TECHNICAL PAPER 35

Kambai Forest Reserve

A biodiversity survey

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

East Usambara Catchment Forest Project

Technical Paper 35

Kambai Forest Reserve

A biodiversity survey

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

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

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

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

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FOREWORD

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

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

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

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

M.I.L. Katigula
Project Manager

Stig Johansson
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Abstract

Kambai forest reserve is situated in the East Usambara mountains in north-east Tanzania. The East Usambaras form part of the mountain chain called the Eastern Arc which ranges from southern Kenya to southern Tanzania. These mountains are known for their rich floral and faunal diversity and high levels of species endemism (Hamilton, 1989). To investigate further this biodiversity, a biological survey of Kambai forest reserve was conducted with a socio-economic component between January and March 1996 for a total of 52 research-days.

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

The survey identified 162 species of tree and shrub, 36 species of mammal, 11 species of bird, 18 species of reptile and 15 species of amphibian.

Flora

Two tree species were recorded which are endemic to the Usambara mountains and 35 which have restricted ranges limited to the Eastern Arc and/or East African lowland forests. Forty-seven species are dependent on primary forest, and of these species, 17 are also endemic or near endemic to the Usambara mountains. Eighteen non-forest tree and shrub species are established within the reserve boundaries.

Species of particular interest encountered during this survey include:

- *Cola usambarensis*, a wet evergreen forest tree, endemic to the East Usambaras was recorded in 10 plots;

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

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

- *Rinorea angustifolia,* a wet evergreen forest tree, endemic to the East and West Usambara mountains was recorded once in the reserve;

- *Monodora minor* is a new range record for the Usambara mountains, previously considered restricted within the coastal forests;

- *Nesogordonia holtzii* is considered a coastal endemic tree. The occurrence of this species in the Usambaras may represent a range extension, however the full description of this species has yet to be published.

Fauna

Four faunal species were recorded which are endemic to the Usambara mountains and nineteen species were recorded as near-endemics, having restricted ranges limited to the Eastern Arc and/or East African lowland forests. Thirty-three species are dependent on primary forest, and of these species, 21 are also endemic or near endemic to the Usambara mountains. Three non-forest species are established in the reserve.

Species of particular interest encountered during this survey include:

- *Crocidura xantippe,* a near-endemic shrew, listed as 'Endangered' by IUCN;

- *Dendrohyrax validus,* the tree hyrax, is considered 'Vulnerable' by IUCN;

- *Galago zanzibaricus,* the greater galago, is considered 'Near threatened' by IUCN;

- The bat, *Scotophilus nucella,* is a first record for Tanzania;

- The Nile monitor, *Varanus niloticus,* was observed. This species, as are all members of the Varanidae, is on the CITES appendix II list of endangered animals;

- The second specimen, and the first female, of the gecko *Lygodactylus kimhowelli* was collected. This represents a range extension. The only other known site of this species is the Amboni Caves forest, outside the town of Tanga. This species is considered 'Endangered' by IUCN;

- The gecko, *Cnemaspis barbouri*, is also considered 'Endangered' by IUCN;

- The reptiles, *Aparallactus werneri, Philothamnus macrops, Crotaphopeltis tornieri, Mabuya m. maculilabris* and *Rhampholeon brevicaudatus* are considered 'Vulnerable' by IUCN;

- The forest fossorial skink, *Melanoseps loveridgei,* was encountered. This represents a north-eastern range extension. Previously this species is known only from the Kiwengoma forest reserve in the coastal forests;

- The toad, *Mertensophryne micranotis,* is considered 'Endangered' by IUCN;

- Amphibians considered 'Vulnerable by IUCN are: *Bufo brauni, Leptopelis barbouri, Leptopelis uluguruensis* and *Arthroleptides martiensseni;*

- *Hoplophryne rogersi*, a ground frog, was collected during the survey. This represents a range extension. It has now been recorded in three East Usambara forests. This species was also previously recorded only from the coastal forest near the Amboni Caves, Tanga. This species is considered 'Vulnerable' by IUCN;

- *Boulengerula boulengeri*, a caecilian, endemic to the East and West Usambaras, was recorded three times during the survey. This suggests that the species is locally common although considered 'Vulnerable' by IUCN;

