	
Phyllanthus ovalifolius Forssk. 1775	Shrub	f	L&S&M[1]	W	
Pycnocoma littoralis Pax 1894	Shrub	F[1]	L	N	
Tragia benthamii Baker 1901	Climber	f[1]	S	W[2]	
GESNERIACEAE					
Saintpaulia diplotricha B.L. Burtt 1947	Herb	F	?	N	E 038°44'74.0" S 05°04'42.6"
Saintpaulia magungensis E.P. Roberts 1950	Herb	F	?	E(EU)	E 038°44'74.0" S 05°04'42.6"
Streptocarpus sp.	Herb	?	?	?	E 038°44'74.0" S 05°04'42.6"
HERNANDIACEAE					
Gyrocarpus americanus Jacq. 1763	Tree	f	L&S	W	
ICACINACEAE					
Alsodeiopsis schumannii (Engl.) Engl. 1897	Tree	F	S&M	N	
Pyrenacantha kaurabassana Baill. 1872	Climber	f	L&S&M	W	
LABIATAE					
Coleus barbatus (Andrews) Benth. 1830 (Basionym *Plectranthus barbatus* Andrews 1810)	Shrub	O	M	W	
Hoslundia opposita Vahl 1805	Shrub	f	L&S&M	W	
Plectranthus lactiflorus (Vatke) Agnew. 1974	Shrub	f	L	W	
Plectranthus sp.	Herb	?	L	?	
Tinnea aethiopica subsp. *litoralis* Vollesen 1975	Shrub	f	L	N	
LECYTHIDACEAE					
Barringtonia racemosa (DC.) Spreng. 1826	Tree	f	L	W	

Table 16 continued.

Species	Lifeform	Ecol. Type	Habitat	Endemic Status	Location of specimen collected
LEGUMINOSAE: subfamily CAESALPINIOIDEAE					
Biancaea decapetela (Roth) O. Deg. 1936 (Basionym *Reichardia decapetala* Roth 1821, syn. *Caesalpinia decapetala* (Roth) Alston 1931)	Climber	f	S&M	W	
Tamarindus indica L.	Tree	O	L&S&M	W	
LEGUMINOSAE: subfamily MIMOSACEAE					
Parkia filicoidea Welw. ex Oliv. 1871	Tree	F	L&S&M	W	
LEGUMINOSAE: subfamily PAPILIONACEAE					
Crotolaria sp.	Shrub	?	?	?	
Dalbergia lacteal Vatke 1879	Climber	f	L&S&M	W	E 038°44'36.6" S 05°04'42.9"
Dolicos sp.	Climber	?	?	?	
Mucuna pruriens (L.) DC. 1825	Climber	O	L&S	W	
Phaseolus unguiculatus (L.) Piper 1912 (Basionym *Dolichos unguiculatus* L. 1753, syn. *Vigna unguiculata* (L.) Walp. 1843)	Climber	O	S	W	
Pterocarpus anglolensis DC. 1825	Tree	f	L&S&M	W	
MALVACEAE					
Hibiscus micranthus L.f. 1781	Shrub	O	L	W	
MELASTOMATACEAE					
Clidemia hirta (L.) D. Don 1823	Shrub	f	L&S	W	
Lijndenia greenwayi (Brenan) Borhidi 1993 (Basionym *Memecylon greenwayi* Brenan 1947*)*	Shrub	F	S	E (EU&WU)	
Memecylon deminutum Brenan 1947	Shrub	F	M	W	
MENISPERMACEAE					
Cissampelos mucronata A. Rich. 1831	Climber	f	L&S&M	W	
Stephania abyssinica (Quart.-Dill. & A. Rich.) Walp. 1842	Climber	f	M	W	
Triclisia sacleuxii (Pierre) Diels 1910	Climber	F	L&S&M	W	
MORACEAE					
Artocarpus heterophyllus Lam. 1789 (cultivated, exotic, naturalized)	Tree	O	L&S&M	W	
Dorstenia holstii Engl. 1894	Herb	F	S&M	N	E 038°44'50.8" S 05°03'57.4"
Ficus sur Forssk. 1775	Tree	f	L&S&M	W	
Ficus sycomorus L. 1753	Tree	?	L&S&M	W	
Ficus vallis-choudae Del. 1843	Tree	f	L&S	W	

Table 16 continued.

Species	Lifeform	Ecol. Type	Habitat	Endemic Status	Location of specimen collected
PASSIFLORACEAE					
Adenia rumicifolia Engl. 1921	Liana	f	L&S&M	W	
Adenia sp.	Climber	?	?	?	
PIPERACEAE					
Piper capense L. f. 1782	Herb	f	S&M	W	
ROSACEAE					
Rubus alba	Climber	?	?	?	
RUBIACEAE					
Coffea pseudozanguebariae Bridson 1982	Tree	f	L	W	
Coffea zanguebariae Lour. 1790	Tree	O[1]	L	W[1]	
Cremaspora sp.	Tree	?	?	N (if sp.A)	
Cremaspora triflora (Thonn.) K. Schum. 1891	Tree	f	S&M	W	
Leptactina platyphylla (Hiern) Wernham 1913	Shrub	f	L&S&M	W	
Pentas bussei K. Krause 1909	Shrub	f	L&S&M	W	E 038°44'52.2" S 05°04'42.6"
Pentas sp.	Shrub	?	?	?	E 038°44'52.2" S 05°04'42.6"
Polysphaeria lanceolata Hiern 1877	Tree	f	L&S&M	W	E 038°44'52.2" S 05°04'42.6"
Psychotria peteri E.M.A. Petit 1964	Shrub	F	S	N	E 038°44'52.2" S 05°04'42.6"
RUTACEAE					
Citrus aurantifolia (Christm.) Swingle 1913 (exotic, cultivated)	Tree	O	L&S&M	W	
Clausena anisata (Willd.) Hook. f. ex Benth. 1849	Tree	f	L&S&M	W	
Toddalia asiatica (L.) Lam. 1797	Shrub	?	L&S&M	W	
SAPINDACEAE					
Deinbollia borbonica Scheff. 1869	Shrub	O	L	W	
Zanha golungensis Hiern 1896	Tree	F	L&S&M	W	
SAPOTACEAE					
Synsepalum cerasiferum (Welw.) T.D. Penn. 1991 (Basionym *Sapota cerasifera* Welw. 1858, *Afrosersalisia cerasifera* (Welw.) Aubrév. 1957)	Tree	F	L&S&M	W	
SIMAROUBACEAE					
Harrisonia abyssinica Oliv. 1868	Climber	f	?	W	

Table 16 continued.

Species	Lifeform	Ecol. Type	Habitat	Endemic Status	Location of specimen collected
SOLANACEAE					
Capsicum sp.	Herb	?	?	?	
Solanum incanum Ruiz & Pav. 1799	Shrub	O	L&S&M	W	
STERCULIACEAE					
Cola lukei	Tree	F	L&S	E(EU)	
Dombeya kirkii Mast. 1866	Shrub	O	M	W	
VERBENACEAE					
Camara trifolia (L.) Kuntze 1891 (Basionym *Lantana trifolia* L. 1753) (exotic weed)	Shrub	O	L&S&M	W	
Clerodendrum sp.	Shrub	?	?	?	
Lantana camara L. 1753 (exotic weed)	Shrub	O	L&S&M	W	
Valerianoides jamaicense (L.) Kuntze 1891 (Basionym *Verbena jamaicensis* L. 1753, syn. *Stachytarpheta jamaicensis* (L.) Vahl 1804)	Shrub	f	L	W	
VITACEAE					
Ampelocissus africana (Lour.) Merr. 1935	Climber	O	L&S&M	W	
Cissus adenocaulis Steud. ex A. Rich. 1847	Climber	O	L&S	W	E 038°44'52.1" S 05°03'33.9"
Cyphostemma adenocaule (Steud. ex A. Rich.) Desc. 1967	Climber	O	L&S	W	
Angiospermae – Monocotyledonae					
ALOEACEAE					
Aloe sp.	Herb	?	?	?	
ARACEAE					
Culcasia orientalis Mayo 1985	Climber	f[1]	L[1]	W[1]	
Zamioculcas zamiifolia Engl.	Herb	f	L	W	
COLCHICACEAE					
Gloriosa superba L. 1753	Herb	f	S&M	W	
DRACAENACEAE					
Dracaena afromontana Mildbr. 1910	Shrub	F	M	W[2]	
Dracaena deremensis Engl.	Shrub	f	?	W[2]	
Dracaena laxissima Engl. 1893	Climber	F	?	W	
Dracaena steudneri Engl. 1895	Shrub	f	M	W[2]	

Table 16 continued.

Species	Lifeform	Ecol. Type	Habitat	Endemic Status	Location of specimen collected
GRAMINEAE					
Ophiurus exaltatus (L.) Kuntze 1891 (Basionym *Aegilops exaltata* L. 1771, syn. *Rottboellia exaltata* (L.) L. f. 1779)	Herb	?	?	?	
Stipa latifolia (L.) Raspail 1825 (Basionym *Olyra latifolia* L. 1759)	Herb	f	L&S	W	
Syntherisma abyssinica (Hochst. ex A. Rich.) Newbold 1924 (Basionym *Panicum abyssinicum* Hochst. ex A. Rich. 1851, syn. *Digitaria abyssinica* (Hochst. ex A. Rich.) Stapf 1907)	Herb	O	L&S&M	W	
Urochloa maxima (Jacq.) R.D. Webster 1987 (Basionym Panicum maximum Jacq. 1781)	Herb	O	L&S&M	W	
PALMAE					
Cocos nucifera L. 1753 (cultivated)	Tree	O[1]	L&S[1]	W[1]	
Pheonix reclinata Jacq.	Palm	f	?	W	
PANDANACEAE					
Pandanus sp.	Shrub	?	?	?	
SMILACACEAE					
Smilax anceps Willd. 1806	Climber	f	L&S&M[1]	W	
ZINGIBERACEAE					
Aframomum angustifolium (Sonn.) K. Schum. 1914	Herb	?	?	?	
Costus sp.	Herb	?	?	?	

KEY TO ABBREVIATIONS FOR TABLE 16 (also refer to section 1.2.1)

Ecological type: (based on Iversen, 1991b)

- F - Forest dependent species: Species previously recorded as restricted to primary or closed canopy forest only, e.g. wet evergreen forest, dry evergreen forest and/or riverine forest;
- f - Forest dwelling but not forest dependent: Species previously recorded in primary or closed canopy forest as defined above and/or in forest edge, clearings, secondary forest, deciduous forest and woodland, and

. O - Non-forest species: These are species that do not occur in primary or secondary forest or forest edge (e.g. species that have been recorded in bushland, heathland, thicket, secondary scrub, grassland, rocky outcrops, swamps, wastelands and cultivation.

Habitat: (based on Hamilton, 1989)

- L - Lowland: Species occurring at altitudes less than 850m above sea level;
- S - Submontane: Species occurring at altitudes greater than 850m above sea level (masl) and below 1,250 masl.
- M – Montane Species occurring at altitudes greater than 1,250m above sea level.

If species occur in more than one habitat range, this has been recorded (e.g. L&S – this species has been recorded at altitudes between 0m and 1,250m above sea level).

Endemic status: (based on Iversen, 1991b)

- E – Usambara endemic: Occurring only in the Usambara mountains, EU – Range limited to the East Usambara Mountains, WU – Range limited to the West Usambata Mountains;
- N – Near-endemic: Species within limited ranges in the Eatern Arc mountains and the adjacent coastal forests (occurring only in the East African biodiversity hotspot);
- W – Widespread distribution.

[1] Information based on FTEA.
[2] Information based on LEAP (Knox, 2000).

Location: Recorded as longitude and latitude

4.3.2 Disturbance transects

A total area of 13.65 ha were assessed for signs of disturbance. Due to varied vegetation, access and topography in the reserve, the extent and type of disturbance differed between areas. Access in the north of the reserve was greatest due to ease of access in low lying woodland habitat. A large footpath accessed the north, central and western parts of the forest reserve and ran between Antakae (subvillage of Misozwe) and Mwembene.

A total of 9,490 stems were sampled throughout the reserve, giving a mean total of 453.8 poles per hectare and 293.8 timber per hectare, 66% and 34% respectively.

4.3.2.1 Pole and Timber extraction

Pole and timber extraction was found along all seven transects, however very few were recent cuttings were noted.

Rates of pole extraction are summarised in Table 17, Figures 13 and 15. A total of 3,522 poles per hectare were alive, 921 dead and 113 cut, representing 77%, 20% and 3% of all poles sampled respectively (Table 17). Transects 1 and 3 showed greatest evidence of pole cutting with 25 and 23 cut poles per hectare (6% and 7.3% of all poles sampled along each respective transect line) (Table 17 and Figure 18). A significant proportion of the poles sampled were dead, particularly along Transects 0 and 1 (Table 17 and Figure 14). Live poles were most abundant along Transects 6 and 0 with 506 and 429 poles per hectare. However, the greatest percentage of live individuals sampled was recorded along Transect 4 (Table 17 and Figure 13).

Pole cutting was most intensive along reserve border areas, particularly in the north (Figure 16). Lowland northern and eastern areas of the forest reserve were most accessible to nearby Misozwe village and sub-villages.

Table 17 Disturbance transect results showing total pole counts and average pole counts per hectare.

Transect number	Transect length (m)	Total no. poles sampled	Live Poles (LP)	Average LP per hectare	Dead Poles (DP)	Average DP per hectare	Cut Poles (CP)	Average CP per hectare
0	1,050	675	450 (67)*	429	209 (31)	199	16 (2.4)	15
1	1,800	745	450 (60)	250	250 (34)	139	45 (6.0)	25
5	3,450	1,499	1,236 (82)	358	243 (16)	70	20 (1.3)	6
2	2,350	1,088	919 (84)	391	161 (15)	69	8 (0.7)	3
6	1,900	1,168	961 (82)	506	193 (17)	102	14 (1.2)	8
3	2,100	670	471 (70)	224	150 (22)	71	49 (7.3)	23
7	200	88	70 (80)	350	18 (20)	90	0 (0)	0
4	800	284	250 (88)	313	33 (12)	41	2 (0.7)	4
Total	**13,650**	**6,217**	**4,807 (77)**		**1,257 (20)**		**154 (3)**	

*Mean percentages shown in brackets. Transect numbers positioned as they lie in Mlinga FR (Figure 3).

Rates of timber extraction are summarised in Table 18 and Figures 15 and 17. A total of 1,840 timbers per hectare were alive, 549 dead and 45 cut, representing 77%, 20% and 3% of all timbers sampled respectively (Table 18). Transect 3 showed greatest evidence of timber cutting with 18 cut timbers per hectare (5.1% of all timber sampled along the transect line) (Table 18 and Figure 14). A significant proportion of the timbers sampled were dead, particularly along Transects 6, 3, 1 and 0 (Table 18 and Figure 15). Live timbers were most abundant along Transects 6 and 2, with 254 and 243 timber per hectare alive respectively. However, the greatest percentage of live individuals sampled was recorded along Transect 4 (Table 18 and Figure 13).

Timber cutting was most intensive along reserve border areas, particularly in the north (Figure 15). The distribution of cutting follows the path that accesses more central western parts of the forest reserve.

Table 18 Disturbance transect results showing total timber counts and average timber counts per hectare.

Transect number	Transect length (m)	Total no. timber sampled	Live Timber (LT)	Average LT per hectare	Dead Timber (DT)	Average DT per hectare	Cut Timber (CT)	Average CT per hectare
0	1050	115	80 (70)	76	34 (30)	32	1 (0.9)	1
1	1800	348	233 (67)	129	106 (30)	59	9 (2.6)	5
5	3450	902	708 (78)	205	173 (19)	50	21 (2.3)	6
2	2350	686	571 (83)	243	107 (16)	46	8 (1.2)	3
6	1900	670	482 (72)	254	184 (27)	97	4 (0.6)	2
3	2100	353	218 (62)	104	117 (33)	56	18 (5.1)	9
7	200	55	44 (80)	220	11 (20)	55	0 (0)	0
4	800	144	127 (88)	159	17 (12)	21	0 (0)	0
Total	**13,650**	**3,273**	**2,463 (75)**		**749 (23)**		**61 (2)**	

*Mean percentages shown in brackets. Transect numbers positioned as they lie in Mlinga FR (Figure 3).

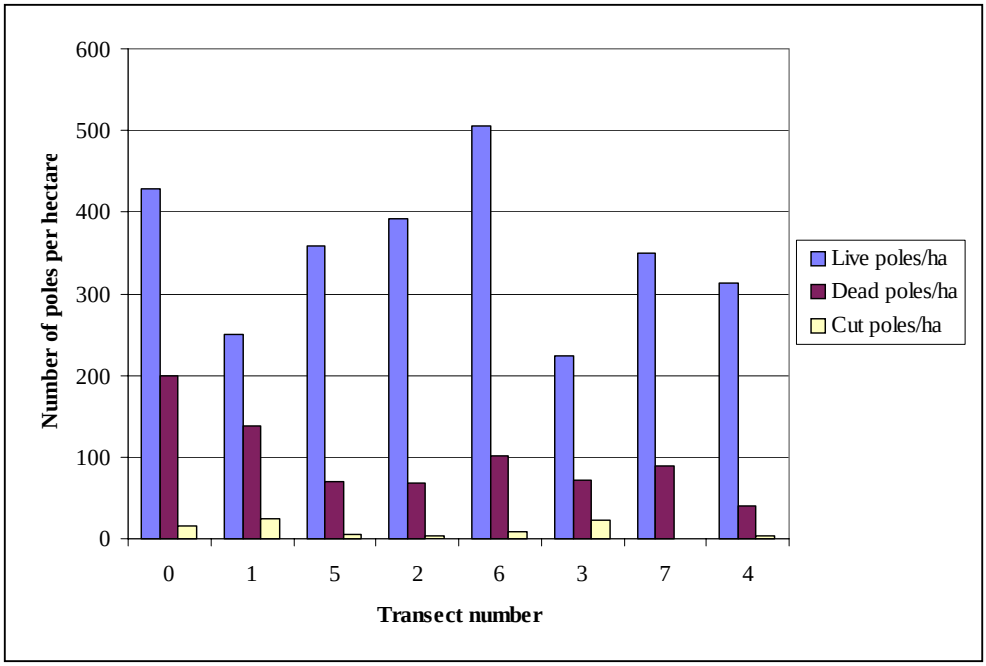

Figure 14 Relative abundance of live, naturally dead and cut poles in Mlinga FR.

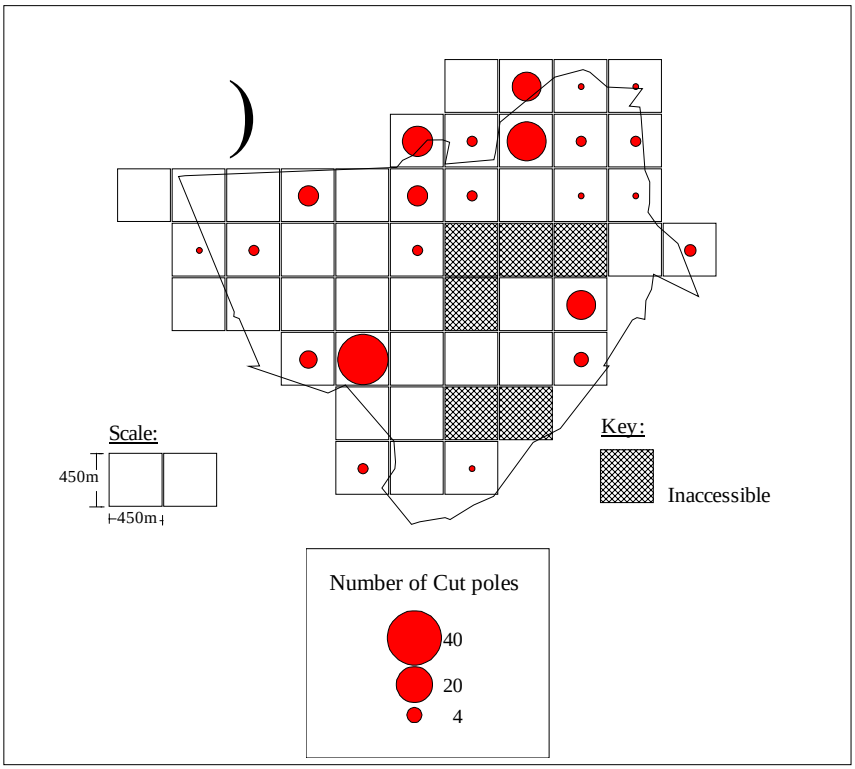

Figure 15 Pole extraction in Mlinga FR.

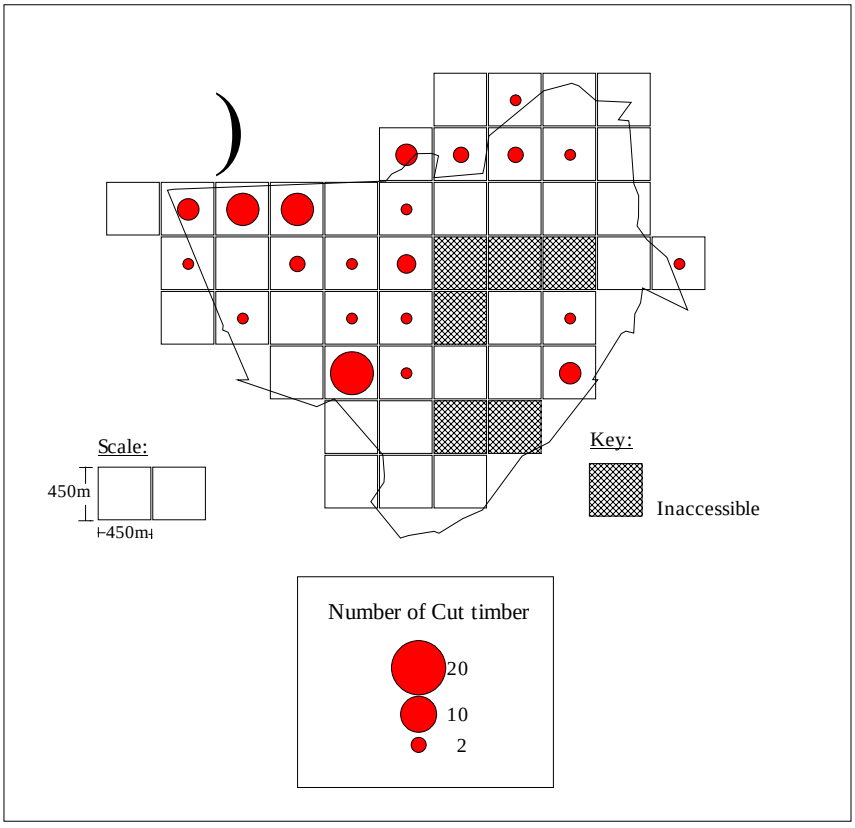

Figure 16 Timber extraction in Mlinga FR.

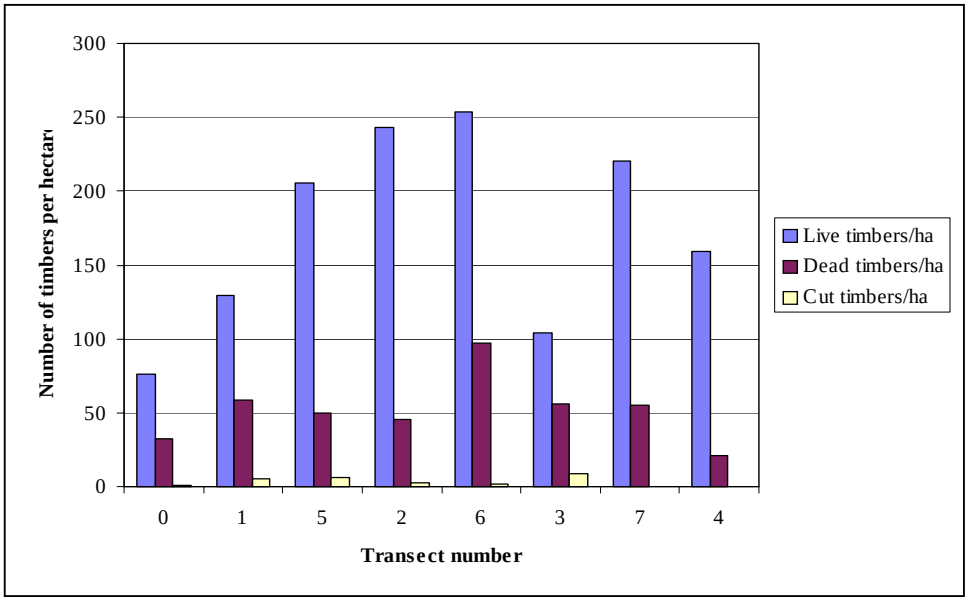

Figure 17 Relative abundance of live, naturally dead and cut timber in Mlinga FR.

4.3.2.2 Other signs of disturbance

Fire

The most common form of disturbance was fire, present within 48% of all 50 metre sections sampled (Table 19). Fire represents the most significant threat to Mlinga Forest Reserve. During the survey, fires spread into the forest reserve on three occasions and destroyed vegetation plot 24. Of the 44 complete and incomplete plots surveyed, 77% had evidence of fire damage (recent or old). Fire incidence was most intense in northern and eastern parts of the reserve (Figure 18).

Cultivation

Evidence of past cultivation, particularly in northern and southern reserve border areas of the reserve (Figure 19) were common, present within 5.5% of all 50 meter sections and 15% of vegetation plots. According to local knowledge, clearance of the forest for cardamom (*Illeteria cadamon*) cultivation was once intense.

All other signs of disturbance were uncommon (Table 19).

Pitsawing

There was no evidence of recent pitsawing activity, although 5.1% of all 50 meter sections (Table 19) and 14% of vegetation plots (Figure 20) contained planks or some other evidence of past timber extraction. Field evidence and local knowledge suggested that past extraction concentrated on *Melicia excelsa*, *Afzelia quanzensis* and *Albizia* species.

Footpaths

Footpaths were not particularly common as a result of extreme terrain, however some did allow access into the forest reserve in eastern and northern parts of the reserve, and centrally up the ridge path between Antakae and Mwembene (Figure 21). These footpaths influenced all forms of disturbance.

Trapping and Grazing

Only two animal traps were seen, a snare for hyrax and a bird trap. Grazing was only seen on two occasions in the south and north of the reserve (Table 19).

Table 19 The incidence of various types of disturbance.

	Fire	Cultivation	Planks/Poles	Paths	Pitsaw	Trapping	Grazing
Incidence Tally	131	15	10	9	4	2	2
Percentage (%)	48.0	5.5	3.6	3.2	1.5	0.7	0.7
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**6**

Incidenced was calculated as presence (1) or absence (0) every 50m transect section.

DEFINITIONS FOR TABLE 19

- Fire refers to an area affected by fire, evidence including burnt trees and ground flora.
- Cultivation refers to evidence of crop production, whether tree or ground crops, past or present.
- Planks/Poles refers to cut timbers and poles laying on the ground ready for transportation.
- Paths refer to all human used footpaths.
- Pitsaw refers to any site with the remains of pitsaw activity past or present.
- Trapping refers to any form of animal trapping.
- Grazing refers to cattle grazing.

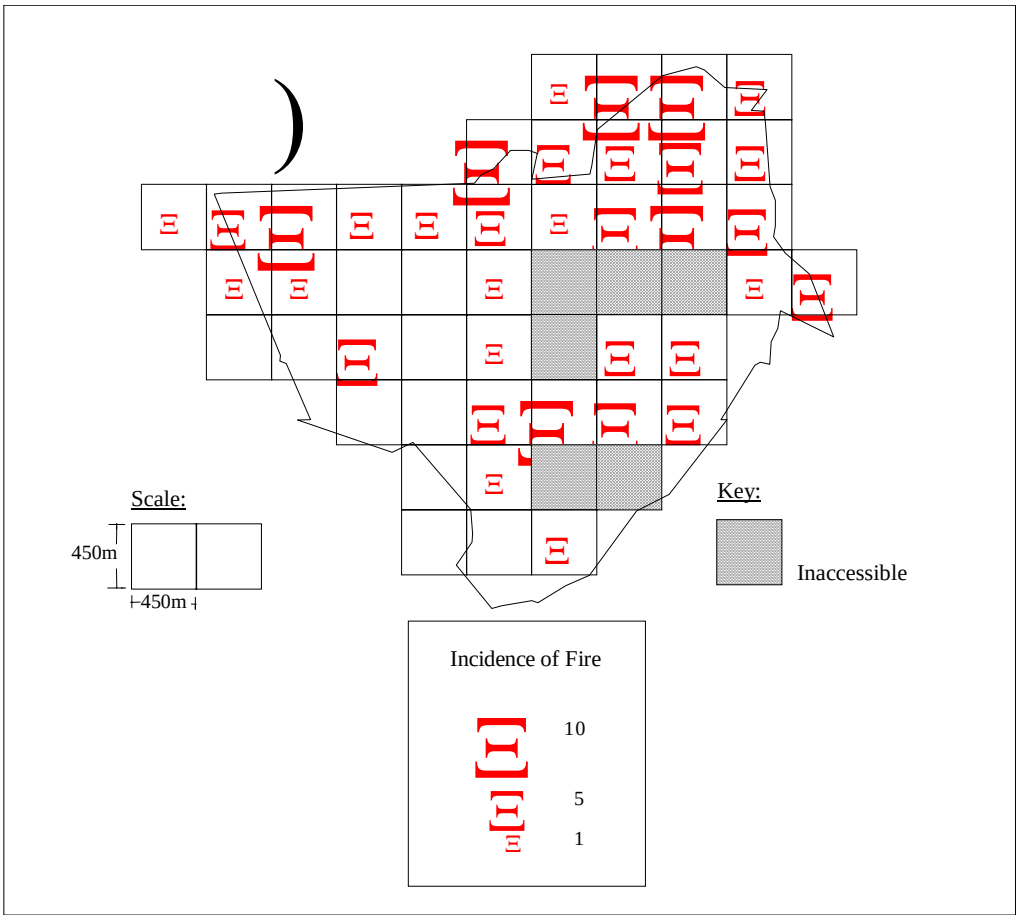

Figure 18 Incidence of fire in Mlinga FR.

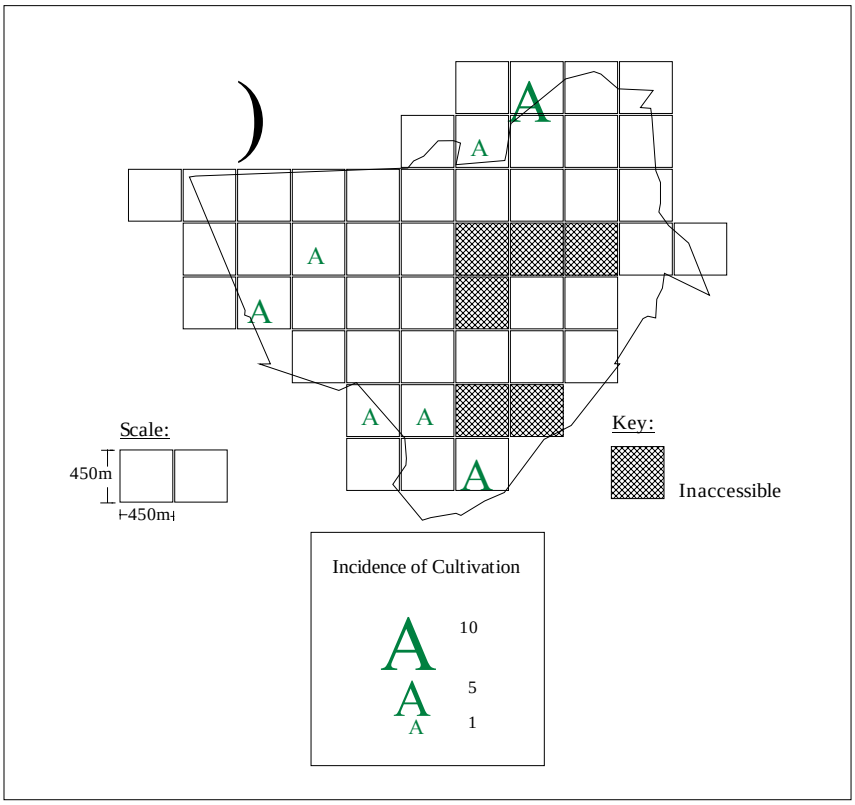

Figure 19 Incidence of past cultivation in Mlinga FR.

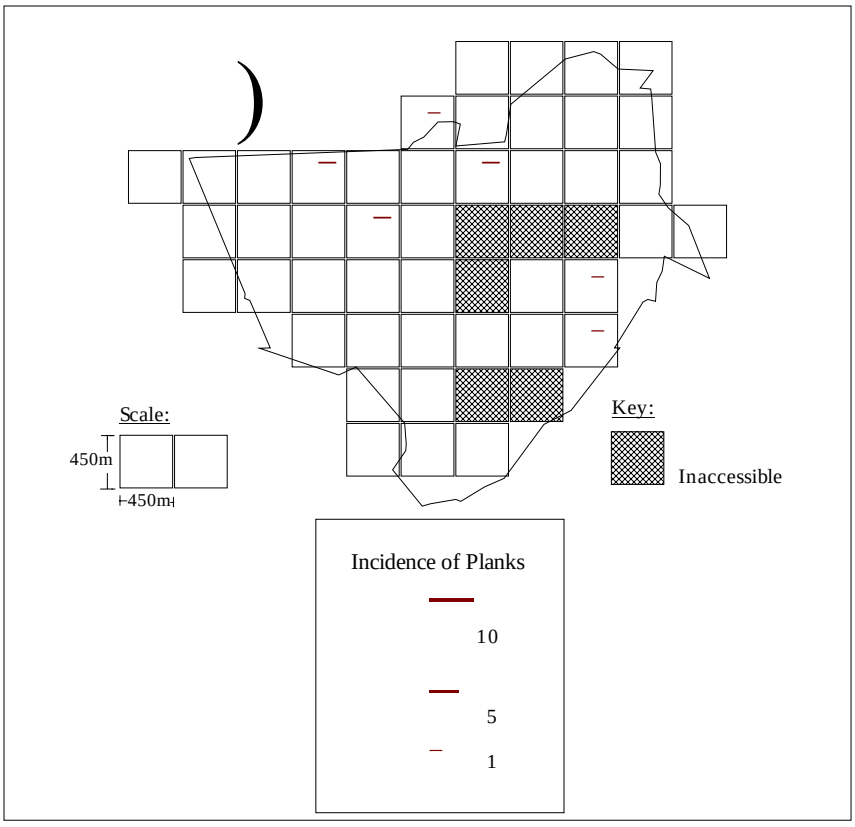

Figure 20 Incidence of planks/poles (as defined in Table 19) in Mlinga FR.

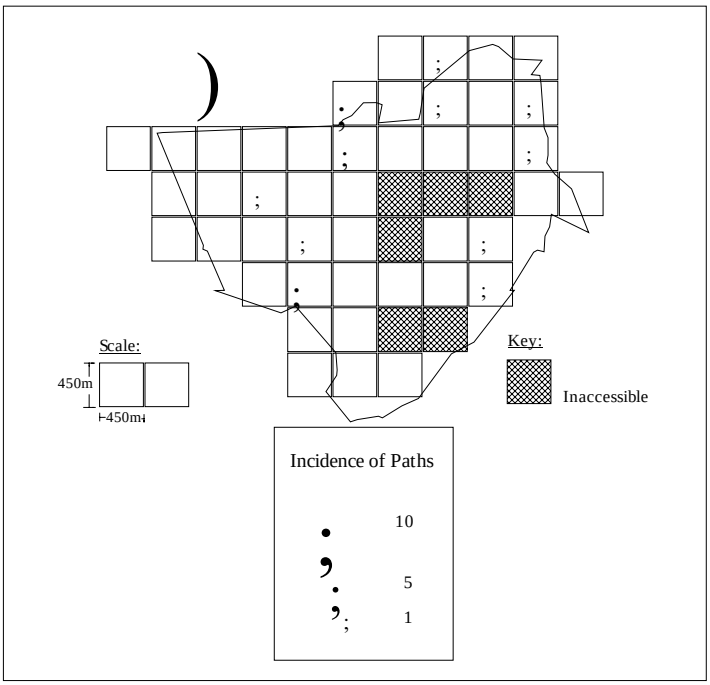

Figure 21 Incidence of footpaths in Mlinga FR.

4.3.2.3 Areas of greatest disturbance

The most disturbed areas within Mlinga FR were located in the northeast, north western southern border areas of the reserve. All endemic, near-endemic and forest dependent plants were found outside the most disturbed areas (Figure 22).

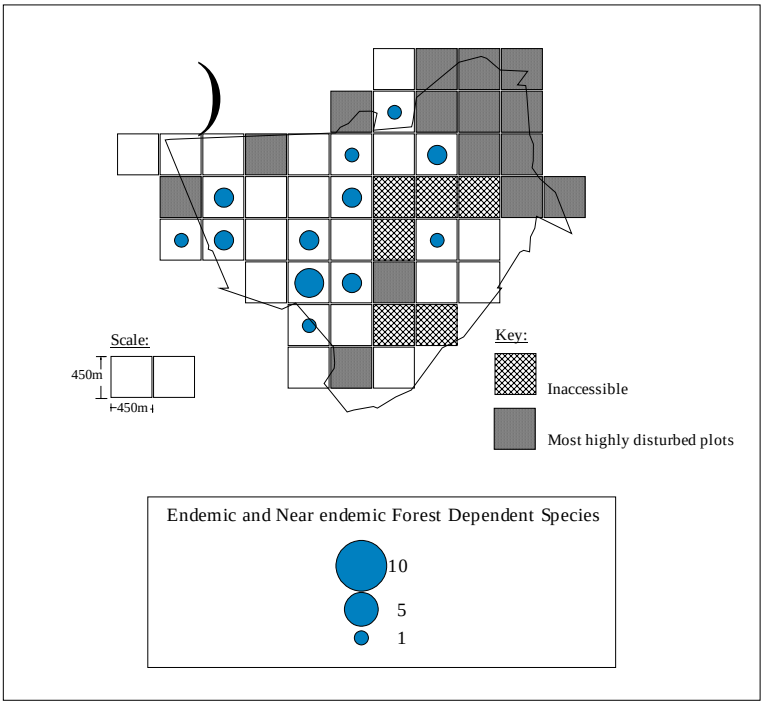

Figure 22 Distribution of forest dependent, endemic and near-endemic plant species in relation to areas of highest disturbance in Mlinga FR.

4.4 Discussion

Mlinga Forest Reserve covers an area of 890 hectares with an altitude range of 220m to 1069m above sea level. Topography is extreme and the landscape rocky. Mlinga FR supports a variety of interesting habitats.

4.4.1 Habitat

Of the 34 vegetation plots surveyed systematically, 11 (32.4%) were lowland forest, 9 (26.5%) open woodland, 3 (8.8%) scrub/grassland/previously disturbed, 4 (11.8%) disturbed lowland forest, 1 (2.9%) disturbed submontane forest, 2 (5.9%) rock and 1 (2.9%) grassland. These figures differ significantly from those recorded by Johannson and Sandy (1996), and suggest a significant decline in forest area in recent years. Only six vegetation plots were recorded with canopy heights greater than 20m. Approximately two-thirds of vegetation plots had been affected by fire and 59% contained rock outcrops.

4.4.2 Species richness

In the systematic vegetation plots 780 trees and shrubs were surveyed, representing 135 species from 39 families. An additional eleven species were recorded in the regeneration plots. Opportunistic observations and collections recorded an additional 123 plant species from 54 families. In total, 269 plant species from 77 families were recorded.

The most abundant species in vegetation plots, representing 10.6% of individuals was the woodland species *Stereospermum kunthianum* (Bignoniaceae), which was dominant within 5 plots. The most commonly encountered species throughout vegetation plots were *Sponia orientalis* (Ulmaceae), *Antiaris toxicaria* (Moraceae) and *Annona senegalensis* (Annonaceae). *S. orientalis* and *A. senegalensis* were seen to be resilient to disturbance and at competitive advantage particularly in fire disturbed areas.

Relative to other forest reserves surveyed in the East Usambara mountains the botanical richness of Mlinga FR was generally low, partly due to the small size, inaccessibility and extensive nature of recent fire disturbance. The richness and diversity of plant species at Mlinga peak summit however added significantly to the biological value of the reserve.

4.4.3 Species Accumulation Rates

The accumulation of species records throughout the systematic vegetation survey showed a general increase with sampling intensity and, although the curve seemed to level off (Figure 5), not enough evidence was available to suggest that the accumulation of species would not increase with greater sampling intensity. Opportunistic collection of flora supplemented the plant checklist significantly.

4.4.4 Endemic Status

The majority of species recorded in vegetation plots (85%) had widespread distributions. Six species were recorded as endemic to the East Usambara mountains and 14 species near-endemic.

The most commonly recorded near-endemic tree and shrub species in the reserve were: *Anglocalyx braunii* (Leguminosae: subfamily Papilionaceae) (12 individuals) and *Dombeya shupangae* (Sterculiaceae) (10 individuals). All endemic and near-endemic species were restricted to only one or two plots each, and never abundant.

All endemic species recorded in vegetation plots were forest dependent and of the 14 near-endemic species, 8 species were considered to be forest dependent. One near-endemic species, *Dombeya shupangae*, is a non-forest species.

The following endemic species were recorded within vegetation plots: *Cynometra brachyrrhachis*, *Cynometra longipedicelata*, *Cynometra sp. A* (Leguminosae: subfamily Caesalpinoideae), *Cola scheffleri* (Sterculiaceae) and *Vitex ferruginea* (Verbenaceae). All are endemic to the East Usambara mountains. All endemic species were found in lowland and submontane forest areas with low or no level of disturbance. Near-endemic species were located throughout the forest reserve, even in open woodland and disturbed habitats. All endemic and near-endemic species (except *Anglocalyx braunii* and *Dombeya shupangae*) were represented by less than 4 individuals.

An additional 3 species endemic to the East Usambara mountains, 1 species endemic to the East and West Usambara mountains, and 9 near-endemic species were recorded opportunistically. The endemic species included: *Justicia oblongifolia* (Acanthaceae), *Sanrafaelia ruffonammari* (Annonaceae), *Saintpaulia magungensis* (Gesneriaceae) and *Lijindenia greenwayi* (Melastomataceae). *Sanrafaelia ruffonammari* is of particular interest because it has only previously been recorded from Kwamgumi Forest Reserve and has only recently been taxonomically described. This record within Mlinga FR represents a range extension for this species.