- The tree frog, *Leptopelis vermiculatus*, is considered 'Near-threatened' by IUCN;

- The Usambara eagle owl, *Bubo vosseleri* and the Southern hyliota, *Hyliota australis* spp. *usambarae*, were recorded in the reserve. Both are endemic to the Usambara mountains. The former species is also a CITES II species and considered 'Vulnerable' by IUCN;

- Sokoke Scops Owl, *Otus ireneae*, is a near-endemic occurring in Kambai as well as other lowland East Usambara forests. It is only otherwise known from Arabuko-Sokoke forest, Kenya. This species is also a CITES II species and considered 'Endangered' by IUCN;

- Swynnerton's forest robin, *Swynnertonia swynnertoni*, and the Amani sunbird, *Anthreptes pallidigaster*, are near-endemics to the Usambara mountains. They are considered 'Near-Threatened' by IUCN;

- East coast akalat, *Sheppardia gunningi*, is considered 'Vulnerable' by IUCN*;*

- The slug, *Urocyclus kirkii*, was collected. This represents a possible northern range extension;

- The water snail, *Lanistes farleri*, is considered 'Endangered' by IUCN.

Soils

Variation in soil type was determined by differences in physiographic units: summit and upper slope, midslope, and lower slope rather than differences in vegetation type.

Disturbance

Five transects were found to have higher than average rates within the reserve of pole and timber extraction. Three of these are characterised by dense forest, one is previously disturbed/open forest, and one is bushland/thicket. From this, it appears that these three forested areas are under considerable more threat than the other areas of the reserve.

Socio-economics

The main concern for the people living around the reserve is that they are landlocked between forest reserves and SHUWIMU land (land belonging to a government parastatal company). Because of this, there is no available land for agricultural expansion. This is of concern as land pressures are likely to increase due to increases in population and correspondingly, an increase in the demand for forest products. Differences exist in the perceived value of the forest reserve (i.e. the biodiversity value versus water catchment value versus timber, pole & firewood resources), and without alternatives to the use of forest products, it appears that conflict between the local people and the Catchment authorities will continue.

1.0 INTRODUCTION: EAST USAMBARA AND FOREST DIVERSITY

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

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

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

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

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

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

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

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

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

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

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

1987). The Usambaras harbour many species which have been geographically separated from their closest relatives for long periods. They also serve as a refuge for formerly widespread flora and fauna that have become extinct over much of their former area (Iversen, 1991). The conservation and preservation of this unique area of biodiversity should be given high priority.

2.0 AIMS OF THE SURVEY

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

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

Furthermore, the aims of the survey methods applied are:

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

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

3.0 DESCRIPTION OF THE FOREST

3.1 General description

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

Kambai forest reserve is situated in the Sigi-Muzi valley in the central area of the East Usambaras (Figure 1). The reserve includes two ridges, one lying on a north-south axis, and the other in the southern extension of the reserve, lying on an east-west axis. In this southern area the slope is steeper than that of the north-south ridge (Figure 2). The Miembeni river runs between these two ridges from the south-west to the east side of the reserve. This river then drains into the Sigi river, which is the main source of water for Tanga town. Throughout the reserve there are many dry rocky riverbeds and many well used paths. The altitudinal zonation ranges from 200 m to 870 m, thus two major types of forest exist: lowland and submontane (Hamilton, 1989). The most recent survey of the area, was carried out by Hyytiäinen (1995), and updated by Johansson & Sandy (1996). The results are summarised in Table 1 below and indicate that the majority of Kambai forest reserve can be classified as 'dense lowland forest', forest that is more or less similar to the original forest species composition with an unbroken crown cover. Lowland forest has been classified as occurring up to 850 m (Hamilton, 1989). Farmland surrounds the forest reserve on all sides with a 50 m buffer zone existing along much of the border.

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

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

3.1.1 History and Status

Kambai forest was gazetted as a forest reserve in 1994. The area east of the reserve has been, since the early 1900's, part of the Sigi-Miembeni Sisal Estate. The Estate closed around 1969. This land is now leased to a government parastatal company called SHUWIMU (Shirika la Uchumi la Wilaya ya Muheza - Development Corporation of the District of Muheza). Since the Sikh Sawmills ceased timber production on the SHUWIMU land in the 1960's, there has been no further development on this land. Newspaper reports however suggest that the parastatal may begin development of an orange tree estate (Nipashe, 1996).