4.4.5 Ecological Type

Forty one species (30%) recorded in vegetation plots were classified as forest dependent, defined as 'limited to primary or closed canopy forest only'. The most commonly recorded forest dependent tree species was *Tabernamontana verticosa* (Apocynaceae) represented by 15 individuals in 6 lowland and submontane forest plots with limited or no disturbance. Five (4%) forest dependent species were endemic to the East Usambara Mountains; a further 7 (5%) were near-endemic.

Sixty four species (47%) were recorded in vegetation plots as forest dwelling and 10 species (6%) non-forest dwelling. *Stereospermum kunthianum* (Bignoniaceae) was the most abundant forest dwelling species represented by 83 individuals in 6 open woodland plots. *Dombeya shupangae* (Sterculiaceae), represented by 10 individuals in 5 plots was the most abundant non-forest species present in open woodland and disturbed lowland forest habitats.

4.4.6 Habitat

Of the tree species surveyed with known altitudinal preferences, 14.1% were considered to be solely typical of lowland forest, 5.9% of submontane forest and 1.1% of montane forest. The remainder were considered to be typical of a combination of habitats, the majority (37% of species) present with lowland, submontane and montane habitats.

At least one submontane or montane species occurred in each of the 13 lowland plots surveyed. Only one lowland species *Zanthoxylum holtzianum* (Rutaceae) occurred in a submontane vegetation plot at 960masl. These data are indicative of the variability in the ecological requirements and niches of these species; however, transitional areas in Mlinga FR were not large.

The most commonly recorded submontane species was *Craiba brevicaudata* (Leguminosae: subfamily Papilionoideae) represented by 3 individuals in only 2 vegetation plots. Species classified as confined to submontane forest were rare in Mlinga FR.

4.4.7 Range Extensions

The vegetation plot data generated a total of 87 new species range extensions for Mlinga FR, when compared to the study by Ruffo *et al.* (1989). Eight of these species were also new to the East Usambara Plant Biodiversity Database.

4.4.8 Regeneration

Thirty two percent of the species found in the vegetation plots were also recorded within the regeneration subplots, these are indicated in Table 14 with an asterisk (* or **). An additional 11 species were recorded in the regeneration layer alone.

Only one endemic species was recorded in the regeneration layer, *Cola scheffleri* (Sterculiaceae), represented by one individual with a dbh less than 1cm. Six regenerating species were near-endemic and included: *Drypetes usambarica* (Euphorbiaceae), *Allanblackia stuhlmannii* (Guttiferae), *Newtonia paucijuga* (Leguminosae subfamily: Mimosoideae), *Anglocalyx braunii* (Leguminosae subfamily: Papilionoideae), *Allophylus melliodorus* (Sapindaceae), *Dombeya shupangae* (Sterculiaceae).

Of the eighteen principle timber and/or plywood species found within the reserve, seven species *Allanblackia stuhlmannii* (Guttiferae), *Albizia gummifera* (Leguminosae subfamily: Mimosoideae), *Bersama abyssinica* (Melianthaceae), *Strombosia scheffleri* (Olacaceae), *Anthocleista grandiflora* (Loganiaceae), *Newtonia buchananii* (Leguminosae subfamily: Mimosoideae), *Antiaris toxicaria* (Moraceae) and *Khaya nyasica* (Meliaceae) were recorded regenerating.

Of those species that were solely found in the regeneration layer, 3 species represented range extensions. Three were new to Ruffo *et al.* (1989) in Mlinga FR.

4.4.9 Opportunistic Collections – interesting records Mlinga Peak

Opportunistic collections added significantly to the floristic value of Mlinga FR. The biological value of the flora of Mlinga Peak and the surrounding submontane forest has in the past been well recognised (Hamilton, 1989; FINNIDA, 1988). Mlinga FR was established to protect this area (Hamilton, 1989). Of particular interest at this site was the opportunistic collection of *Podocarpus latifolius* (Podocarpaceae), one of two gymnosperms recorded during the biodiversity survey. Gymnosperms are the most ancient seed plants having originated during the Palaeozoic era (about 130 million years ago) (Kokworo, 1993). It is thought that this species has therefore been in Mlinga FR for a very long time and it is unknown why the species has not spread to other forest areas. *P. latifolius* was found growing with *Lijndenia greenwayi* (Melastomataceae) which has been recorded by Knox (2000) as 'endemic to Mount Mlinga'. Iversen (1991b) however classifies it as endemic to the East and West Usambara mountains.

Mlinga peak area, as a consequence of its rocky nature, also supports many *Streptocarpus* and *Saintpaulia* species, most of which are endemic to the Usambara mountains. The distinctive rocky summit also supported populations of the gymnosperm *Encephalartos hildebrandtii* (Zamiaceae); *Pandanus* sp. (Pandanaceae) and *Pheonix reclinata* (Palmae), found nowhere else in the forest reserve.

The submontane forest that surrounds the peak has been partly disturbed by fire, particularly on the eastern side. In undisturbed areas however, the forest was tall and supported a significant number of folicolous epiphytes of unknown species.

Lowland riverine forest within Mlinga FR was home to the recently described *Sanrafaelia ruffonammari*, previously only recorded from Kwamgumi FR.

4.4.10 Sampling Intensity

An increase in sampling intensity from 0.25% to 0.5% increased the value of the vegetation survey significantly. An additional 17 vegetation plots were established, recording an additional 442 individuals representing 45 species. An additional 1 endemic, 3 near-endemic and 10 forest dependent species were recorded as a consequence of increasing sampling

intensity. In small reserves it is therefore recommended that a sampling intensity of 0.5% be used.

An increase in the sampling intensity of regeneration plots from 3m x 3m to 6m x 6m significantly increased the number of individuals sampled in the regeneration layer, but did not increase species numbers significantly enough to be able to recommend its use in future. This however, may not be the case for large, more species diverse reserves such as Amani Nature Reserve or Nilo Forest Reserve. Further analysis is required to investigate this.

4.4.11 Disturbance

All disturbance within Mlinga FR was dependent on accessibility. Lowland forest reserve border areas and forest near to footpaths in more elevated areas were most under pressure.

The most significant threat recorded in Mlinga FR was fire disturbance. Evidence of fire was noted in 77% of vegetation plots, distributed throughout the forest reserve. Fire disturbance was particularly intense in eastern areas and north western borders of the forest reserve, and likely explains the large numbers of dead poles and tiumbers sampled along transects 0 and 1. In these areas there was little forest canopy and open wooded grassland generally dominated. *Sponia orientalis* was particularly abundant in such habitats, particularly in the east. During the survey, fires spread into the forest reserve on three occasions along northwestern borders. Fires are a serious concern to the future of Mlinga FR, particularly the summit area.

Due to the patchy, yet extensive nature of fire disturbance throughout Mlinga FR, it was difficult to draw conclusions as to the effect of fire on the distributions of endemic and forest dependent species. It was however evident in the field that there were fewer forest dependent and endemic/near-endemic species and individuals in the most severely fire affected areas. Fire has decreased forest area significantly in recent years and was limiting the regeneration of forest species thereby inhibiting forest growth within the forest reserve.

Pole and timber cutting was not such a present concern with an average of 10.5 cut poles per hectare and 3.3 cut timber per hectare. Recent extraction was greatest along reserve border areas, particularly in the north. The intensity of pole and timber extraction was, along all transects, less than the number of dead poles and timber.

The number of dead poles and timber were exceptionally high compared to other forest reserves previously studied by EUBS. Twenty percent of poles and 23% of all timber sampled were dead. The greatest abundance of dead poles and timber correlated with areas most disturbed by fire. Recent fire disturbance within the forest reserve has caused the large number of deaths and is likely to significantly affect future forest composition.

All signs of cultivation were old, and mostly located in northern areas where settlement used to occur prior to gazettment of the forest reserve. Evidence of past cultivation also occurred near to villages in the south and west of the reserve.

All signs of pitsawing were old, and located in eastern and northern areas of the reserve. Low densities of valuable timber species within the forest reserve suggest past unsustainable extraction. Pitsawing activities have however decreased substantially and are presently not of great concern within Mlinga FR.

Since the introduction of *Maesopsis eminii* into the Amani area this species has spread rapidly throughout the Usambara mountains (Binggeli 1989). This invasive tree species was only recorded in 1 vegetation plot in Mlinga FR, and is therefore presently of little concern.

Only two areas in Mlinga FR were seen to have animal traps. These traps were targeting hyrax and birds. Some evidence of hunting was seen casually throughout non-systematically

surveyed areas of the forest. There were a limited number of large mammal sightings and signs. This suggested that hunting activity was great in the recent past, and has been supported by local knowledge.

Cattle grazing sites were observed on two occasions in the south and north of the reserve near to sub-villages of Misozwe. Grazing was not considered a significant threat at present.

5.0 FAUNA

Authors: Oliver, S., Hall, S.M., Smith, J. and Murphy, A. pp. 57-82

5.1 Introduction

The fauna of Mlinga FR was studied to assess diversity within specific taxonomic groups. Inventories were compiled of mammal, reptile, amphibian, butterfly, mollusc and millipede species. Practicalities of capture methods, identification techniques and potential information that could be extracted from the data, influenced the taxonomic groups chosen for the study. The results of the inventories were used to assess the relative biodiversity value of the reserve's fauna.

5.2 Methods

Within Mlinga FR, target groups of fauna were surveyed using a combination of standardised, repeatable methods at 'zoological trapsites'. Transect surveys of dung and other animal signs, and the opportunistic collection and observation of all animals were also implemented. Brief descriptions of the methods employed and trapsite locations follow. A more detailed methodology of survey techniques can be found in the FT FRP *Methodology Report* (SEE, 1998).

5.2.1 Bucket pitfall traps

Small mammals, amphibians and reptiles were sampled using bucket pitfall traps. Three 50m linear transects were created at zoological trapsite locations whereby eleven 10 litre plastic buckets were sunk into the ground with their rims flush to ground level. Buckets contained small holes to allow rainwater to drain from them and each bucket was positioned 5m apart. A sheet of vertical plastic (approximately 0.5m high, and no less than 0.2m) was run along the bucket line crossing the centre of each bucket to form a 'drift fence'. A 10-15cm lip of plastic sheeting was left flat on the ground onto which soil and leaf litter was placed to prevent any gap in the drift fence at ground level. Animals moving into the area from either side would be channelled along the plastic towards the bucket traps.

Each line was placed no more than 50m apart, but was located to encompass a range of micro-habitats. Brief habitat notes were taken for each bucket position. Traps were checked early each morning for the duration of the trapsite period and data recorded on standardised data sheets regarding the identification of each animal captured.

5.2.2 Sherman traps

Small rodents and insectivores were sampled using 100 Sherman traps (standard size) baited with toasted coconut and peanut butter. Traps were placed at least 2m apart, forming a wide loop around the bucket pitfall trap lines; 33 around two of the lines and 34 around the third. Traps were baited each evening (16.00hr or later) for the duration of the trapsite and checked early the following morning (08.00hr or earlier). Traps were closed during each day of the trapsite.

Data were recorded on standardised sheets regarding the identification, sex, breeding status and biometrics of each animal captured, as well as habitat notes. Specimens were retained when species level could not be ascertained and in cases where sexed specimens were required; these specimens were subsequently sent to international taxonomic experts (refer to Appendix 1).

In the case of small rodents, individuals released were each given a distinct mark-code made by trimming small patches of fur in a given pattern. 'Recaptured' individuals were then able to be identified.

5.2.3 Bat mist-netting

Bats were sampled using varying combinations and configurations of mist-nets within 5 trapping sessions. Up to four mist-nets of varying sizes (3m x 3.5m, 6m x 3.5m, 9m x 3.5m) were utilised at any one time. Nets were placed across assumed 'flight corridors' such as rivers and paths. Nets were opened at dusk (approximately 18.30hr) and checked every 15 minutes for the duration of the netting session.

Data were recorded on standardised data sheets regarding the identification, sex, breeding status, weight and biometrics of each bat captured. Detailed habitat notes were taken for each mist-netting location and the number of net-metre hours calculated for each session.

5.2.4 Butterfly sweep-netting

Low-flying butterflies were sampled using hand-held sweep-nets. Two man-hours were spent netting along the bucket pitfall lines each day for the duration of the trapsite.

5.2.5 Butterfly canopy traps

Five Blendon-style canopy traps were set up at the trapsites, one trap close to one bucket pitfall line, and two traps on the remaining two lines. Traps were baited with fermented banana in the mornings (usually around 08.00hr). Traps were checked morning and late afternoon. One individual of each species captured was taken; any 'repeat species' butterflies were identified, recorded and released.

5.2.6 Mollusc plots

Molluscs were sampled in three 1m x 1m quadrats per trapsite; whereby quadrats were established close to each of the bucket pitfall trap lines and located in order to encompass a range of microhabitats. Two man-hours were spent searching the leaf litter, to a depth of 5cm within each quadrat. All molluscs encountered were collected and preserved.

5.2.7 Millipede plots

Millipedes were sampled in three 3m x 3m quadrats per trapsite; again, one established close to each of the bucket pitfall trap lines and located in order to encompass a range of microhabitats. Four man-hours were spent searching the leaf litter, to a depth of 5cm within each quadrat. All millipedes encountered were collected and preserved.

5.2.8 Dung and sign surveys

Spoor and other signs of animal presence were assessed along every established transect line through the forest reserve (Figure 3). A 2m strip either side of each transect line was assessed for animal dung, tracks and paths, as well as other signs such as burrows, diggings, feathers etc. All animal signs were recorded along with brief geographical and habitat details. To determine identification of indirect evidences, the knowledge of experienced field assistants was utilised, in conjunction with a Reference Dung Collection and Walker (1996).

5.2.9 Opportunistic collection and observations

All taxa were also collected and observed on a casual basis throughout the survey period. Opportunistic collections of amphibians, reptiles, molluscs and millipedes were taken and direct and indirect observations of birds and larger mammals were recorded to determine the presence of species otherwise omitted in the standardised techniques.

5.3 Trapping sites and sampling intensity

Zoological trapsites were established at five different locations in Mlinga FR. Trapsites were strategically positioned to incorporate a range of habitats reflective of the reserve. The location of trapsites within Mlinga FR are shown in Figure 23.

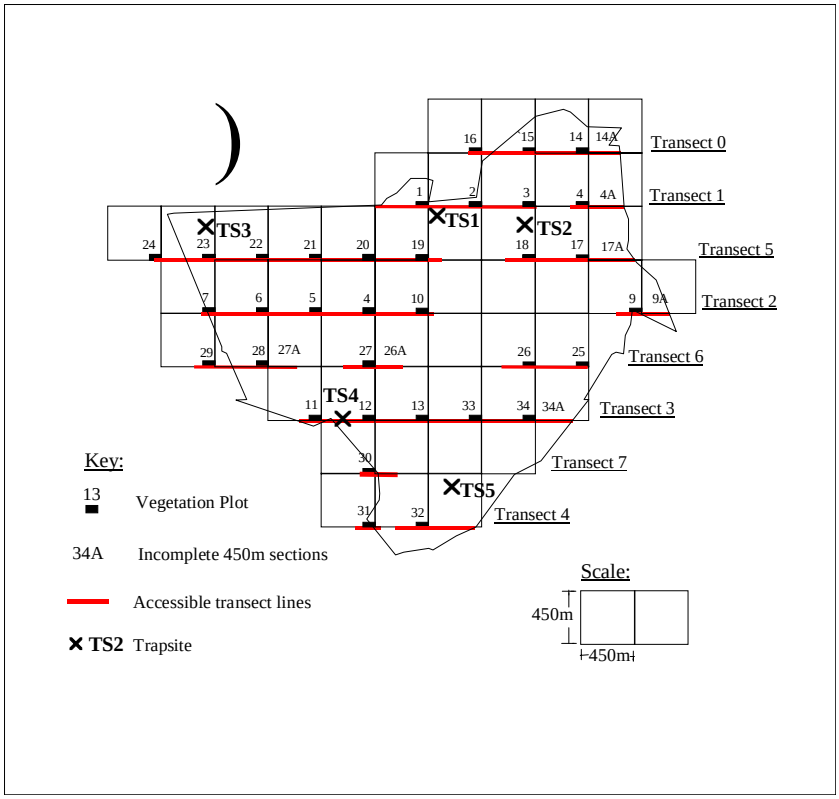

Figure 23 Location of trapsites in Mlinga FR.

Table 20 provides brief descriptions of the trapping sites. Table 21 summarises the sampling intensity for each site and each trapping method. Table 22 briefly describes bat mist-netting sites.

Table 20 Descriptions and locations of zoological trapsites in Mlinga FR.

Trapsite Number	Duration (nights)	Vegetation type	Altitude (masl)	Topography	Co-ordinates
1	10	Lowland Riverine Forest and Old Cultivation	240	Gentle Lower Slope	S 05° 03' 33.9" E 038° 44' 52.1"
2	10	Lowland Forest	300	Gentle Lower Slope	S 05° 03' 32.5" E 038° 45' 14.1"
3	10	Lowland Forest with Fire Disturbance	240-260	Gentle Lower Slope	S 05° 03' 41.1" E 038° 43' 52.1"
4	10	Sub-montane Forest	800	Steep Mid Slope	S 05° 04' 28.6" E 038° 44' 32.8"
5	2	Ridge top/Peak, Sub-montane Forest	915	Steep Upper Slope	S 05° 04' 58.6" E 038° 44' 41.0"

Table 21 Zoological sampling intensities in Mlinga FR.

Trapsite Number	Trapsite Duration (dates)	Sherman traps x trap nights	Bucket traps x trap nights	Butterfly traps x trap days	Butterfly sweepnetting hours	Mollusc plots per trapsite	Millipede plots per trapsite
1	13/10/01-23/10/01	1000	330	50	20	3	3
2	26/10/01-05/11/01	1000	330	50	20	3	3
3	08/11/01-18/11/01	1000	330	50	20	3	3
4	21/11/01-01/12/01	1000	330	50	20	3	3
5	06/12/01-08/12/01	98	0	0	0	0	0
	TOTAL	**4098**	**1320**	**200**	**80**	**12**	**12**

Table 22 Bat mist-netting sites and sampling intensities in Mlinga FR.

Net site number	Site location	Site description	Co-ordinates	Altitude (m)	Sampling intensity (square metres of net x no. of hours)
1	Base camp, (near Vegetation Plot 2)	Along vehicle track, grassland and scrubby woodland area. Gentle lower slope.	S 05° 03' 16.1" E 038° 45' 04.2"	240	294
2	Trapsite 1 (near Vegetation Plot 1)	Dry stream bed within Lowland Riverine Forest and close to forest edge. Gentle lower slope.	S 05° 03' 33.9" E 038° 44' 52.1"	240	735
3	Trapsite 2 (near Vegetation Plot 3)	Dry stream valley in Lowland Forest. 20m canopy height, gentle lower slope.	S 05° 03' 32.5" E 038° 45' 14.1"	380	1087
4	Near Vegetation Plot 1	Stream in lowlying disturbed forest/cultivated land, just outside Reserve border.	S 05° 03' 16.1" E 038° 45' 04.2"	240	1015
5	Trapsite 4 (near Vegetation Plot 12)	Stream in Sub-montane forest. Gentle mid slope.	S 05° 04' 28.6" E 038° 44' 32.8"	740	131
				TOTAL	**3262**

5.4 Results

5.4.1 Mammals

5.4.1.1 Small mammals (not including bats)

A total of 101 small mammals were captured during 4098 Sherman trapping nights in Mlinga FR and, of these, 31 specimens were retained for taxonomic purposes (Table 23). Identifications remain tentative while awaiting taxonomic verifications from Frankfurt Zoological Museum (refer to Appendix 1). The specimens collected represent at least 10 species from 4 families (Table 23). A summary of trapping data is shown in Appendix 8a and, species list of captured small mammals with their corresponding ecological, endemic and threat status presented in Table 23.

Ecological type, endemic status and threat status for the mammal tables 23, 24, 25 and 26 were compiled using the National Biodiversity Database (UDSM, 1997), IUCN (Hilton-Taylor, 2000), Kingdon (1974 and 1997) and CITES listings (2001). Nomenclature follows Kingdon (1997).

Table 23 Summary of captured small mammals from Mlinga Forest Reserve.

Species	**Ecol. type**	**End. status**	**IUCN 2000**	**UDSM 1997**	**CITES 2001**	**Total nos. captured**	**No. of specimens taken**
SORICIDAE							
Crocidura flavescens (White-toothed Shrew)	f	W				-	-
Crocidura hildegardeae (White-toothed Shrew)	f	W				-	-
Crocidura sp.	?	?				10	10
CRICETOMYINAE							
Beamys hindei (Lesser Pouched Rat)	F	N	VU	DD		30	1
MURIDAE							
*Acomys spinosissimus (*Spiny Mouse)	f	W					
Acomys sp.	?	?				7	4
Lophuromys flavopunctatus (Brush Furred Rat)	F	W				17	2
Praomys delectorum (Soft-Furred Rat)	f	W				26	5
Praomys sp.	?	?				1	1
Grammomys ibeanus (Narrow–footed Woodland Mouse)	O	W				3	2
Grammomys macmillani (Narrow-footed Woodland Mouse)	O	W				3	3
Rattus rattus (Common Rat)	O	W				1	1
Unknown sp. 1	?	?				1	1
Unknown sp. 2	?	?				1	1
GALAGONIDAE							
Galagoides zanzibaricus (Zanzibar Galago)	f	N	LR /NT		II	1	0
TOTAL						**101**	**31**

Key to abbreviations on the next page.

KEY TO ABBREVIATIONS FOR TABLES 23 and 24

Ecological (Ecol.) type:
F – Forest dependent species: Species confined to primary forest only; not including forest edge or secondary forest.
f – Forest dwelling but not forest dependent species: Species occurring in primary forest, forest edge or secondary forest.
O – Non-forest species: Species that do not occur in primary or secondary forest or forest edge.

Endemic (End.) status:
E – Endemic: Species only found in the Usambara mountains.
N – Near-endemic: Species with limited ranges usually only including coastal forest and/or East African lowland forests.
W – Widely distributed species.

IUCN status:
EN – Endangered
VU – Vulnerable
LR/NT – Lower Risk/Near Threatened
DD – Data Deficient

CITES listings:
I – Appendix One listed species
II – Appendix Two listed species
(Appendix Three species not included in Table)

Of particular interest was the trapping of *Galago zanzibaricus* (Zanzibar Galago), a near-endemic, lower risk/near threatened species (IUCN, 2000) (Table 23) that was surprisingly captured in a ground-level Sherman trap in lowland forest at trapsite 2 (Appendix 8a).

Two species captured were classified as forest dependent, *Lophuromys flavopunctatus* (Brush furred Rat) and the near-endemic and vulnerable *Beamys hindei* (Lesser pouched Rat) (IUCN, 2000) (Table 23).

5.4.1.2 Dung survey

Dung from 6 mammal species were recorded. The most interesting record was that of *Dendrohyrax validus* (Eastern Tree Hyrax), considered forest dependent, near-endemic, vulnerable (IUCN, 2000) and endangered (UDSM, 1997) (Table 24).

Table 24 Summary of dung survey in Mlinga FR.

Species	Ecol. type	End. status	IUCN 2000	UDSM 1997	CITES 2001	No. of occurrences	Altitude of dung findings
CERCOPITHECIDAE							
Papio cynocephalus (Yellow Baboon)	F	W			II	6	270-420
Cercopithecus (n.) mitis (Gentle Monkey)	F	W			II	1	410
THRYONOMYIDAE							
Thryonomys gregorianus (Marsh Cane-Rat)	O	W				11	270-960
SUIDAE							
Potamochoerus larvatus (Bush Pig)	f	W				2	340-370
PROCAVIDAE							
*Dendrohyrax validus** (Eastern Tree Hyrax)	F	N	VU	EN		1	240
ANTILOPINAE							
Cephalophus sp. (Duiker sp.)	f	W				3	260-300

* A casual collection

Key to abbreviations as Table 23.

5.4.1.3 Mammal observations

A total of 11 species from 7 families were observed but not retained for taxonomic purposes (Table 25). Some of these species had previously been recorded in traps (Table 23) or as dung (Table 24). An 'identification confidence' column clarifies the reliability of each sighting (Table 25). Identification was ranked as follows: Certain, Near Certain, Probable or Possible.

A significant number of mammal observations were classified as forest dependent species, the majority of these were primates (Colobidae, Cercopithecidae and Galagonidae) (Table 25). Of most interest were the observations of a group of *Colobus angolensis palliatus* in tall-canopy lowland forest at trapsite 2, and the squirrels, the near-endemic *Paraxerus lucifer* (UDSM, 1997) and vulnerable *Paraxerus palliatus* (IUCN, 2000) (Table 25) seen at trapsite 3 and on the edge of the forest reserve respectively.

Table 25 Summary of mammal observations in Mlinga FR.

Species	Common Name	Ecol. type	End. status	IUCN 2000	UDSM 1997	CITES 2001	Identification confidence
COLOBIDAE							
Colobus angolensis palliatus	Angola Pied Colobus	F	W	DD		II	Certain
CERCOPITHECIDAE							
Papio cynocephalus	Yellow Baboon	F	W			II	Certain
Cercopithecus (n.) mitis	Gentle Monkey	F	W			II	Certain
GALAGONIDAE							
Otolemur crassicaudatus	Greater Galago	F	W			II	Certain
Galagoides zanzibaricus	Zanzibar Galago	F	W	LR/NT		II	Certain
Otolemur garnettii	Small-eared Galago	f	W			II	Certain
MACROSCELIDINAE							
*Petrodromus tetradactylus**	Four-toed elephant shrew	f	W				Probable
ANTILOPINAE							
Cephalophus harveyi	Harvey's Duiker	f	W				Probable
SCIURIDAE							
Paraxerus lucifer	Tanganyika mountain squirrel	F	N		LR		Possible
Paraxerus palliatus	Red-bellied coast Squirrel	F	W	VU			Possible
PROCAVIDAE							
Dendrohyrax validus	Eastern Tree Hyrax	F	N	VU	EN		Certain

* Aurally recorded

KEY TO ABBREVIATIONS FOR TABLE 25

Ecological (Ecol.) type:
- F – Forest dependent species: Species confined to primary forest only; not including forest edge or secondary forest.
- f – Forest dwelling but not forest dependent species: Species occurring in primary forest, forest edge or secondary forest.
- O – Non-forest species: Species that do not occur in primary or secondary forest or forest edge.

Endemic (End.) status:
- E – Endemic: Species only found in the Usambara Mountains.
- N – Near-endemic: Species with limited ranges usually only including coastal forest and/or East African lowland forests.
- W – Widely distributed species.

IUCN status:
- EN – Endangered
- VU – Vulnerable
- LR/NT – Lower Risk/Near Threatened
- DD – Data Deficient

CITES listings:
- I – Appendix One listed species
- II – Appendix Two listed species

(Appendix Three species not included in Table)

5.4.1.4 Bats

A total of 29 individuals were caught during 3262 net-metre-hours of trapping in Mlinga FR. These individuals represented at least 9 species from 5 families. Eighteen individuals were retained for taxonomic purposes (Table 26). Trapping data is summarized in Appendix 8b, and a species list presented in Table 26. Identifications remain tentative while awaiting taxonomic verification from Frankfurt Zoological Museum (refer to Appendix 1).

The majority of captures were insectivorous species (Nycteridae, Rhinolophidae and Vespertilionidae). Five fruit bats representing 2 species were captured, all within a single trapsite in submontane forest (Appendix 8). Of most interest was the single capture of near-endemic *Myonycteris relicta* at trapsite 4. This species is listed as vulnerable by UDSM (1997) (Table 26).

Table 26 Summary of bat records in Mlinga FR.

Species	Common name	Ecol. type	End. status	IUCN 2000	UDSM 1997	CITES 2001	Total nos. captured	No. of specimens taken
NYCTERIDAE								
Nycteris grandis	Large Slit-faced bat	f	W				1	1
PTEROPODIDAE								
Lissonycteris angolensis	Angola fruit bat	f	W				4	3
Myonycteris relicta	Collared fruit bat	f	N		VU		1	1
RHINOLOPHIDAE								
Hipposideros caffer	Leaf-nosed bat	O	W				9	4
Hipposideros ruber	Leaf-nosed bat	O	W				?	?
Hipposideros sp.	Leaf-nosed bat	?	?				1	1
Rhinolophus clivosus	Horseshoe bat	O	W				5	3
Rhinolophus fumigatus	Horseshoe bat	O	W				3	3
Rhinolophus sp.	Horseshoe bat	?	?				1	?
VESPERTILIONIDAE								
Miniopterus schriebersi	Long-fingered bat	O	W	LR/NT			1	1
Pipistrellus kuhli/rueppelli	Pipistrelle	O	W				1	1
TOTAL							**29**	**18**

KEY TO ABBREVIATIONS FOR TABLE 24

Ecological (Ecol.) type:
F – Forest dependent species: Species confined to primary forest only; not including forest edge or secondary forest.
f – Forest dwelling but not forest dependent species: Species occurring in primary forest, forest edge or secondary forest.
O – Non-forest species: Species that do not occur in primary or secondary forest or forest edge.

Endemic (End.) status:
E – Endemic: Species only found in the Usambara mountains.
N – Near-endemic: Species with limited ranges usually only including coastal forest and/or East African lowland forests.
W – Widely distributed species.

IUCN status:
EN – Endangered
VU – Vulnerable
LR/NT – Lower Risk/Near Threatened
DD – Data Deficient

CITES listings:
I – Appendix One listed species
II – Appendix Two listed species
(Appendix Three species not included in Table)

5.4.2 Birds

A total of 47 species from 25 families were recorded (Table 27). As no systematic survey of bird fauna was undertaken, the findings do not represent a complete inventory. An 'identification confidence' column is presented in Table 27 to clarify the reliability of each sighting. Identification was ranked as follows: Certain, Near Certain, Probable or Possible.

Where possible Mlingwa *et al.* (2000) and Stuart (1989) were used to determine ecological type and Stattersfield *et al.* (1998) used to define endemic status. When this was not possible, ecological type, endemic and threat status' were compiled using the National Biodiversity Database (UDSM, 1997), IUCN (Hamilton, 2001), CITES (2001) and Zimmerman *et al.* (1996).

Of most interest was the probable sighting of *Emberiza cabanisi* (Cabanis's bunting), a forest dependent endemic to the Usambara mountains (Tables 27 and 29).

Table 27 Summary of birds observed opportunistically in Mlinga FR.

Species	Common name	Ecol. type	End. status	IUCN 2000	UDSM 1997	CITES 2001	Identification confidence
ACCIPITRIDAE							
Aquila rapax	Tawny Eagle	f	W			II	Probable
Gypohierax angolensis	Palm-nut Vulture	f	W		LR	II	Certain
Lophaetus occipitalis	Long-crested Eagle	**f**	W		LR	II	Certain
Terathopius ecaudatus	Bateleur	f	W		LR	II	Certain
ALCEDINIDAE							
Halcyon albiventris	Brown-hooded Kingfisher	f	W				Certain
Alcedo semitorquata	Half-collared Kingfisher	FF	N				Possible
BUCEROTIDAE							
Bycanistes brevis	Silvery Cheeked Hornbill	**F**2	W				Probable
Bycanistes bucinator	Trumpeter Hornbill	**F**2	W				Certain
Tokus alboterminatus	Crowned Hornbill	F1	W				Certain
COLUMBIDAE							
Treron calva	African Green Pigeon	**F**	W				Probable
Turtur tympanistria	Tambourine Dove	**F**	W				Certain
CORACIIDAE							
Eurystomus glaucurus	Broad-billed Roller	**f**	W				Certain
CORVIDAE							
Corvus albicollis	White-naped Raven	f	W				Near Certain
CUCULIDAE							
Centropus superciliosus	White-browed Coucal	f	W				Certain
Ceuthmochares aereus	Yellowbill	**F**2	W				Certain
CAPITONIDAE							
Stactolaema leucotis	White-eared Barbet	**F**1	W				Certain
DICRURIDAE							
Dicrurus adsimilis	Common Drongo	f	W				Certain
Dicrurus ludwigii	Square-tailed Drongo	**F**3	W				Certain
EMBERIZIDAE							
Emberiza cabanisi	Cabanis's Bunting	F	E				Probable
ESTRILDIDAE							
**Cryptospiza reichenovii*	Red-faced Crimsonwing	F2	W				Certain
**Estrilda astrild*	Common Waxbill	f	W				Certain
Hypargos niveoguttatus	Peter's Twinspot	**F**1	W				Possible
Lonchura bicolor	Black and White Mannikin	**f**	W				Probable
**Mandingoa nitidula*	Green-backed Twinspot	**FF**2	W				Certain
Spermophaga ruficapilla	Red-headed Bluebill	F3	W				Probable

Table 27 continued.

Species	Common name	Ecol. type	End. status	IUCN 2000	UDSM 1997	CITES 2001	Identification confidence
HIRUNDINIDAE							
Psalidoprocne holomelas	Rough-wing	f	W				Certain
MALACONOTIDAE							
Tchagra minuta	Marsh Tchagra	f	W				Possible
MONARCHIDAE							
Erythrocercus holochlorus	Little Yellow Flycatcher	**FF**3	N				Probable
Terpsiphone viridis	African Paradise Flycatcher	f1	W				Certain
MUSOPHAGIDAE							
Tauraco fischeri	Fischer's Turaco	**F**2	N*	LR/NT	NT	II	Certain
Tauraco hartlaubi	Hartlaub's Turaco	f	W		NT	II	Possible
NUMIDIDAE							
Numida meleagris	Helmeted Guineafowl	f	W				Certain
ORIOLIDAE							
Oriolus chlorocephalus	Green-headed Oriole	F2	N				Probable
Oriolus larvatus	Black-headed Oriole	f	W				
PLATYSTEIRIDAE							
Batis mixta	Forest Batis	**FF**3	W		NT		Probable
PLOCEIDAE							
Euplectes hordeaceus	Black-winged Red Bishop	f	W				Probable
Ploceus bicolor	Dark-backed Weaver	F3	W				Possible
Ploceus subaureus	African Golden Weaver	f	W				Probable
PYCNONOTIDAE							
Pycnonotus barbatus	Common Bulbul	f	W				Certain
STRIGIDAE							
Bubo vosseleri	Usambara Eagle Owl	**FF**3	N*	VU	VU	II	Probable
STURNIDAE							
Lamprotornis corruscus	Black-bellied Starling	**F**2	W				Probable
Cinnyricinclus leucogaster	Violet-backed Starling	**f**	W				Certain?
TIMALIIDAE							
Turdoides jardineii	Arrow-marked Babbler	F	W				Possible
TURDIDAE							
Cossypha natalensis	Red-capped Robin-chat	**F**1	W				Certain
Swynnertonia swynnertoni	Swynnerton's Robin	**FF**	N*	VU	VU		Near Certain
UPUPIDAE							
Phoeniculus purpureus	Green Wood-hoopoe	F	W				Certain
Rhinopomastus cyanomelas	Common Scimitarbill	f	W				Certain

*****Endemic status determined using Stattersfield *et al* (1998)
Bold text Ecological type determined using Mlingwa *et al*. (2000)

KEY TO ABBREVIATIONS FOR TABLE 27

Forest dependence Mlingwa *et al.* (2000):
Forest specialist (FF): Species that are typical of forest interior and likely to disappear when the forest is modified to any extent.
Forest generalist (F): Species that can occur in undisturbed forest but which are able to exist (and may even be numerous) at the forest edge or in modified/ fragmented forests. However, these generalists continue to depend upon forests for some of their resources, such as nesting sites.
Non-forest birds (f): Forest visitors

Key to abbreviations for Table 27 continues on the next page.

KEY TO ABBREVIATIONS FOR TABLE 27 continued.

Forest dependence Stuart (1989) categories:
1. those which live in forest but are not dependent upon it for their survival
2. those which live in forest and 'overspill' into adjacent habitats, but are dependent upon forest for their survival
3. those that can only survive in forest and hardly 'overspill' into adjacent habitats.

Endemic (End.) status:
E – Endemic: Species only found in the Usambara mountains.
N – Near-endemic: Species with limited ranges usually only including coastal forest and/or E. African lowland forests.
W - Widely distributed species

IUCN status:
EN - Endangered
VU - Vulnerable
LR/NT - Low Risk/Near Threatened
DD - Data Deficient

CITES listings:
I – Appendix One listed species
II – Appendix Two listed species
(Appendix Three not included in Table)

Twenty-two species of bird (46%) recorded in Mlinga FR were non-forest species (Mlingwa *et al*, 2000), with 20 species (42%) forest generalists, and 6 species (12%) forest specialists. Forest specialists are summarised in Table 28.

Table 28 Summary of forest specialist birds with corresponding threat status categories.

Species name	Common name	Ecol. type	End. status	IUCN 2000	UDSM 1997	CITES 2001
Alcedo semitorquata	Half-collared Kingfisher	FF	N			
Batis mixta	Forest Batis	**FF**3	W		NT	
Bubo vosseleri	Usambara Eagle Owl	**FF**3	N*	VU	VU	II
Erythrocercus holochlorus	Little Yellow Flycatcher	**FF**	N			
Mandingoa nitidula	Green-backed Twinspot	**FF**	W			
Swynnertonia swynnertoni	Swynnerton's Robin	FF	N*	VU	VU	

*****Endemic status determined using Stattersfield *et al.* (1998)

Seven bird species observed in Mlinga FR were of restricted range and are summarised in Table 29.

Table 29 Restricted ranges of endemic and near-endemic birds.

Species name	Common name	Range
Bubo vosseleri	Usambara Eagle Owl	East and West Usambara Mountains and Uluguru Mountains
Tauraco fischeri	Fischer's Turaco	East and West Usambara Mountains and East African Coastal forests
Swynnertonia swynnertoni	Swynnerton's Robin	Usambara and Udzungwa Mountains, also Zimbabwe and Mozambique
Oriolus chlorocephalus	Green-headed Oriole	Some coastal Kenyan forests and East and West Usambara Mountains
Erythrocercus holochlorus	Little Yellow Flycatcher	Coastal lowland north to Boni Forest and East Usambara Mountains.
Emberiza cabanisi	Cabanis's Bunting	East and West Usambara Mountains, also found south of area.
Alcedo semitorquata	Half-collared Kingfisher	Mt Kilimanjaro and East Usambaras.

Primary source: Stattersfield *et al.* (1998), secondary source: UDSM (1997), tertiary source: Zimmerman *et al.* (1996).

5.4.3 Reptiles

Twenty-five reptile species were recorded within Mlinga FR. Twenty-three individuals representing 18 species and 6 families were captured during 1320 pitfall trapping nights and opportunistic collection. These species are summarised in Table 30. All individuals were taken as specimens for taxonomic purposes. Identifications have been verified by D.G. Broadley (Appendix 1).

Table 30 Summary of reptile pitfall and opportunistic captures in Mlinga FR.

Family	Common Name	Ecol. type	End. status	IUCN 2000	UDSM 1997	CITES 2001	No.of individuals captured
AGAMIDAE							
Agama montana	Montane Rock Agama	F	N		VU		1
CHAMAELEONIDAE							
Chamaeleo fischeri*	Eastern Usambara Two-horned Chameleon	F	N		VU	II	1
Chamaeleo tenue*	Usambara Soft-horned Chameleon	F	N		VU	II	1
Chamaeleo dilepis	Common Flap-necked Chameleon	f	W			II	1
COLUBRIDAE							
Dasypeltis medici	East African Egg-eater	f	W				2
Lamprophis capensis	Common House Snake	f	W				2
Lamprophis fuliginosus	Brown House Snake	O	W				2
Buhoma vauerocegae	Usambara Forest Snake	F	N		VU		1
Aparallactus werneri	Usambara Centipede Eater	F	N				1
Philothamnus macrops	Usambara Green Snake	f	W		VU		1
Crotaphopeltis hotambeia	Herald Snake	O	W				2
Crotaphopeltis tornieri	Tornier's Cat-Snake	F	W		VU		1
Thelotornis usambaricus	Usambara Vine Snake	?	?				2
CORDYLIDAE							
Cordylus tropidosternum	E.African Spiny-tailed Lizard	f	W			II	1
GEKKONIDAE							
Hemidactylus mabouia	Tropical House Gecko	f	W				1
SCINCIDAE							
Mabuya maculilabris	Speckle-lipped Skink	f	W				1
Lygosoma afrum	Peter's Writhing Skink	f	W				1
Leptosiaphos kilimensis	Kilimanjaro Five-toed Skink	F	N		VU		1
TOTAL							**23**

*Formally *Bradypodium*

KEY TO ABBREVIATIONS FOR TABLE 30

Ecological (Ecol.) type:
- F – Forest dependent species: Species confined to primary forest only; not including forest edge or secondary forest.
- f – Forest dwelling but not forest dependent species: Species occurring in primary forest, forest edge or secondary forest.
- O – Non-forest species: Species that do not occur in primary or secondary forest or forest edge.

Endemic (End.) status:
- E – Endemic: Species only found in the Usambara mountains.
- N – Near-endemic: Species with limited ranges usually only including coastal forest and/or East African lowland forests.
- W – Widely distributed species.

IUCN status:
- EN – Endangered
- VU – Vulnerable
- LR/NT – Lower Risk/Near Threatened
- DD – Data Deficient

CITES listings:
- I – Appendix One listed species
- II – Appendix Two listed species

(Appendix Three species not included in Table)

Ecological type, endemic status and threat status were compiled from the National Biodiversity Database (UDSM, 1997), IUCN (Hilton-Taylor, 2000) and Spawls *et al.* (2002).

Fifty percent of all individuals were captured opportunistically (Appendix 9). Seven species captured were categorised as forest dependent, 6 near-endemic, 7 listed as vulnerable (UDSM, 1997) and 4 listed on Appendix II of CITES (CITES, 2001).

Seven additional species were recorded in Mlinga FR as observations (Table 31). An 'identification confidence' column has been presented in Table 31 to clarify the reliability of each sighting. Identification was ranked as follows: Certain, Near Certain, Probable or Possible.

Table 31 Summary of reptile observations in Mlinga FR.