Table 2. Status of Kambai forest reserve.

Name	Status	Size (ha)	Gazettement Notice and Date
Kambai	Forest Reserve	1046.3	GN 310 (1994)

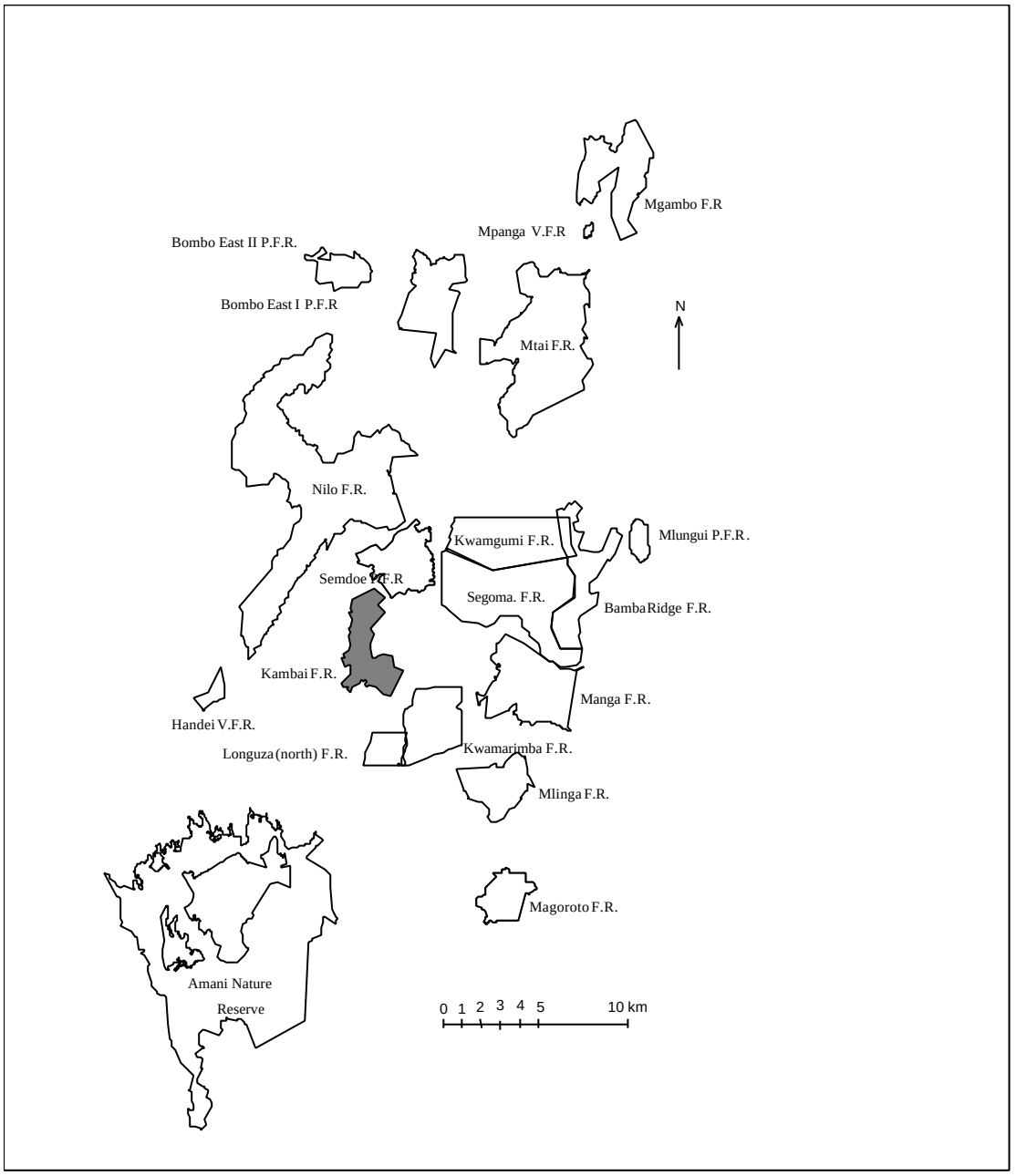

Figure 1. The location of Kambai forest reserve in relation to other East Usambara forests.