Species	Common Name	Ecol. type	End. status	IUCN 2000	UDSM 1997	CITES 2001	Identification confidence
CHAMAELEONIDAE							
Chamaeleo deremensis	Usambara 3-horned Chameleon	F	N	EN	EN	II	Certain
Rhampholeon brevicaudatus	Bearded Pigmy Chameleon	F	N	VU	LR		Certain
COLUBRIDAE							
Psammophis sudanensis	Northern Stripe-bellied Sand Snake	O	W				Probable
ELAPSOIDEA							
Elapsoidea sp.	Garter Snake	O	W				Probable
TESTUDINIDAE							
Kinixyz belliana	Bell's Hinged Tortoise	O	W				Near Certain
VIPERIDAE							
Bitis gabonica	Gaboon Viper	f	W				Certain
ELAPIDAE							
Naja melanoleuca	Forest Cobra	O	W				Certain

KEY TO ABBREVIATIONS FOR TABLE 31

Ecological (Ecol.) type:
F – Forest dependent species: Species confined to primary forest only; not including forest edge or secondary forest.
f – Forest dwelling but not forest dependent species: Species occurring in primary forest, forest edge or secondary forest.
O – Non-forest species: Species that do not occur in primary or secondary forest or forest edge.

Endemic (End.) status:
E – Endemic: Species only found in the Usambara mountains.
N – Near-endemic: Species with limited ranges usually only including coastal forest and/or East African lowland forests.
W – Widely distributed species.

IUCN status:
EN – Endangered
VU – Vulnerable
LR/NT – Lower Risk/Near Threatened
DD – Data Deficient

CITES listings:
I – Appendix One listed species
II – Appendix Two listed species
(Appendix Three species not included in Table)

An additional 2 forest dependent and 2 near-endemic reptile species were recorded through observation. Two chameleon species, *Chamaeleo deremensis* and *Rhampholeon brevicaudatus* are listed as endangered and vulnerable respectively (IUCN, 2000).

Of all captured and observed reptiles within Mlinga FR, a total of 9 have restricted ranges (Table 32).

Table 32 Restricted ranges of endemic and near-endemic reptiles, UDSM (1997).

Species name	Common name	Range
Chamaeleo deremensis	Usambara 3-horned Chameleon	Usambara and Nguru Mountains.
Agama montana	Montane Rock Agama	Usambara, Uluguru and Nguru Mountains.
Chamaeleo fischeri	East Usambara 2-horned Chameleon	Usambara and Nguru Mountains.
Chamaeleo tenue	Usambara Soft-horned Chameleon	Usambara Mountains and Shimba Hills (Kenya).
Rhampholeon brevicaudatus	Bearded Pigmy Chameleon	Forests of coastal Tanzania and Usambara Mountains.
Leptosiaphos kilimensis	Kilimanjaro 5-toed Skink	Montane forests of Kenya and Northern Tanzania.
Buhoma vauerocegae*	Usambara Forest Snake	(East) Usambara Mountains, Magrotto and Uluguru Mountains.
Aparallactus werneri	Usambara Centipede Eater	Usambara and Uluguru Mountains.
Philothamnus macrops	Usambara Green Snake	Usambara; Uluguru, Uzungwa Mountains and south to Misuku Mountains.

*formally *Geodipsas*

5.4.4 Amphibians

A total of 944 amphibians were captured during 1320 pitfall trapping nights. An additional 25 individuals were captured opportunistically. These individuals represented at least 19 species and 7 families (Table 33). Thirty-seven individuals were retained for taxonomic purposes. A summary of trapping data is presented in Appendix 10. Ecological type, endemic status and IUCN status were compiled from the National Biodiversity Database (UDSM, 1997), IUCN (Hilton-Taylor, 2000) and Poynton & Broadley (1991). J. Poynton (Appendix 1) has verified specimen identifications. Common names are taken from Passmore and Carruthers (1995).

Table 33 Summary of pitfall and opportunistic amphibian captures in Mlinga FR.

Species	Common name	Ecol. type	End. status	IUCN 2000	UDSM 1997	CITES 2001	No. of individuals captured
ARTHROLEPTIDAE							
Arthroleptis stenodactylus	Squeaker	f	W				59
Arthroleptis xenodactyloides	Squeaker	f	W				783
Arthroleptis sp. (cf. *xenodactylus*)*	Squeaker	(F)	(N)		(VU)		(98)
BUFONIDAE							
Bufo maculatus	Flat backed Toad	O	W				1
Nectophrynoides tornieri		F	N		VU	I	2
Mertensophryne micranotis		?	N		EN		2
Schismaderma carens		?	W				3
HYPEROLIIDAE							
Afrixalus sp.	Leaf-folding Frog	?	?				1
Afrixalus ulugurensis	Leaf-folding Frog	F	N		VU		1
Hyperolius tuberilinguis	Reed Frog	O	W				1
Leptopelis barbouri	Tree Frog	F	W				1
Leptopelis flavomaculatus	Tree Frog	F	W				1
Leptopelis parkeri	Tree Frog	F	N		VU		1
Leptopelis ulugurensis	Tree Frog	F	N		VU		1
MICROHYLIDAE							
Callulina kreffti		F	N		VU		1
Probreviceps macrodactylus	Rain Frog	F	N		NT		3
RHACOPHORIDAE							
Chiromantis xerampelina	Foam-nest Frog	O	W				1
RANIDAE							
Arthroleptides martiensseni		F	N		VU		3
Phrynobatrachus krefftii	Puddle Frog	F	N		VU		5
Phrynobatrachus acridoides	Puddle Frog	O	W				1
TOTAL							**969**

KEY TO ABBREVIATIONS FOR TABLE 33 and 34

Ecological (Ecol.) type:

F – Forest dependent species: Species confined to primary forest only; not including forest edge or secondary forest.
f – Forest dwelling but not forest dependent species: Species occurring in primary forest, forest edge or secondary forest.
O – Non-forest species: Species that do not occur in primary or secondary forest or forest edge.

Endemic (End.) status:

E – Endemic: Species only found in the Usambara mountains.
N – Near-endemic: Species with limited ranges usually only including coastal forest and/or East African lowland forests.
W – Widely distributed species.

KEY TO ABBREVIATIONS FOR TABLE 33 and 34 continued.

IUCN status:
EN – Endangered
VU – Vulnerable
LR/NT – Lower Risk/Near Threatened
DD – Data Deficient

CITES listings:
I – Appendix One listed species
II – Appendix Two listed species
(Appendix Three species not included in Table)

* Questionable field identification as *Arthroleptis xenodactylus*, potentially *A. xenodactyloides*.

The only commonly captured genus in pitfall traps was *Arthroleptis*, the Squeakers that dwell in leaf litter (Table 33). Individuals in this genus were particularly difficult to identify to species level therefore particular care must be taken with the field identifications shown in Table 33 as *Arthroleptis* sp. (cf. *xenodactylus*). J. Poynton did not identify any of the voucher specimens as *A. xenodactylus*.

The most interesting amphibian record was that of *Schismaderma carens* (Bufonidae). This record is thought to be a range extension, and represent the northern most record of this species (pers. comm. J. Poynton, 2002).

In addition to pitfall trap and opportunistic captures, two further species were observed casually but not retained (Table 34).

Table 34 Amphibians observed casually in Mlinga FR.

Species	Common name	Ecol. type	End. status	IUCN 2000	UDSM 1997	CITES 2001	Certainty of identification
RANIDAE							
Rana angolensis	Common River Frog	O	W				Certain
CAECILIDAE							
Boulengerula boulengeri	Caecilian	F	N			I	Certain

A significant number of amphibians within Mlinga FR were either forest dependent, near-endemic or both. Eleven (52.4% of all amphibian species captured and observed) were forest dependent, and 10 (47.6%) classified as near-endemic. Seven species (33.3%) were vulnerable and one, *Mertensophryne micranotis* (Bufonidae) endangered (IUCN, 2000). The caecilian *Boulengerula boulengeri* was listed on Appendix I of CITES (CITES, 2001) (Tables 32, 33 and 34). Eleven amphibian species have restricted ranges (UDSM, 1997) (Table 35).

Table 35 Restricted ranges for endemic and near-endemic amphibians (UDSM, 1997).

Species	Common name	Range
Phrynobatrachus krefftii	Puddle Frog	Usambara and Magrotto Mountains.
Boulengerula boulengeri	Caecilian	Usambara and Magrotto Mountains, and possibly Nguru Mountains.
Arthroleptis xenodactylus	Squeaker	Usambara, Nguru and Uluguru Mountains.
Nectophrynoides tornieri		East Usambara, Uluguru, Nguru and Udzungwa Mountains.
Mertensophryne micranotis		
Afrixalus ulugurensis	Leaf-folding Frog	Usambara, Magrotto, Uluguru, Nguru and Udzungwa Mountains.
Leptopelis parkeri	Tree Frog	Usambara and Uluguru Mountains.
Leptopelis ulugurensis	Tree Frog	Usambara, Uluguru, Nguru and Udzungwa Mountains.
Callulina kreffti		Usambara, Magarotto, Nguru, Uluguru and Udzungwa Mountains.
Probreviceps macrodactylus	Rain Frog	Usambara, Uluguru and Rungwa, Udzungwa Mountains.
Arthroleptides martiensseni		Usambara, Magarotto, Uluguru, Nguru and Udzungwa Mountains.

5.4.5 Invertebrates

5.4.5.1 Butterflies

At least 103 species of butterfly were captured in Mlinga FR, using sweepnets and canopy traps. These species represented 5 families (Table 36). One hundred and fifty four specimens were retained for taxonomic purposes. Official verification of taxonomic identifications has yet to be obtained. Ecological type and endemic status were compiled using Larsen (1996), and Kielland (1990).

The butterfly species list for Mlinga FR is presented to subspecies level in Table 36. This table also indicates whether butterflies have previously been recorded in the East Usambara mountains. Capture data is summarised in Appendix 11.

Eighty seven percent of all butterfly species captured in Mlinga FR were widespread in distribution with only two species of near-endemic status. Thirty four percent of butterfly species were forest dependent, 26% forest dwelling, 30% non-forest species, and 12% unknown. If identifications are accurate (to be confirmed) at least five species records represent range extensions and eight represent those of uncommon, localised or rare species (Table 36).

Table 36 Summary of butterflies captured in Mlinga FR.

Species	Ecol. type	End. status	Other information	Existing EU Record (Y / N)
HESPERIIDAE				
Pardaleodes incerta	F	W		Y
Sarangesa maculata	F	W		N
Tagiades flesus	f	W		Y
Teniorhinus herilus	f	W	Not common.	N
LYCAENIDAE				
Unknown sp.	?	?		?
Alaena picata	f	W		Y
Axiocerses punicea	f	W	Not common in Usambaras	N
Azanus moriqua	O	W		N
Eicochrysops hippocrates	f	W		Y
Eicochrysops masai	O	W	Localised, mountains escarpments	N
Lampides boeticus	O	W		N
Leptotes pirithous	O	W		Y
Pentila tropicalis	F	W		Y
Pilodeudorix rodgersi	f	W		N
Teriominia subpunctata	F	W		Y
Tuxentius margaritaceus	F	W		N
NYMPHALIDAE				
Acraea sp.	?	?		?
Acraea acara	O	W		N
Acraea acrita	O	W		N
Acraea aganice montana	O	W		N
Acraea alcinoe camerunica	F	W	Rare	N
Acraea boopis ama	F	W	Isolated populations, dry forest	N
Acraea cerasa cerasa	F	W	Rare in Tanzania	Y
Acraea egina egina	O	W		Y
Acraea eponina eponina	F	W		Y
Acraea macaria hemileuca	O	W		N
Acraea natalica natalica	O	W		Y
Acraea quirina rosa	F	W		Y

Table 36 continued.

Species	Ecol. type	End. status	Other information	Existing EU Record (Y / N)
NYMPHALIDAE continued.				
Acraea satis	F	W		Y
Acraea servona kenya	F	W	Usambara mountains	Y
Acraea uvui uvui	?	W		N
Amauris sp.	?	?		?
Amauris niavius dominicanus	F	W		Y
Amauris niavius niavius	F	W		Y
Apaturopsis cleochares schulzei	f	W	Very local and uncommon	Y
Bicyclus auricrudus fulgidus	F	W		N
Bicyclus campinus carcassoni	F	W		Y
Bicyclus campinus ocelligerus	F	W		Y
Bicyclus safitza safitza	O	W		Y
Bicyclus sp.	?	?		?
Byblia sp.	?	?		?
Byblia ilithyia	O	W		Y
Charaxes sp. 1	?	?		?
Charaxes sp. 2	?	?		?
Charaxes bohemani	O	W		N
Charaxes brutus natalensis	f	W		Y
Charaxes candiope candiope	f	W		Y
Charaxes castor castor	O	W		Y
Charaxes chepalungu	F	W	Kenya and Serengeti only	N
Charaxes cithaeron nairobicus	F	W		Y
Charaxes contrarius	F	W		Y
Charaxes jahlusa kenyensis	f	W	Uncommon, local race	Y
Charaxes lasti kimbozae	F	W		Y
Charaxes lasti lasti	f	N		Y
Charaxes pollux mirabilis	?	?		Y
Charaxes protoclea azota	f	W		Y
Charaxes smaragdalis homonymus	F	W		N
Charaxes varanes vologese	f	W		Y
Charaxes violetta	O	W		Y
Charaxes violetta maritimus	O	W		Y
Charaxes xiphares	F	W	Montane and sub-montane forests	Y
Charaxes zoolina zoolina	O	W		Y
Danaus chrysippus/dorippus	O	W		Y
Euphaedra neophron littoralis	F	W		Y
Euptera kinugnana	F	W		Y
Euryphura achlys	F	N		Y
Eurytela sp.	?	?		?
Eurytela dryope angulata	f	W		Y
Eurytela hiarbas lita	O	W		Y
Euxanthe wakefieldi	F	W	Lowland forest	Y
Gnophodes betsimena diversa	F	W		Y
Henotesia perspicua	O	W		N
Henotesia phaea phaea	O	W		N
Hypolimnas anthedon anthedon	F	W		Y
Junonia oenone oenone	O	W		Y
Junonia terea elgiva	f	W		Y
Melantis leda leda	O	W		Y
Neptidopsis fulgurata platyptera	f	W		N
Neptidopsis ophione velleda	F	W		Y

Table 36 continued.

Species	Ecol. type	End. status	Other information	Existing EU Record (Y / N)
Neptis sp.	?	?		?
Neptis carcassoni	F	W	Lowland forest	Y
Neptis jordani	O	W		N
Neptis laeta	O	W		Y
Neptis melicerta	f	W		Y
Neptis penningtoni	O	W	West Tanzania	N
Neptis rogersi	O	W	Coastal Kenya and Tanzania	N
Neptis saclava marpessa	f	W		Y
Neptis serena serena	O	W		Y
Neptis trigonophora trigonophora	F	W	East Usambaras	N
Phalanta eurytis eurytis	F	W		N
Physcaeneura leda	O	W	Coastal N.E. Tanzania and Kenya	Y
Pseudacraea lucretia protracta	F	W		Y
Pseudathyma plutonica plutonica	F	W	West Tanzania	N
Sallya boisduvali omissa	f	W		Y
Sallya garega garega	f	W	West Tanzania	N
Sallya natalensis	f	W		Y
PAPILIONIDAE				
Catopsilia florella	O	W		Y
Papilio ophidicephalus	f	W		Y
Papilio dardanus polytrophus	f	W		Y
PIERIDAE				
Appias lasti lasti	f	W	Coastal and Masagati	Y
Belenois creona severina	O	W		Y
Belenois thysa thysa	f	W		Y
Colotis sp.	?	?		?
Colotis euippe omphale	O	W		Y
Dixeia charina	?	?		N
Eronia cleodora	O	W		N
Eurema floricola orientis	F	W		Y
Eurema hapale	O	W		Y
Eurema regularis regularis	f	W		Y
Eurema senegalensis	F	W		Y
Leptosia alcesta inalcesta	f	W		Y
Nepheronia argia argia	f	W		Y
Nepheronia thalassina	f	W		Y

Existing EU record: Yes (Y) or No (N). This column only considers specimens to species level.

KEY TO ABBREVIATIONS FOR TABLE 36

Ecological (Ecol.) type:
- F – Forest dependent species: Species confined to primary forest only; not including forest edge or secondary forest.
- f – Forest dwelling but not forest dependent species: Species occurring in primary forest, forest edge or secondary forest.
- O – Non-forest species: Species that do not occur in primary or secondary forest or forest edge.

Endemic (End.) status:
- E – Endemic: Species only found in the Usambara Mountains.
- N – Near-endemic: Species with limited ranges usually only including coastal forest and/or East African lowland forests.
- W – Widely distributed species.

5.4.5.2 Molluscs

A total of 297 molluscs were collected in zoological trapsites and opportunistically. Taxonomic determinations were not available at the time of publication. Specimens were deposited at the Zoological Museum of Copenhagen (refer to Appendix 1).

5.4.5.3 Millipedes

A total of 161 millipedes were collected in zoological trapsites and opportunistically. Taxonomic determinations were not available at the time of publication. Specimens were deposited at the Zoological Museum of Copenhagen (refer to Appendix 1).

5.4.6 Distribution of endemic and forest dependent species

Almost all endemic, near-endemic and forest dependent fauna were captured or observed outside the 12 most disturbed areas (Figure 24). Fire was the most significant form of disturbance in Mlinga FR and it is likely that fire poses the greatest threat to endemic and forest dependant fauna within the reserve.

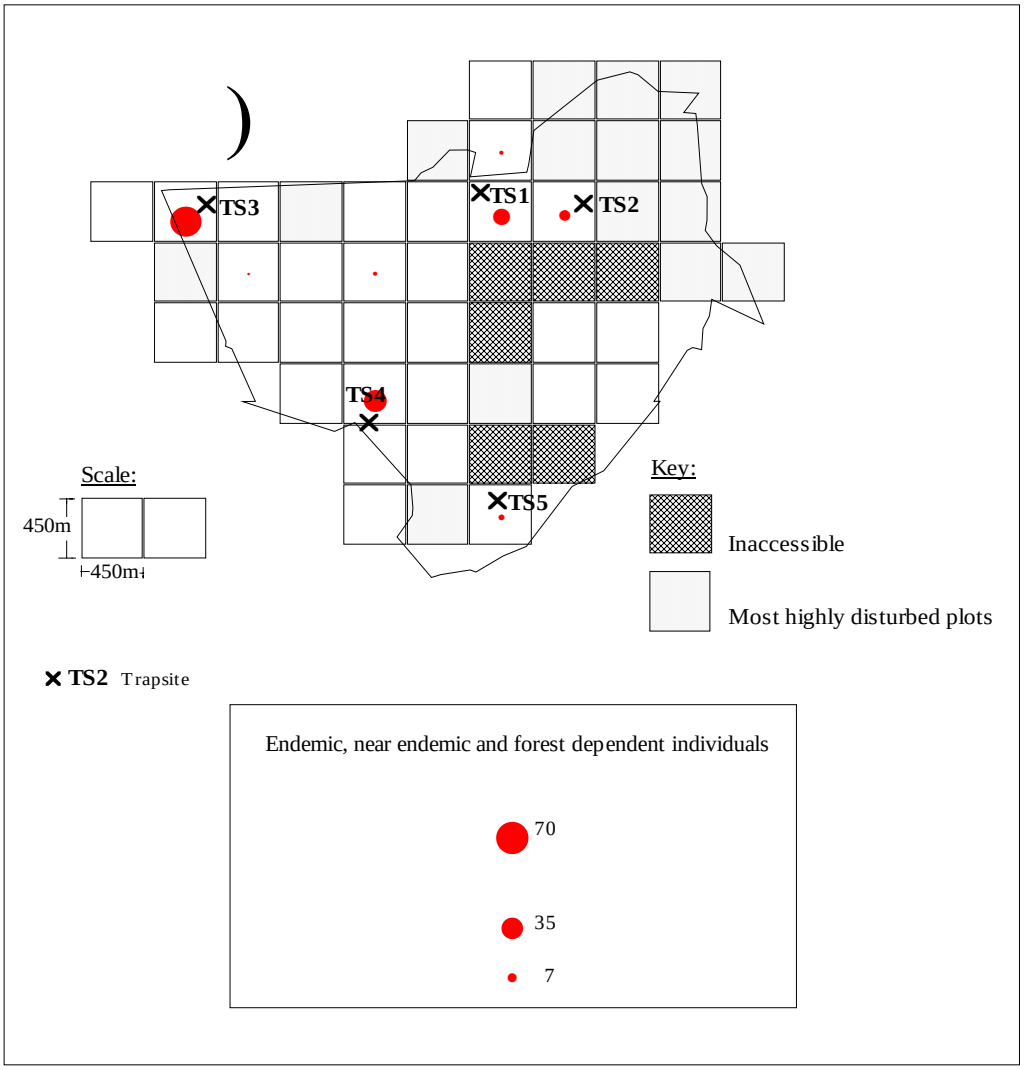

Figure 24 Distribution of endemic, near-endemic and forest dependent fauna in comparison with the 12 most disturbed areas in Mlinga FR.

The most endemic and near-endemic species found during the four 10 day trapsites were at trapsite 4, in submontane habitat (Figure 25).

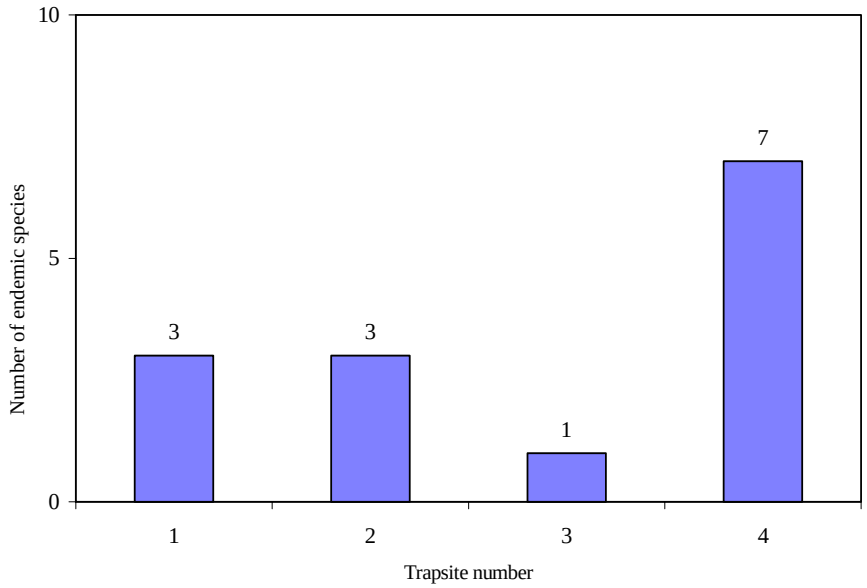

Figure 25 Distribution of endemic or near-endemic species found at trapsites 1-4.

Trapsite 1 (dominated by lowland riverine forest and cultivation habitat) supported the largest number of forest dependent species (Figure 26). Trapsite 2 (tall canopy lowland forest) supported least forest dependent species (Figure 26). The majority of forest dependent species at trapsite 1 were butterflies.

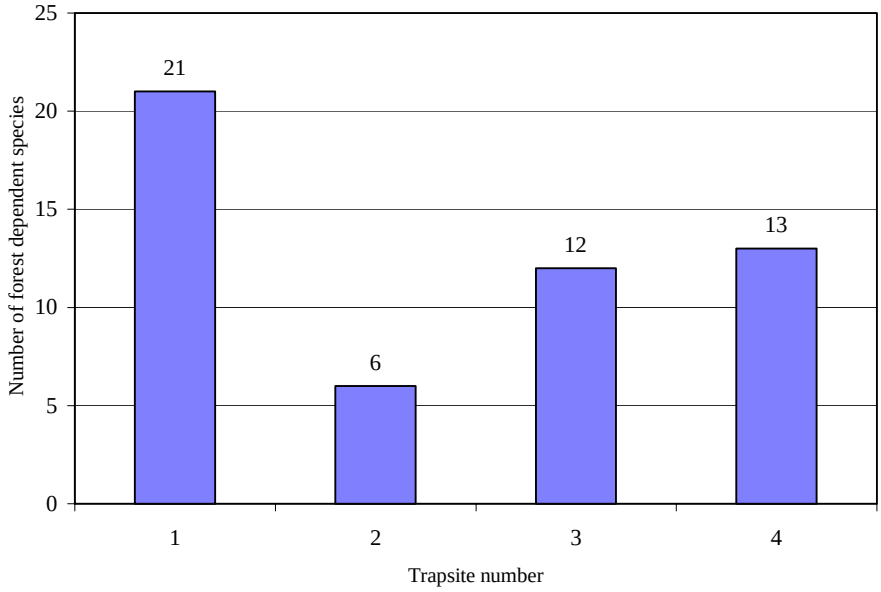

Figure 26 Distribution of forest dependant species found at trapsites 1-4.

5.4 Discussion

5.5.1 Introduction

Mlinga FR is only 890ha but, despite its small size, the number of animal species recorded was comparable to those found in nearby forest reserves, such as Manga (size 1616ha) and Magarotto FR (size 1124ha) (refer to Frontier Tanzania, 1999 and Frontier Tanzania, 1996).

Table 37 Summary of faunal families and species (identified to date) and inclusive of casual observations, dung surveys etc.

Taxon	Number of families	Number of species
Mammals (not including bats)	12	23
Bats	5	9
Birds	25	47
Reptiles	10	25
Amphibians	8	21
Butterflies	5	125

5.5.2 Species Abundance and Importance

To provide a concept of species abundance, the frequency of species-capture was investigated. This makes the assumption that the frequency with which an animal is recorded reflects its general abundance. However, it must be noted that the abundance of highly cryptic species may not be reflected accurately. Also, this method does not provide a good measure of species distribution within the reserve.

5.5.2.1 Mammals

The most commonly captured mammal species was the forest dependent, near-endemic *Beamys hindei* (Lesser pouched Rat, 30 individuals captured), also listed as vulnerable by IUCN (2000). Other locally common captures included *Praomys delectorum* (Soft-furred Rat, 26 individuals captured) and *Lophuromys flavopunctatus* (Brush-furred Rat, 17 individuals captured). Almost all of these captures took place at trapsite 4 in submontane forest. Lowland forest trapsites had less successful trapping success, particularly trapsites 2 and 3 with no water association.

Other species recorded more than three times were *Crocidura* species (White-toothed shrews), *Acomys* species (Spiny mice) and *Grammomys* species (Narrow-footed woodland mice, although as identifications have not yet been verified, it cannot be determined whether these represent one or more species.

Of the larger mammals, the most commonly encountered was *Cercopithecus (n.) mitis* (Gentle/Blue Monkey) sighted on at least 6 separate occasions in forested areas. *Papio cynocephalus* (Yellow Baboon) sightings were also common near the forest borders. *Colobus angolensis palliatus* (Angola Pied Colobus) were observed and heard a number of times, although it is unclear how many groups of individuals this may represent as the majority of observations were taken close to trapsite 2 in one forest patch. Potentially isolated populations such as these are locally vulnerable (Kingdon, 1997).

Frequent aural records of *Dendrohryax validus* (Eastern Tree Hyrax), *Otolemur crassicaudatus* (Greater Galago) and *Galagoides zanzibaricus* (Zanzibar Galago) were heard during the survey suggesting that they are locally common throughout Mlinga FR.

Species recorded indirectly through spoor on many occasions were *Thryonomys gregorianus* (Cane Rat) and *Cephalophus* sp. (Duiker sp.), however it is difficult to establish how abundant such species are without further study.

The most commonly captured bat species in all trapping locations except trapsite 3, where no bats were caught was *Hipposideros caffer* (Leaf-nosed Bat represented by 9 individuals). This species has relatively unspecific habitat preferences and is widespread in distribution. It is assumed therefore that this species is common throughout Mlinga FR. However, fruitbats (*Lissonycteris angolensis* and *Myonycteris relicta*) were only captured in submontane habitats at trapsite 4 and represented by few individuals (4 and 1 respectively). These species are likely to be locally threatened due to the limited amount of suitable forest habitat remaining in Mlinga FR, particularly *Myonycteris relicta* listed as vulnerable to extinction by UDSM (1997).

5.5.2.2 Birds

Bird species observed frequently, on more than three occasions, throughout the reserve by visual observation during the survey included; *Lophaetus occipitalis* (Long-crested eagle), *Terathopius ecaudatus* (Bateleur), *Gypohierax angolensis* (Palm-nut vulture), *Tokus alboterminatus* (Crowned Hornbill), *Bycanistes bucinator* (Trumpeter Hornbill), *Mandingoa nitidula* (Green-backed Twinspot), *Tauraco fischeri* (Fischer's Turaco) and *Numida meleagris* (Helmeted Guineafowl). Of these, *Mandingoa nitidula* (Green-backed Twinspot) is a forest specialist and *Tauraco fischeri* (Fisher's Turaco) has a restricted range to the East and West Usambara mountains and East African coastal forests.

5.5.2.3 Reptiles

No reptiles were captured in abundance; however, there were certain areas, for example trapsite 1, where *Mabuya maculilabris* (Speckle-lipped Skink) and *Agama montana* (Montane Rock Agama) individuals were frequently observed in open habitats. A significant proportion (27 %) of reptile records were forest dependent and near-endemic, and listed as vulnerable or endangered by UDSM (1997). The endangered *Chamaeleo deremensis* (Usambara 3-horned Chameleon) was observed only once during the survey near to trapsite 4 in submontane forest.

5.5.2.4 Amphibians

By far the most abundant amphibian genus was *Arthroleptis* (Squeakers) with 940 individuals captured. It is questionable whether the near-endemic and forest dependent species of this genus (*A. xenodactylus*) was captured in Mlinga FR. Tree frogs (Hyperolidae) in particular were not commonly encountered throughout Mlinga FR.

The capture of three *Schismaderma carens* (Bufonidae) individuals in Mlinga FR represented a new amphibian species record for the East Usambara mountains (J. Poynton). Previously, this species had been recorded from Dodoma, Haubi Kondoa, Liwale, Marambangombe, Rukwa Hotel, Tendaguru and Sanjeri Pass (Passmore and Caruthers, 1995). Captures within Mlinga FR are therefore thought to represent the most northerly records of this species (J. Poynton, pers. comm.).

More than 50% of all amphibian records in Mlinga FR were forest dependent and near-endemic.

5.5.2.5 Invertebrates

The relative abundance of molluscs and millipedes was not determined as identifications are presently unavailable.

Ten species of butterfly were caught 10 or more times. They were as follows (the number of individuals captured are shown in brackets): *Bicyclus safitza safitza* (71), *Eurytela dryope angulata* (59), *Charaxes cithaeron nairobicus* (20), *Charaxes lasti lasti* (18), *Bicyclus campinus ocelligerus* (17), *Charaxes violetta maritimus* (17), *Euptera kinugnana* (14), *Sallya garega garega* (14), *Acraea aganice montana* (12), *Eurema floricola orientis* (10). All but *Eurema floricola orientis* were members of the Nymphalidae family.

Field identifications suggest that 32 (11%) of Mlinga FR's captured butterfly species have not previously been recorded in the East Usambara mountains previously (analyses based on Pohjonen, 2001).

5.5.2.6 Endemics and near-endemic species

Of the 30 mammal, bird, reptile and amphibian species recorded in Mlinga FR, which were endemic or near-endemic to the Usambara mountains, only the following were recorded frequently during the survey, *Beamys hindei* (Lesser pouched Rat) (30 individuals captured), *Dendrohyrax validus* (Eastern Tree Hyrax) (heard regularly throughout the forest reserve) and *Tauraco fischeri* (Fischer's Turaco) (recorded regularly throughout the forest reserve). Of these 31 endemic or near-endemic species, 11 were amphibians and 8 reptiles none of which were frequently encountered. Of the 2 near-endemic butterflies captured in Mlinga FR, only one *Charaxes lasti lasi* (Nymphalidae) was captured frequently (18 times).

5.5.2.7 Forest dependent species

Of the 35 mammal, bird, reptile and amphibian species which were dependant on primary or closed canopy forest, only the following were recorded frequently during this survey, *Beamys hindei* (Lesser pouched Rat), *Lophuromys flavopunctatus* (Brush-furred Rat) and *Tauraco fischeri* (Fischer's Turaco). Of these 35 forest dependent species, 12 were amphibians and 9 reptiles, none of which were frequently encountered.

Of the 35 (32%) forest dependant butterfly species, only four species were caught frequently during the survey. These were *Bicyclus campinus ocelligerus*, *Charaxes cithaeron nairobicus*, *Euptera kinugnana* (all of the family Nymphalidae) and *Eurema floricola orientis* (Pieridae).

5.5.2.8 High risk species

With the assumption that species observed rarely may have a low abundance, species of conservation concern in Mlinga FR can be determined. The species that were observed infrequently (on less than two occasions) and were both forest dependent and endemic or near-endemic were as follows:

Mammals: *Paraxerus lucifer* (Tanganyika mountain Squirrel).

Birds: *Alcedo semitorquata* (Half-collared Kingfisher), *Oriolus chlorocephalus* (Green-headed Oriole), *Bubo vosseleri* (Usambara Eagle-owl), *Swynnertonia swynnertoni* (Swynnerton's Robin).

Reptiles: *Chamaeleo fischeri* (Eastern Usambara Two Horned Chameleon), *Chamaeleo tenue* (Usambara Soft Horned Chameleon), *Chamaeleo deremensis* (Usambara Three Horned Chameleon), *Rhampholeon brevicaudatus* (Bearded Pigmy Chamaleon), *Buhoma vauerocegae* (Usambara Forest Snake), *Aparallactus werneri* (Usambara Centipede-eater), *Leptosiaphos kilimensis* (Kilimanjaro Five-toed Skink).

Amphibians: *Afrixalus ulugurensis* (Leaf-folding Frog), *Leptopelis ulugurensis* (Tree Frog), *Callulina kreffti*, *Probreviceps macrodactylus* (Rain Frog), *Boulengerula boulengeri* (Caecilian).

5.5.3 Ecological Type

A total of at least 228 faunal species were discovered in Mlinga FR. Of these, 72 species (31%) were classified as forest dependant or forest specialist (Table 38); 9 of these were mammals, 6 birds, 9 reptiles, 11 amphibians and 37 butterflies. A similar number of species were forest dwelling but not forest dependent, and non-forest species (Table 38). A total of 8 species (% of all faunal species) lacked information regarding ecological type (Table 38).

Table 38 Summary of ecological type of mammal, bird, reptile, amphibian and butterfly species.

Ecological type	No. of species	% of total species recorded
Forest dependent	72	31
Forest dwelling but not forest dependent	72	31
Non-forest species	76	33
Unknown	8	5
Total:	**228**	**100**

5.5.4 Endemic Status

Only 1 of the minimum 228 faunal species recorded in Mlinga FR were classified as endemic to the Usambara mountains (Table 39), this was the bird *Emberiza cabanisis* (Emberizidae). Thirty-one faunal species recorded (14%) were classified as near-endemic (Table 39). Of these 5 were mammals, 6 birds, 8 reptiles, 10 amphibians and 2 butterflies. The majority, 192 faunal species (84%) recorded in Mlinga FR had distributions classified as widespread, whilst 4 species (2%) lacked information regarding endemic status (Table 39).

Table 39 Summary of endemic status of mammal, bird, reptile, amphibian and butterfly species.

Endemic status	No. of species	% of total species recorded
Endemic to the Usambara Mountains	1	0
Near-endemic: ranges in restricted locations	31	14
Widespread	192	84
Unknown	4	2
Total:	**228**	**100**

5.5.5 Threat Status

5.5.5.1 National Biodiversity Database (NBD) of Tanzania

According to NBD (UDSM 1997) criteria, many species were categorised as endangered, vulnerable, near threatened or data deficient.

Three species from Mlinga FR were categorised as **Endangered** towards extinction by the NBD. These species were *Dendrohyrax validus* (Eastern Tree Hyrax), *Chamaeleo deremensis* (Usambara Three-horned Chameleon) and *Mertensophryne micranotis* [Amphibian].

Nineteen species from Mlinga FR were categorised as **Vulnerable** to extinction by the NBD. These species were *Myonycteris relicta* (Collared Fruit Bat), *Bubo vosseleri* (Usambara Eagle-owl), *Swynnertonia swynnertoni* (Swynnerton's Robin), *Agama montana* (Montane Rock Agama), *Chamaeleo fischeri* (E.Usambara Two-horned Chameleon), *Chamaeleo tenue* (Usambara Soft-horned Chameleon), *Buhoma vauerocegae* (Usambara Forest Snake), *Crotaphopeltis tornieri* (Tornier's Cat-snake), *Leptosiaphos kilimensis* (Kilimanjaro Five-toed

Skink), *Philothamnus macrops* (Usambara Green Snake), *Arthroleptis xenodactylus* (Squeaker), *Bufo brauni* (Dead leaf Toad), *Nectophrynoides tornieri* [Amphibian], *Afrixalus ulugurensis* (Leaf-folding Frog), *Leptopelis parkeri* (Tree Frog), *Leptopelis ulugurensis* (Tree Frog), *Callulina kreffti* [Amphibian], *Arthroleptides martiensseni* [Amphibian] and *Phrynobatrachus krefftii* (Puddle Frog).

Four species from Mlinga FR were categorised as **Near threatened** to extinction by the NBD. These species were *Tauraco fischeri* (Fisher's Turaco), *Tauraco hartlaubi* (Hartlaub's Turaco), *Batis mixta* (Forest Batis) and *Probreviceps macrodactylus* (Rain Frog).

One species from Mlinga FR was categorised as **Data deficient** by the NBD, *Beamys hindei* (Lesser Pouched Rat).

5.5.5.2 IUCN 2000

According to IUCN 2000 criteria, species were categorised as endangered, vulnerable and lower risk/ near threatened to extinction.

Only one species found in Mlinga FR was listed as **Endangered** to extinction by IUCN 2000. This was *Chamaeleo deremensis* (Usambara Three-horned Chameleon).

Six species found in Mlinga FR, were categorised as **Vulnerable** to extinction by IUCN 2000. These species were *Beamys hindei* (Lesser pouched Rat), *Dendrohyrax validus* (Eastern Tree Hyrax), *Paraxerus palliatus* (Tanganika mountain Squirrel), *Bubo vosseleri* (Usambara Eagle-owl), *Swynnertonia swynnertoni* (Swynnerton's Robin) and *Rhampholeon brevicaudatus* (Bearded Pigmy Chameleon).

Three species found in Mlinga FR, were categorised as **Lower risk/ near threatened** to extinction by IUCN 2000. These species were *Galagoides zanzibaricus* (Zanzibar Galago), *Miniopterus schriebersi* (Long Fingered bat) and *Tauraco fischeri* (Fisher's Turaco).

5.5.5.3 CITES 2001

Twenty species recorded during the survey of Mlinga FR were listed within Appendices I and II of CITES 2001.

Two species were listed by **Appendix I**: *Nectophrynoides tornieri* [Amphibian] and *Boulengerula boulengeri* (Caecilian).

Eighteen species were listed by **Append ix II**: *Galagoides zanzibaricus* (Zanzibar Galago), *Otolemur crassicaudatus* (Greater Galago), *Otolemur garnettii* (Small-eared Galago), *Papio cynocephalus* (Yellow Baboon), *Cercopithecus (n.) mitis* (Gentle Monkey), *Colobus angolensis palliates* (Angolan Pied Colobus), *Aquila rapax* (Tawny Eagle), *Gypohierax angolensis* (Palm-nut Vulture), *Lophaetus occipitalis* (Long-crested Eagle), *Terathopius ecuadatus* (Bateleur), *Tauraco fischeri* (Fisher's Turaco), *Tauraco hartlaubi* (Hartlaub's Turaco), *Bubo vosseleri* (Usambara Eagle Owl), *Chamaeleo fischeri* (East Usambara Two-horned Chameleon), *Chamaeleo tenue* (Usambara Soft-horned Chameleon), *Chamaeleo dilepis* (Common Flap-necked Chameleon), *Chamaeleo deremensis* (Usambara Three-horned Chameleon) and *Cordylus tropidosternum* (East African Spiny-tailed Lizard).

6.0 CONCLUSIONS

Authors: Hall, S.M. and Oliver, S. pp. 83-84

This report presents the data collected during the baseline biodiversity survey of Mlinga Forest Reserve. The report presents preliminary checklists of flora and fauna groups and categorises the ecological type, endemic and threat status of species. These two factors provide an indication of three 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.

Mlinga Forest Reserve was gazetted in 1996. The gazetted reserve covers an area of 890ha, with an altitude range of 220m to 1069m. The forest reserve has altered significantly in recent years as a consequence of intensive widespread fires and is presently composed of a mixture of lowland forest, submontane forest, open woodland and rocky outcrop/summit habitat, all subject to a variety of different levels of disturbance.

6.1 Disturbance

Fire was the most significant threat to both flora and fauna in Mlinga FR, and was recorded in two thirds of all vegetation plots sampled. A comparison of present figures with those of Johannson and Sandy (1996) suggest that fire has significantly reduced forest area in Mlinga FR. Only six vegetation plots surveyed were recorded with canopy heights greater than 20m. Open grass/bushland and woodland habitats dominated in burnt areas, increasing the susceptibility of the reserve to future fire disturbance.

Other forms of disturbance including pole and timber extraction, animal trapping, cultivation and pitsawing were low in Mlinga FR. Areas of particularly high levels of disturbance were mainly concentrated in north eastern areas of the forest reserve. The invasive species *Maesopsis eminii* was represented in only 1 vegetation plot by 1 individual, and is therefore not considered as a threat to the reserve at present.

6.2 Species Richness

Mlinga FR was found to contain a minimum of 269 species of plant, 23 mammal, 9 bat, 47 bird, 25 reptile, 21 amphibian and 103 butterfly species (figures for molluscs and millipedes have yet to be determined). The number of fauna species found in Mlinga FR was comparable with nearby forest reserves despite its small size (refer to Frontier Tanzania, 1996 a & b and Frontier Tanzania, 1999). Relative to the other thirteen forest reserves surveyed by Frontier-Tanzania, Mlinga FR has an average species richness for plants and fauna. Species richness is likely to be associated with forest reserve size and the degree of forest isolation or fragmentation. Mlinga FR is both small in size with patchy distribution of forest habitats that are isolated as a consequence of fire disturbance. Genetic exchange between populations is thought to be limited and the future of all vulnerable and/or restricted range species is of concern.

6.3 Flora

Six tree and shrub species were recorded in the vegetation plots that were endemic to the Usambara Mountains and 17 had ranges restricted to the Eastern Arc and/or East African lowland forests. 41 species were recorded as dependent on primary or closed canopy forest, and of these species, 5 were endemic and 7 were near-endemic to the Usambara Mountains.

Ten non-forest tree and shrub species had established within the reserve boundaries.

6.4 Fauna

One bird sighted in Mlinga FR was categorised as endemic to the Usambara mountains, and thirty-two other faunal species were listed as near-endemic. Seventy-two faunal species were classified as forest dependant or forest specialist, many of which were butterflies.