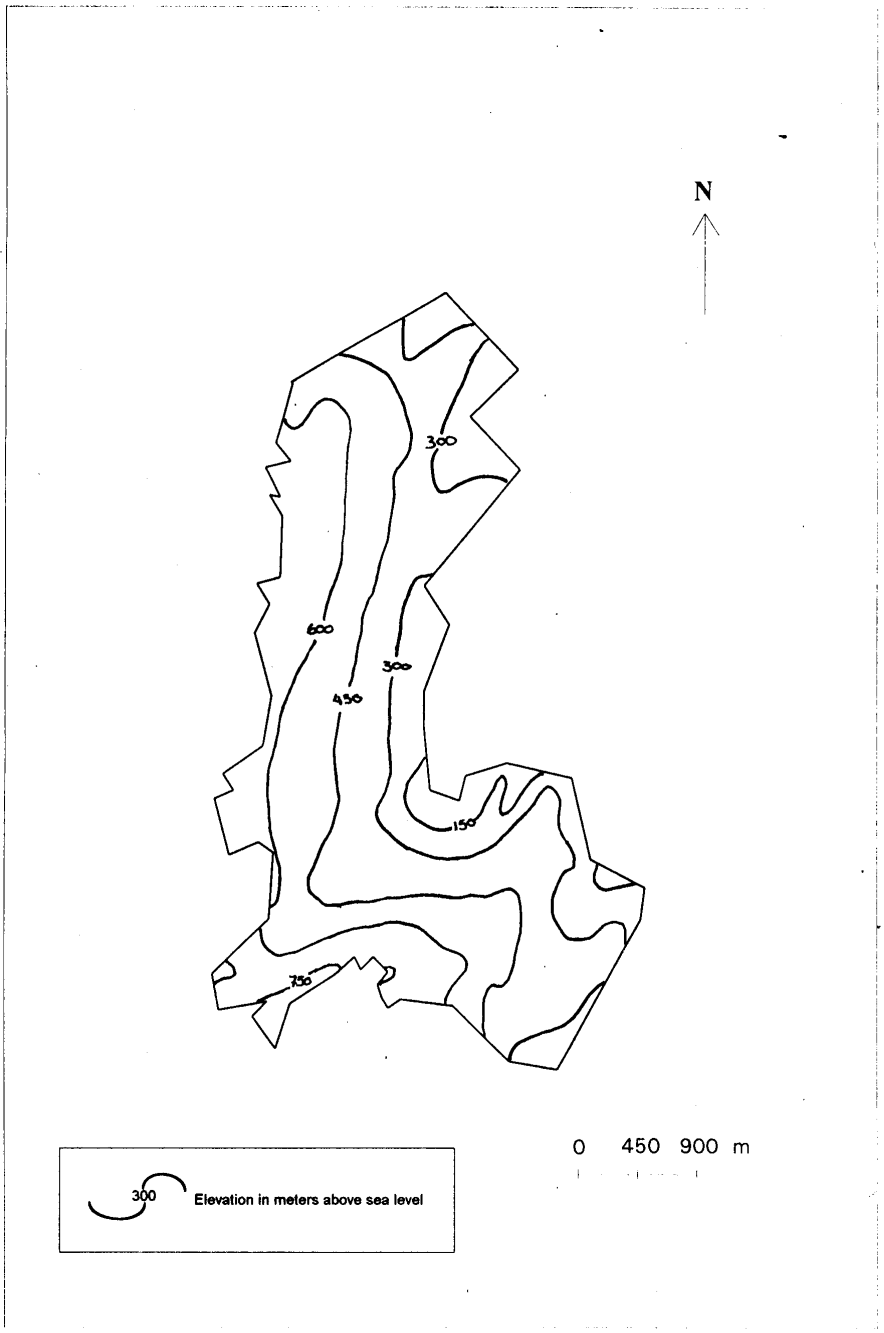

Figure 2. Topographical map.

4.0 SOILS

4.1 Introduction

On a separate contract from the survey, the National Soil Service (NSS) carried out a soil survey of Kambai forest reserve. The objectives of the study were to assess the nature and distribution of different soil types (Shaka *et al.* 1996).