Three species recorded in Mlinga FR had endangered status (either listed by IUCN, 2000 or UDSM, 1997) these were: *Dendrohyrax validus* (Eastern Tree Hyrax), *Chamaeleo deremensis* (Usambara Three-horned Chameleon) and *Mertensophryne micranotis* [Amphibian].

6.5 Conservation

The forests of the East Usambara mountains are recognised as being part of a Biodiversity Hotspot (Mittermeier, 1999), an Endemic Bird Area (ICBP, 1992), a Centre of Plant Diversity (WWF and IUCN) and a Globally Important Ecoregion (WWF). They are a conservation priority due to their floral and faunal diversity and to the high number of endemic species. The forests also have a direct value to surrounding communities as a principle water catchment area and as a source of fuel-wood and medicinal plants.

The forests of the East Usambara mountains have been reduced to fragments within a matrix of agricultural land. Little forest remains outside of the gazetted forest reserves. For those species that are forest dependent, the forest reserves now provide almost the only available habitat.

There are differences in the perceived value of the forests between the villagers and the Forest and Beekeeping Division. Alternative sources of building material and fuel are required in order to meet the needs of surrounding villages while ensuring the protection of the forests.

The impact of fire is of serious concern throughout Mlinga Forest Reserve and increased protection is required to prevent future disturbance destroying the patches of forest that remain. Further degradation of forest habitats in Mlinga FR will lead to local population extinctions, particularly of those species identified as being at high risk. The loss of forested areas in Mlinga will also reduce the reliability of the water supply to neighbouring communities.

According to local communities, past hunting has seriously depleted large mammal populations. Present data supports this. Little can presently be done to reverse this problem unless the need for forest meat disappears.

Mlinga FR, as one of the smallest forest blocks in the East Usambara mountains, has a particularly high risk of flora and faunal population extinctions compared to larger forest reserves. Unfortunately since independence, the value of the Mlinga forest has not been so well understood by local communities, possibly as a result of population immigration from other regions of Tanzania. There is a need for older generations and forestry managers to reinstall a sense of responsibility amongst younger and less knowledgeable generations, to ensure the importance of the remaining forest is known. This will go some way towards helping the sustainable management of their forest reserve. Small-scale environmental education activities during the present survey went some way to promote such an idea (refer to Frontier Tanzania, 2002a and Frontier Tanzania, 2002b), but much work remains. Mlinga FR is thought to be a very suitable location for the implementation of Joint Forest Management activities. Surrounding communities have well organised and active village and environmental committees.

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8.0 APPENDICES

Appendix 1: Taxonomic Verification

BOTANY

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ZOOLOGY

Mammals:

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Millipedes:

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Appendix 2: GPS Co-ordinates of vegetation plots

Summary of GPS Coordinates of vegetation plots in Mlinga FR.

Vegetation Plot	Longitude	Latitude	Grid Ref. 37M	Grid Ref. UTM
1	E 038°44'51.6"	S 05°03'29.7"	0472029	9440942
2	E 038°45'06.1"	S 05°03'28.5"	0472496	9440941
3	E 038°45'21.1"	S 05°03'29.8"	0472939	9440939
4	E 038°44'36.7"	S 05°03'58.9"	0471570	9440045
5	E 038°44'22.2"	S 05°04'00.4"	0471125	9440001
6	E 038°44'07.5"	S 05°04'00.3"	0470673	9440002
7	E 038°43'53.2"	S 05°03'59.6"	0470231	9440026
8	E 038°45'35.7"	S 05°03'29.8"	0473389	94404940
9	E 038°45'35.7"	S 05°03'59.2"	0473389	9440039
10	E 038°44'50.8"	S 05°03'57.4"	0472005	9440092
11	E 038°44'21.8"	S 05°03'28.4"	0471112	9439131
12	E 038°44'36.6"	S 05°04'28.2"	0471570	9439145
13	E 038°44'49.9"	S 05°04'28.9"	0471979	9439125
14	E 038°45'35.8"	S 05°03'15.1"	0473389	9441390
15	E 038°45'21.9"	S 05°03'14.9"	0472962	9441399
16	E 038°45'07.3"	S 05°03'15.1"	0472513	9441390
17	E 038°45'35.7"	S 05°03'44.5"	0473389	9440490
18	E 038°45'21.5"	S 05°03'44.6"	0472952	9440485
19	***E 038°44'50.7"***	***S 05°03'47.0"***	***0472002***	***9440412***
20	E 038°44'36.9"	S 05°03'44.5"	0471578	9440489
21	E 038°44'22.7"	S 05°03'45.6"	0471141	9440453
22	E 038°44'08.2"	S 05°03'46.4"	0470698	9440437
23	E 038°43'53.6"	S 05°03'46.3"	0470245	9440433
24	E 038°43'36.0"	S 05°03'47.0"	0469703	9440411
25	E 038°45'35.2"	S 05°04'13.0"	0473372	9439614
26	E 038°45'21.1"	S 05°04'13.8"	0472939	9439589
27	E 038°44'36.6"	S 05°04'13.6"	0471570	9439595
28	E 038°44'07.4"	S 05°04'13.1"	0470671	9439609
29	E 038°44'22.0"	S 05°04'13.6"	0470215	9439606
30	E 038°44'36.6"	S 05°04'42.9"	0471570	9438695
31	E 038°44'37.1"	S 05°04'57.3"	0471584	9438254
32	E 038°44'49.8"	S 05°04'57.4"	0471976	9438252
33	E 038°45'05.7"	S 05°04'27.6"	0472464	9439164
34	E 038°45'24.2"	S 05°04'30.5"	0473034	9439075

Italic font: questionable GPS co-ordinate as a result of poor satellite response.

Appendix 3: General vegetation plot descriptions

Summary of vegetation plot descriptions in Mlinga FR.

Plot Number	Topography	Altitude (masl)	Slope (degrees)	Vegetation Condition	Canopy Height (m)	Disturbance Category	Features of Interest	No. species	No. Indivs	Dominant sp.
1	GLS	280	16	Open woodland	<10	Cultivation (old)	Rock outcrops	6	6	
2	GMS	380	30	Open woodland	<10	Cultivation (old), Fire (old)	Jackfruit trees	13	18	
3	SMS	340	41	Lowland Forest	10-20	Fire	Rock outcrops	9	35	*Mesogyne insignis & Anglocalyx braunii*
4	SLS	440	30	Open woodland	10-20	Fire	Rock outcrops	3	19	*Stereospermum kunthianum*
5	SLS	360	22	Open woodland	<10	Fire(old)	None	4	28	*Stereospermum kunthianum*
6	GLS	280	15	Lowland Forest	10-20	None	Rock outcrops	12	22	*Cynometra brachyrrhachis*
7	GMS	380	10	Open woodland	10-20	None	None	11	22	
8	GLS	340	28	Grassland	<10	Fire	Rock outcrops	0	0	
9	SMS	300	33	Scrub/Grassland	<10	Fire	None	0	0	
10	GMS	440	3	Lowland Forest	10-20	None	Rock outcrops	8	40	*Tabernamontana verticosa, Rothmania manganjae*
11	Ridge top	740	7	Lowland Forest	<10	Fire	None	10	18	*Rhus natalensis*
12	GMS	880	12	Submontane Forest	20-30	None	*Maesopsis eminii* present	20	34	*Macaranga capensis*
13	GMS	960	29	Submontane Forest	10-20	Fire	Rock outcrops	13	26	
14	GMS	360	21	Scrub/Grassland	<10	Fire	Rock outcrops	1	3	*Sponia orientalis*
15	GLS	260	15	Open woodland	<10	Fire	None	6	15	*Annona senegalensis*
16	GLS	240	4	Open woodland	<10	Fire (old)	Forest Reserve Border	3	4	
17	GLS	520	27	Scrub/Previously disturbed	<10	Fire	None	6	14	
18	GUS	330	30	Lowland Forest	20-30	None	Rock outcrops	18	36	
19	GUS	380	10	Lowland Forest	20-30	Cutting (old), Fire (old)	Rock outcrops	19	33	*Tabernamontana verticosa*
20	GLS	340	10	Lowland Forest & Open woodland	10-20	None	Rock outcrops	8	28	*Stereospermum kunthianum*
21	GLS	240	6	Lowland Forest	10-20	Fire (old)	None	19	53	*Tabernamontana verticosa*

Appendix 3 continued.

Plot Number	Topography	Altitude (masl)	Slope (degrees)	Vegetation Condition	Canopy Height (m)	Disturbance Category	Features of Interest	No. species	No. Indivs	Dominant sp.
22	GLS	360	15	Lowland Forest	10-20	Fire	None	8	28	*Stereospermum kunthianum*
23	GLS	360	12	Open woodland	<10	Fire	None	4	14	*Dombeya shupangae & Annona senegalensis,*
24	GLS	280	12	Open woodland	<10	Fire	None	8	28	*Stereospermum kunthianum & Annona senegalensis*
25	GLS	290	10	Previously Disturbed Lowland Forest	<10	Fire	Rock outcrops	5	8	*Sponia orientalis*
26	SMS	410	35	Previously Disturbed Lowland Forest	<10	Fire	Rock outcrops	5	17	*Sponia orientalis*
27	GLS	610	4	Lowland Forest	20-30	None	Rock outcrops	18	57	*Strombosia scheffleri & Funtumia africana*
28	GLS	460	19	Lowland Forest	20-30	Cutting (old), Fire (old)	Rock outcrops	28	53	*Celtis africana* etc.
29	Gully	440	14	Lowland Forest	10-20	Fire (old)	Dry stream valley	22	39	
30	GUS/Ridge top	960	25	Submontane Forest & Scrub	10-20	Fire	Rock outcrops	6	11	
31	GUS/Ridge top	980	22	Submontane Forest	20-30	Fire	Rock outcrops	16	58	*Bridelia micrantha,Tarenna pavettoides, Maesa lanceolata, Ficus sur*
32	GMS	760	22	Disturbed Submontane Forest	10-20	Cultivation (old), grazing nearby	Rock outcrops	10	11	
33	SMS	600	40	Rock	<10	Fire	Rock outcrops	1	1	
34	SMS	370	35	Rock, Previously Disturbed	<10	Fire	Rock outcrops	0	0	

KEY TO ABBREVIATIONS FOR APPENDIX 3
Topography:
GLS – Gentle lower slope
GMS – Gentle mid-slope
GUS – Gentle upper slope
SLS – Steep lower slope
SMS – Steep mid slope

Appendix 4: New flora for the East Usambara plant biodiversity database

Summary of new flora records for the East Usambara Plant Biodiversity Database (Pohjonen, 2001) from vegetation plots and opportunistic collection, Mlinga FR.

VEGETATION PLOT TREES AND SHRUBS

EUPHORBIACEAE	*Pycnocoma littoralis* Pax 1894
MELASTOMATACEAE	*Warneckea schliebenii* (Markgr.) Jacq.-Fel 1978
MORACEAE	*Ficus holstii* Warb 1894
STERCULIACEAE	*Sterculia rogersii* N.E.Br. 1921

OPPORTUNISTIC COLLECTION AND OBSERVATION

Angiospermae – Dichotyledonae	
CAPPARIDACEAE	*Ritchiea albersii* Gilg 1903
COMPOSITAE	*Aspilia abyssinica* Vatke 1875
CONNARACEAE	*Rourea coccinea* (Schumach. & Thonn.) Roberty 1954
EUPHORBIACEAE	*Acalypha forbesii* S. Moore 1914
EUPHORBIACEAE	*Erythrococca fischeri* Pax 1894
EUPHORBIACEAE	*Pycnocoma littoralis* Pax 1894
EUPHORBIACEAE	*Tragia benthamii* Baker 1901
LABIATAE	*Plectranthus lactiflorus* (Vatke) Agnew 1974
MALVACEAE	*Hibiscus micranthus* L.f. 1781
MELASTOMATACEAE	*Memecylon deminutum* Brenan 1947
RHIZOPHORACEAE	*Anisophyllea stuhmanii*
RUBIACEAE	*Polysphaeria lanceolata* Hiern 1877
VITACEAE	*Cyphostemma adenocaule* (Steud. Ex A. Rich.) Desc. 1967

Angiospermae – Monocotyledonae	
GRAMINEAE	*Ophiurus exaltatus* (L.) Kuntze 1891

Appendix 5: Useful plants

A summary of useful plants sampled systematically in vegetation plots and opportunistically in Mlinga FR (based on Ruffo, 1989).

	Building Poles	Fuelwood	Tool handles	Pestles	Mortars	Ornamental	Dyes	Honey	Edible fruits	Other
ANACARDIACEAE										
*Sorindeia madagascariensis**		+	+		+				+	Wooden spoons
APOCYNACEAE										Wooden cups
*Rauvolfia caffra**					+			+		
BORAGINACEAE										
Cordia Africana			+		+	+				
Fernandoa magnifica						+				
COMBRETACEAE										
Combretum schumannii	+	+		+				+		
Terminalia sambesiaca				+				+		
EBENACEAE										
Diospyros abyssinica	+			+						
EUPHORBIACEAE										
*Bridelia micrantha**	+	+	+	+			+	+		
GUTTIFERAE										
*Allanblackia stuhlmannii**					+		+	+	+ (fat)	
Haronga madagascariensis	+	+		+			+	+		
LEGUMINOSAE subfamily: CAESALPINOIDEAE										
Cynometra sp. A (of FTEA)	+	+	+		+			+		
Dialium holtzii		+		+						

Appendix 5 continued.

Species	Building Poles	Fuelwood	Tool handles	Pestles	Mortars	Ornamental	Dyes	Honey	Edible fruits	Other
LEGUMINOSAE subfamily: MIMOSOIDEAE										
Inga glaberrima (bas. *Albizia glaberrima*)*		+			+			+		
*Albizia gummifera**		+			+			+		
*Newtonia buchananii**		+			+		+	+		
*Newtonia paucijuga**		+								
Parkia filicoidea						+				
LOGANIACEAE										
*Anthocleista grandiflora**								+		
MELIANTHACEAE										
*Bersama abyssinica**					+					
MORACEAE										
*Antiaris toxicaria**								+		Balls & bird line
*Ficus exasperata**										Balls & bird line
Ficus sur										Balls & bird line
Milicia excelsa					+		+			
MYRSINACEAE										
Baeobotrys lanceolata (bas. *Maesa lanceolata*)*								+		
MYRTACEAE										
Eugenia guineensis (syn. *Synzigium guineense afromontanum*)		+							+	
OLACACEAE										
*Strombosia scheffleri**							+	+		

Appendix 5 continued.

Species	Building Poles	Fuelwood	Tool handles	Pestles	Mortars	Ornamental	Dyes	Honey	Edible fruits	Other
RUBIACEAE	+		+							
Oxyanthus speciosus										
Vangueria infausta									+	
SAPINDACEAE										
Phialodiscus unijugatus (bas. *Blighia unijugata*)*	+		+	+						
*Zanha golungensis**								+		
SAPOTACEAE										
Synsepalum cerasiferum (syn. *Afrosersalisia cerasifera*)										Wooden cups
STERCULIACEAE										
*Cola clavata**	+		+							Wooden spoons
*Cola scheffleri**									+	
Leptonychia usambarensis										Wooden spoons
ULMACEAE										
Celtis mildbraedii	+		+	+						

* Species also recorded in the regeneration layer.

Appendix 6: Medicinal plants

Summary of Medicinal Plants recorded in Mlinga FR (base on Ruffo *et al.*, 1989b).

Family	Species	Local name (kisambaa)	Treatments
ARISTOLOCHIACEAE	*Aristolochia densivenia*	Unkuhe	
BASELLACEAE	*Basella alba*	Ndelema	Frigidity
BURSERACEAE	*Commiphora zimmermannii*	Mnyakwa	Preventing abortion
CARICACEAE	*Cylicomorpha parviflora*	Mtondo	
COMPOSITAE	*Crassocephalum bojeri*	Eza	Stomachache, dementia
	Baccharoides lasiopus (bas. *Vernonia colorata*)	Hasanda	Generalized body pains, hernia, rhematism
EUPHORBIACEAE	*Tragia benthamii*	mbawa	
LABIATAE	*Hoslundia opposita*	Mshwee	Infertility, stomach ache, impotence, generalised body pains, malaria, wounds, chronic cough and colds, convulsions
LEGUMINOSAE: subfamily PAPILIONACEAE	*Mucuna pruriens*	Upupu	
	Phaseolus unguiculatus (syn. *Vigna unguiculata*)	Mkunde	
MENISPERMACEAE	*Triclisia sacleuxii*	Usisi	
PIPERACEAE	*Piper capensis*	ng'oko	Epilepsy, infertility

Appendix 6 continued.

Family	Species	Local name (kisambaa)	Treatments
RUBIACEAE	*Pentas bussei*	Mnyampome	Infertillity, kidney troubles especially in women, pneumonia
RUTACEAE			
	Citrus aurantifolia	Ushuza	Headache, dementia, generalized body pains, hernia, reumatism
	Clausena anisata	Mjavikavi	Infertility, leprosy, dementia, madness, gonorrhoea
	Toddalia asiatica	Mdongonyezi	Generalized body pains, chronic coughs and colds, tuberculosis
SAPOTACEAE	*Afrosersalicia cerasifera*	Muhoe	
SIMAROUBACEAE	*Harrisonia abyssinica*	Mdadai	Kidney troubles especially in women
SOLANACEAE	*Capsicum sp.*	Mpilipili kisaka	
	Solanum incanum	Mtua	Bewitchment, convulsions in children, hernia, madness, infertility, stomach ache in adults only, aphrodisiac
Angiospermae - Monocotyledonae			
GRAMINEAE	*Stipa latifolia* (bas. *Olyra latifolia*)	Ufiha	Allergy, convulsions, constipation, stomach ache
	Ophiurus exaltatus (syn. *Rottboellia exaltata*)	Ushushi	Allergy, prevention of abortion, convulsions, epilepsy, rashes
DRACAENACEAE	Dracaena deremensis	Ung'weng'we	
ZINGIBERACEAE	*Aframomum angustifolium*	Samaka	Schistomiasis, infertility

Appendix 7: Regeneration plot descriptions

Summary of rgenereration plot descriptions in Mlinga FR.

Regen. plot	Habitat	Ground cover (%)				Dominance (%)				Soil Texture	Soil Colour	No. Individuals		No. species	
		Herbaceous vegetation	Bare soil	Litter	Rocks	Grasses	Forbs	Mosses /lichens	Ferns			3x3m	6x6m	3x3m	6x6m
1	Woodland	90	0	10	0	80	20	0	0	Loamy-clay	Brown	1	1	1	1
2	Woodland	60	20	20	0	70	30	0	0	Sandy-clay	Red brown	15	17	5	5
3	Lowland Forest	80	10	10	0	70	30	0	0	Loamy-clay	Brown	23	57	5	11
4	Woodland	20	5	5	50	80	20	0	0	Loamy-clay	Dark grey	14	17	3	3
5	Woodland	90	10	0	0	80	20	0	0	Sandy-loam	Dark grey	9	24	4	5
6	Lowland Forest	40	10	30	20	5	95	0	0	Sandy-loam	Black	4	4	2	2
7	Woodland	95	5	80	0	80	20	0	0	Sandy-clay	Dark brown	2	2	1	1
8	Grassland	70	0	10	20	95	5	0	0	Rocky	Brown	0	0	0	0
9	Scrub/Grassland	80	0	20	0	90	10	0	0	Sandy-loam	Dark grey	0	0	0	0
10	Lowland Forest	20	20	30	40	20	80	0	0	Sandy-loam	Dark grey	10	13	6	7
11	Lowland Forest / Grassland	90	5	20	0	70	30	0	0	Loamy-clay	Brown	1	3	1	2
12	Sub-montane Forest	95	5	20	0	80	20	0	10	Sandy-clay	Red brown	3	5	2	3
13	Sub-montane Forest	40	20	20	20	90	10	0	0	Sandy-loam	Light grey	5	8	2	3
14	Scrub/Grassland	70	10	20	0	80	20	0	0	Sandy-clay	Dark brown	4	6	2	2
15	Woodland/Grassland	40	30	30	0	80	20	0	0	Loamy-clay	Dark brown	3	3	2	2
16	Woodland/Grassland	70	0	30	0	80	20	0	0	Loamy-clay	Brown	2	2	2	2
17	Scrub	60	30	10	0	95	5	0	0	Loamy-clay	Light grey	10	10	2	2
18	Lowland Forest	40	30	10	20	20	80	0	0	Sandy-loam	Dark grey	0	0	0	0
19	Lowland Forest/Scrub	70	20	80	5	95	0	0	0	Loamy-clay	Red brown	3	19	3	6

Appendix 7 continued.

Regen. plot	Habitat	Ground cover (%)				Dominance (%)				Soil Texture	Soil Colour	No. Individuals		No. species	
		Herbaceous vegetation	Bare soil	Litter	Rocks	Grasses	Forbs	Mosses /lichens	Ferns			3x3m	6x6m	3x3m	6x6m
21	Lowland Forest	50	0	100	0	10	90	0	0	Sandy-clay	Red brown	13	34	5	6
22	Lowland Forest/Grassland	90	40	60	0	95	5	0	0	Sandy-loam	Dark brown	1	6	1	2
23	Woodland/Grassland	80	0	20	0	90	10	0	0	Sandy-clay	Dark brown	2	7	2	4
24	Woodland/Grassland	90	5	5	0	95	5	0	0	Loamy-clay	Dark grey	0	0	0	0
25	Disturbed Lowland Forest	100	0	20	80	90	10	0	0	Sandy-loam	Dark brown	1	13	1	1
26	Disturbed Lowland Forest	100	0	0	60	50	50	0	0	Sandy-loam	Dark grey	3	8	1	1
27	Lowland Forest	0	10	90	25	0	10	20	0	Sandy-clay	Brown	59	86	5	8
28	Lowland Forest	30	40	20	10	60	20	0	20	Sandy-clay	Red brown	8	12	4	5
29	Lowland Forest	70	10	20	0	80	20	0	0	Loamy-clay	Brown	21	22	7	7
30	Sub-montane Forest/Scrub	20	70	10	15	10	90	0	0	Loamy-clay	Dark brown	3	6	2	2
31	Sub-montane Forest	10	40	50	0	0	90	0	10	Loamy-clay	Brown	19	34	8	12
32	Disturbed Sub-montane Forest	30	20	60	10	30	70	0	0	Loamy-clay	Dark brown	2	2	2	2
33	Rock	80	0	0	20	60	20	10	10	Rocky		0	0	0	0
34	Rock	20	20	0	60	80	10	10	0	Rocky		0	0	0	0
	MEAN	**61.18**	**14.26**	**28.24**	**13.38**	**64.85**	**30.59**	**1.18**	**1.47**			**7.18**	**12.50**	**2.41**	**3.18**
	Standard Deviation	29.70	16.15	27.10	21.10	32.04	29.92	4.09	4.36			11.18	17.92	2.12	3.09

Appendix 8: Mammal capture data

8a Summary of small mammal capture at zoological trapsites in Mlinga FR (refer to Tables 18 and 19 for trapsite locations, descriptions and sampling intensity).

Species	**Number of individuals caught in trapsites 1-5 (sampling intensity in Sherman trap nights)**					**No. of individuals captured**	**No. of recaptures**	**Total specimens taken**
	1 (1000)	**2 (1000)**	**3 (1000)**	**4 (1000)**	**5 (98)**	**(4098)**		
SORICIDAE								
Crocidura flavescens	-	-	-	-	-	-	-	
Crocidura hildegardeae	4	-	-	-	-	**4**	-	
Crocidura sp.	1	1	1	2	-	**6**	-	**10**
CRICETOMYINAE								
Beamys hindei	1	-	-	29	-	**11**	**19**	**1**
MURIDAE								
Acomys spinosissimus	2	2	2	-	-	**6**	-	**3**
Acomys sp.	1	-	-	-	-	**1**	-	**1**
Lophuromys flavopunctatus	-	-	-	15	2	**10**	**7**	**2**
Praomys delectorum	-	-	-	26	-	**14**	**12**	**5**
Praomys sp.	-	-	-	-	1	**1**	-	**1**
Grammomys ibeanus	1	1	-	1	-	**3**	-	**2**
Grammomys macmillani	1	-	1	1	-	**3**	-	**3**
Rattus rattus	1	-	-	-	-	**1**	-	**1**
Unknown sp. 1	1	-	-	-	-	**1**	-	**1**
Unknown sp. 2	1	-	-	-	-	**1**	-	**1**
GALAGONIDAE								
Galago zanzibaricus	-	1	-	-	-	**1**	-	
TOTAL	14	5	4	74	3	**100**	**38**	**31**

8b Summary of bat capture at bat-netting sites in Mlinga FR (refer to Table 20).

Species	**Number of individuals caught in bat net sites 1-5 (sampling intensity in net square meter hours)**					**Total no. individuals captured**	**Total specimens taken**
	1 (294)	**2 (735)**	**3 (1087)**	**4 (1015)**	**5 (131)**	**(3262)**	
NYCTERIDAE							
Nycteris grandis	-	1	-	-	-	**1**	**1**
PTEROPODIDAE							
Lissonycteris angolensis	-	-	-	-	4	**4**	**3**
Myonycteris relicta	-	-	-	-	1	**1**	**1**
RHINOLOPHIDAE							
Hipposideros caffer	1	2	-	3	1	**9**	**4**
Hipposideros ruber	?	?	-	?	?	**?**	
Hipposideros sp.	-	2	-	1	-	**1**	**1**
Rhinolophus clivosus	2	-	-	1	2	**5**	**3**
Rhinolophus fumigatus	1	2	-	-	1	**5**	**3**
Rhinolophus sp.	-	1	-	-	-	**1**	
VESPERTILIONIDAE							
Miniopterus schriebersi	1	-	-	-	-	**1**	**1**
Pipistrellus kuhli/rueppelli	-	-	-	1	-	**1**	**1**
TOTAL	5	8	0	6	9	**29**	**18**

Appendix 9: Reptile capture data

Summary of reptile capture at zoological trapsites and during opportunistic collection in Mlinga FR (refer to Tables 18 and 19 for trapsite locations, descriptions and sampling intensity).

Species	**Number of individuals caught in traps at trapsites 1-4 (SAMPLING INTENSITY IN TRAP NIGHTS)**				**Casual collections**	**Total no. individuals captured**	**Total specimens taken**
	1 (330)	**2 (330)**	**3 (330)**	**4 (330)**			
AGAMIDAE							
Agama montana	-	-	-	-	1	**1**	**1**
CHAMAELEONIDAE							
Chamaeleo fischeri*	-	-	-	-	1	**1**	**1**
Chamaeleo tenue*	-	-	-	-	1	**1**	**1**
Chamaeleo dilepis	-	-	-	-	1	**1**	**1**
COLUBRIDAE							
Dasypeltis medici	-	1	-	-	1	**2**	**2**
Lamprophis capensis	-	-	-	-	1	**2**	**2**
Lamprophis fuliginosus	1	-	-	-	1	**2**	**2**
Buhoma vauerocegae	-	-	-	1	-	**1**	**1**
Aparallactus werneri	-	1	-	-	1	**2**	**2**
Philothamnus sp.	-	-	-	-	1	**1**	**1**
Philothamnus macrops	-	-	-	-	1	**1**	**1**
Crotaphopeltis hotambeia	1	-	-	-	-	**1**	**1**
Crotaphopeltis tornieri	-	-	-	-	1	**1**	**1**
Thelotornis usambaricus	1	-	-	-	1	**2**	**2**
CORDYLIDAE							
Cordylus tropidosternum	-	1	-	-	-	**1**	**1**
GEKKONIDAE							
Hemidactylus mabouia	1	-	-	-	-	**1**	**1**
SCINCIDAE							
Mabuya maculilabris	1	-	-	-	-	**1**	**1**
Lygosoma afrum	1	-	-	-	-	**1**	**1**
Leptosiaphos kilimensis	-	-	-	1	-	**1**	**1**
TOTAL	**6**	**3**	**0**	**2**	**12**	**24**	**24**

*previously *Bradypodion*

Appendix 10 : Amphibian capture data

Summary of amphibian capture at zoological trapsites and during opportunistic collection in Mlinga FR (refer to Tables 18 and 19 for trapsite locations, descriptions and sampling intensity).

Species	**Number of individuals caught in traps Trapsites 1-4 (sampling intensity in bucket pitfall nights)**				**Casual collections**	**Total no. indivuals captured***	**Total specimens taken**
	1 (330)	**2 (330)**	**3 (330)**	**4 (330)**			
ARTHROLEPTIDAE							
Arthroleptis stenodactylus	37	12	-	9	1	**59**	**1**
Arthroleptis xenodactyloides	571	11	195	4	2	**783**	**10**
Arthroleptis sp. (cf. *xenodactylus*)^	18	8	70	2	-	**98**	**0**
BUFONIDAE							
Bufo maculatus	-	-	-	-	1	**1**	**1**
Nectophrynoides tornieri	-	-	-	-	2	**2**	**2**
Mertensophryne micranotis	-	1	-	-	1	**2**	**2**
Schismaderma carens	1	-	-	?	2	**3**	**3**
HYPEROLIIDAE							
Afrixalus brachycnemis	-	-	-	-	1	**1**	**1**
Afrixalus ulugurensis	-	-	-	-	1	**1**	**1**
Hyperolius tuberilinguis	-	-	-	-	1	**1**	**1**
Leptopelis barbouri	-	-	-	-	1	**1**	**1**
Leptopelis flavomaculatus	-	-	-	-	1	**1**	**1**
Leptopelis ulugurensis	-	-	-	-	2	**2**	**2**
MICROHYLIDAE							
Callulina kreffti	-	-	-	1	-	**1**	**1**
Probreviceps macrodactylus	-	-	-	3	-	**3**	**1**
RHACOPHORIDAE							
Chiromantis xerampelina	-	-	-	-	1	**1**	**1**
RANIDAE							
Arthroleptides martiensseni	-	-	-	-	3	**3**	**3**
Phrynobatrachus krefftii	-	-	-	1	4	**5**	**3**
Phrynobatrachus acridoides	-	-	-	-	1	**1**	**1**
TOTAL	**627**	**32**	**265**	**20**	**25**	**969**	**37**

*May include recaptures
^ Questionable field identification – potentially *Arthroleptis xenodactyloides*.

Appendix 11: Butterfly capture data

11a Summary of butterfly capture in canopy traps at zoological trapsites 1 to 4 in Mlinga FR (refer to Tables 18 and 19 for trapsite locations, descriptions and sampling intensity).

Species	**Number of individuals caught in canopy traps Trapsites 1-4 (sampling intensity in butterfly trap days)**				**Total no. individuals captured**	**No. of specimens taken**
	1 (50)	**2 (50)**	**3 (50)**	**4 (50)**		
LYCAENIDAE						
Unknown sp.	-	-	-	1	**1**	**1**
NYMPHALIDAE						
Acraea satis	-	1	-	-	**1**	**0**
Amauris niavius dominicanus	-	-	1	-	**1**	**1**
Apaturopsis cleochares schulzei	2	2	-	-	**4**	**2**
Bicyclus auricrudus fulgidus	1	-	-	-	**1**	**1**
Bicyclus campinus carcassoni	2	1	-	-	**3**	**0**
Bicyclus campinus ocelligerus	11	-	6	-	**17**	**3**
Bicyclus safitza safitza	12	14	32	-	**58**	**1**
Bicyclus sp.	1	1	-	-	**2**	**1**
Byblia ilithyia	1	-	1	-	**2**	**1**
Byblia sp.	-	-	1	-	**1**	**1**
Charaxes sp.	2	1	2	-	**5**	**5**
Charaxes bohemani	-	-	1	-	**1**	**1**
Charaxes brutus natalensis	-	-	3	-	**3**	**2**
Charaxes candiope candiope	2	-	-	1	**3**	**1**
Charaxes castor castor	-	-	1	-	**1**	**1**
Charaxes chepalungu	-	-	1	-	**1**	**0**
Charaxes cithaeron nairobicus	-	4	16	-	**20**	**1**
Charaxes contrarius	1	-	-	-	**1**	**1**
Charaxes jahlusa kenyensis	-	-	1	-	**1**	**1**
Charaxes lasti kimbozae	1	1	-	-	**2**	**1**
Charaxes lasti lasti	1	9	8	-	**18**	**1**
Charaxes pollux mirabilis	-	-	1	-	**1**	**1**
Charaxes protoclea azota	-	-	1	-	**1**	**1**
Charaxes smaragdalis kigoma	-	-	1	-	**1**	**1**
Charaxes smaragdalis homonymus	2	-	-	-	**2**	**1**
Charaxes varanes vologese	-	1	-	1	**2**	**1**
Charaxes violetta	1	-	-	-	**1**	**1**
Charaxes violetta maritimus	2	15	-	-	**17**	**0**
Charaxes xiphares	3	-	-	-	**3**	**2**
Danaus chrysippus/dorippus	-	-	1	-	**1**	**1**
Euptera kinugnana	1	5	8	-	**14**	**1**
Euryphura achlys	-	3	-	-	**3**	**1**
Eurytela sp.	1	-	-	-	**1**	**1**
Eurytela dryope angulata	13	17	28	1	**59**	**4**
Eurytela hiarbas lita	-	-	-	2	**2**	**1**
Euxanthe wakefieldi	-	1	-	-	**1**	**1**
Gnophodes betsimena diversa	2	-	-	-	**2**	**1**
Henotesia perspicua	-	-	3	-	**3**	**0**
Henotesia phaea phaea	1	-	-	-	**1**	**1**
Melantis leda leda	2	3	1	-	**6**	**1**
Neptidopsis fulgurata platyptera	-	-	1	-	**1**	**1**

Appendix 11a continued.

Species	Number of individuals caught in canopy traps Trapsites 1-4 (sampling intensity in butterfly trap days)				Total no. individuals captured	No. specimens taken
	1 (50)	2 (50)	3 (50)	4 (50)		
NYMPHALIDAE continued.						
Neptidopsis ophione velleda	-	-	1	-	**1**	**0**
Neptis carcassoni	-	-	1	-	**1**	**0**
Neptis rogersi	-	-	1	-	**1**	**0**
Neptis saclava marpessa	1	1	-	-	**2**	**1**
Neptis serena serena	-	-	1	-	**1**	**1**
Neptis trigonophora trigonophora	-	-	1	-	**1**	**1**
Pseudacraea lucretia protracta	1	-	-	-	**1**	**1**
Pseudathyma plutonica	1	-	-	-	**1**	**1**
Sallya boisduvali omissa	1	-	-	-	**1**	**1**
Sallya garega garega	1	2	11	-	**14**	**1**
Sallya natalensis	1	-	1	-	**2**	**0**
PAPILIONIDAE						
Papilio dardanus polytrophus	1	-	-	-	**1**	**1**
UNKNOWN						
Unknown sp.	4	-	-	-	**4**	**4**
TOTALS	76	82	136	6	**300**	**61**

11b Summary of butterflies caught sweepnetting at zoological trapsites and casually in Mlinga FR (refer to Tables 18 and 19 for trapsite locations, descriptions and sampling intensity).

Species	Number of individuals caught in systematic sweepnetting Trapsites 1-4 (sampling intensity in sweepnet hours)				Casual sweepnet captures	Total no. individuals captured	No. of specimens taken
	1 (20)	2 (20)	3 (20)	4 (20)			
HESPERIIDAE							
Pardaleodes incerta	2	-	-	-	-	**2**	**1**
Sarangesa maculata	1	-	-	-	-	**1**	**1**
Tagiades flesus	1	-	-	-	-	**1**	**1**
Teniorhinus herilus	1	-	-	-	-	**1**	**1**
Unknown sp.	-	-	-	1	-	**1**	**1**
LYCAENIDAE							
Alaena picata	2	2	-	2	-	**6**	**2**
Axiocerses punicea	1	-	-	-	-	**1**	**1**
Azanus moriqua	-	-	1	-	-	**1**	**1**
Eicochrysops hippocrates	1	-	-	-	-	**1**	**1**
Eicochrysops masai	1	-	-	-	-	**1**	**1**
Lampides boeticus	1	-	-	-	-	**1**	**1**
Leptotes pirithous	-	-	-	-	1	**1**	**1**
Unknown sp.	1	-	-	-	-	**1**	**1**
Pentila tropicalis	1	-	1	-	-	**2**	**1**
Pilodeudorix rodgersi	1	-	-	-	-	**1**	**1**
Teriominia subpunctata	-	1	-	-	-	**1**	**1**
Tuxentius margaritaceus	-	-	1	-	-	**1**	**1**

Appendix 11b continued.

Species	Number of individuals caught in systematic sweepnetting Trapsites 1-4 (sampling intensity in sweepnet hours)				Casual sweepnet captures	No. individuals captured)	No. of specimens taken
	1 (20)	2 (20)	3 (20)	4 (20)			
NYMPHALIDAE							
Acraea sp.	1	-	-	2	1	**4**	**4**
Acraea acara	-	1	-	-	-	**1**	**1**
Acraea acrita	-	-	1	-	-	**1**	**1**
Acraea aganice montana	5	3	3	1	-	**12**	**2**
Acraea alcinoe camerunica	-	-	3	-	-	**3**	**2**
Acraea boopis ama	1	-	-	-	-	**1**	**1**
Acraea cerasa cerasa	-	1	-	-	-	**1**	**1**
Acraea egina egina	-	-	-	1	-	**1**	**1**
Acraea eponina eponina	-	-	1	-	-	**1**	**1**
Acraea macaria hemileuca	1	2	-	-	-	**3**	**2**
Acraea natalica natalica	2	-	1	-	1	**4**	**3**
Acraea quirina rosa	-	-	-	8	-	**8**	**1**
Acraea satis	-	3	-	-	-	**3**	**1**
Acraea servona kenya	-	-	-	2	-	**2**	**2**
Acraea uvui uvui	1	-	-	-	-	**1**	**1**
Amauris sp.	2	-	-	-	-	**2**	**1**
Amauris niavius dominicanus	-	-	1	2	1	**4**	**0**
Amauris niavius niavius	4	-	-	-	-	**4**	**1**
Bicyclus campinus carcassoni	-	-	1	-	-	**1**	**0**
Bicyclus safitza safitza	2	2	9	-	-	**13**	**1**
Byblia ilithyia	1	-	-	-	-	**1**	**1**
Danaus chrysippus/dorippus	-	1	-	-	-	**1**	**1**
Euphaedra neophron littoralis	1	-	-	-	-	**1**	**1**
Eurytela dryope angulata	2	-	1	-	-	**3**	**1**
Henotesia perspicua	1	-	-	-	-	**1**	**1**
Hypolimnas anthedon anthedon	-	-	1	-	1	**2**	**1**
Junonia oenone oenone	1	-	-	-	-	**1**	**1**
Junonia terea elgiva	1	-	-	-	-	**1**	**1**
Neptidopsis ophione velleda	3	-	-	2	1	**6**	**3**
Neptis sp.	2	-	-	1	-	**3**	**2**
Neptis carcassoni	1	-	-	-	-	**1**	**1**
Neptis jordani	1	-	-	-	-	**1**	**1**
Neptis laeta	3	-	-	-	-	**3**	**1**
Neptis melicerta	-	-	-	1	-	**1**	**1**
Neptis rogersi	1	-	-	-	-	**1**	**1**
Neptis saclava marpessa	-	1	-	-	-	**1**	**0**
Unknown sp.	1	-	-	-	-	**1**	**1**
Phalanta eurytis eurytis	-	-	-	-	1	**1**	**1**
Physcaeneura leda	4	-	1	-	-	**5**	**2**
Sallya garega garega	-	-	-	-	1	**1**	**1**
PAPILIONIDAE							
Catopsilia florella	1	-	-	-	-	**1**	**1**
Papilio dardanus polytrophus	1	5	-	-	-	**6**	**0**
Papilio ophidicephalus	-	-	1	2	-	**3**	**0**
PIERIDAE							
Appias lasti lasti	-	-	-	3	-	**3**	**1**
Belenois creona severina	1	-	-	-	-	**1**	**1**
Belenois thysa thysa	4	1	2	-	-	**7**	**3**

Appendix 11b continued.

Species	**Number of individuals caught in systematic sweepnetting Trapsites 1-4 (sampling intensity in sweepnet hours)**				**Casual sweepnet captures**	**Total no. individuals captured**	**No. of specimens taken**
	1 (20)	**2 (20)**	**3 (20)**	**4 (20)**			
PIERIDAE continued							
Colotis sp.	1	-	-	-	-	**1**	**1**
Colotis euippe omphale	2	-	1	-	-	**3**	**2**
Dixeia charina	-	-	1	-	-	**1**	**1**
Eronia cleodora	2	-	-	-	-	**2**	**1**
Eurema floricola orientis	3	-	4	-	3	**10**	**1**
Eurema sp.	2	-	-	1	-	**3**	**1**
Eurema hapale	1	1	2	-	-	**4**	**1**
Eurema regularis regularis	2	-	-	-	-	**2**	**2**
Eurema senegalensis	8	-	-	-	-	**8**	**2**
Leptosia alcesta inalcesta	5	1	2	-	-	**8**	**1**
Nepheronia argia argia	2	1	-	-	-	**3**	**1**
Nepheronia thalassina	1	-	-	-	-	**1**	**1**
UNKNOWN	-	-	-	-	-		
Unknown sp.	2	-	-	2	-	**4**	**2**
TOTAL	**94**	**26**	**39**	**31**	**11**	**202**	**91**

Appendix 12: Photographs

Photograph taken from northern border of Mlinga FR, grassland in foreground at the border, woodland transition into lowland and submontane forest on slopes and ridge respectively.

Photograph from noth western border of Mlinga FR, looking south. *Stereospermum kunthiam* with pink flowers in foreground.

Appendix 13: East Usambara Conservation Area Management Programme Technical Paper Series

(ISSN 1236-620X)

The East Usambara Conservation Area Management Programme Technical Papers Series consists of reports on forestry issues in the East Usambara Mountains. This series started in 1991. These reports aim to make information more widely available to staff members of the East Usambara Conservation Area Management Programme, to the Forestry and Beekeeping Division, and to other institutions and individuals concerned and interested in the conservation of the East Usambara forests.

The reports are prepared by staff members of the East Usambara Conservation Area Management Programme or by other researchers, consultants and interested individuals. The views expressed in the reports are those of the author(s).

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   Räsänen, P.K. 1991. Outline of a research planning programme for the East Usambara Catchment Forest Project.
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5. Häkkinen, I. & Wambura, M. 1992. A Frame plan for the Amani Nature Reserve.
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