4.2 Methods

The FT FRP constructed a total of 51 vegetation analysis plots in a grid system, each measuring 450 m x 450 m. Soil samples were taken from the south-west corner of each of these vegetation plots from altitudes ranging between 200 m and 850 m. The floristic composition of a 50 m x 20 m sub-plot, also located in the south-west corner of the larger vegetation plot, was analysed in terms of tree species density and tree species dominance.

A total of 51 soil-auger hole observations were established to a depth of 150 cm where possible. Data was recorded on the soil cores extracted by the auger according to FAO (1977) guidelines for describing soil profiles. Soil colour was described using the Munsell notation. Soil samples were taken from both the surface horizon, at a depth between 0-25 cm, and from the sub-soil, at a depth between 25-50 cm. These samples were analysed at the NSS Central Laboratory to determine the following properties: soil texture; pH; total nitrogen; organic carbon; available phosphorus; cation exchange capacity; and exchangeable calcium, potassium, magnesium and sodium.

4.3 Results

Altitudinal variation was limited to lowland sites. The topography was undulating and slope gradients were between 10-45%. The soils are formed from metamorphic rocks of the Usagaran system. The rocks are dominantly gneiss. Soils on steeper slopes are very prone to severe erosion if vegetation cover was removed.

The soils of Kambai ranged from very shallow (<20 cm) to very deep (>120 cm) and were dominantly well drained. Rock outcrops were recorded in 67% of the plots surveyed. Soil texture was generally clay loam to clay. Soils were dark reddish brown to dark red and in some places red.

Soil reaction, measured by pH, was variable ranging from slightly acidic (7.0-4.1) in the topsoil to medium or strongly acidic in the subsoil (3.3-6.8). Organic carbon are dominantly very high in the topsoil (aver. 5.13%) and decreases to low or very low levels in the subsoil (aver. 0.48%). Total nitrogen is also high in the topsoil (aver. 1.04) and decreases to low levels in the subsoil (aver. 0.14%). Levels of organic carbon were variable ranging from very high to high in topsoils (>3.5-2.5%) and decreasing to low levels in subsoils (0.6-1.25%).

Available phosphorus in all plots is low (topsoil: 2.5-6.6 mg/kg; subsoil: 1.3-6.0 mg/kg) while exchangeable bases vary from very high to high. The low levels of available phosphorus occurs because the materials from which the soils are formed are dominantly

low in phosphorus. Cation exchange capacity (CEC) generally decreases with soil depth (topsoil: aver. 14.8; subsoil: aver. 9.4). Because of this, the ability of the soil to retain and supply nutrients for plant uptake is considered medium compared to other soils. Potassium levels are medium to low or very low (0.21-7.0 Cmolc/kg). The carbon, nitrogen ratio generally shows good quality organic matter (C/N: 8-15).

4.4 Discussion

The majority of the sample plots supported dense, mature and mixed lowland forest. The Miembeni river flows from the south-west boundary of the reserve to the eastern boundary. In these plots the vegetation is dominated by typical riparian elements. The boundaries of the reserve are bordered by agricultural land. Half of these boundary plots are characterised by mature forest while the half are poorly stocked forest, bush and thicket, grassland and previously cultivated.

Soil type did not show significant differences in variability between plots with mature forest and those of disturbed areas in terms of pH, soil colour, soil depth or CEC. Rather, the major difference in soil type occurred with physiographic units: summit and upper slope, mid-slope and lower slope. These differences are: soil depth and acidity increasing moving down the slope.

The soils sampled in Kambai forest reserve were largely similar to the soils studied in other East Usambara forests, such as Magoroto and Bamba Ridge (Cunneyworth & Stubblefield, 1996a,b). They were deep, well drained, acidic, red clays and clay loams which can be classified as Ferralsols (FAO, 1988). These soil properties are characteristic of sedentary soils developed *in situ* over weathered granitoid gneiss (Holmes, 1995), the underlying parent material of Kambai. The soil reaction is acidic due to the high quartz content of the gneiss.

The soils sampled were generally dark reddish brown. This is typical of tropical forest soils, particularly the Rhodic Ferralsols, which are sedentary soils subject to heavy weathering. The soils are typically red due to high levels of aluminium and iron sesquioxides since other more soluble bases are washed down the profile (Holmes, 1995), and the inorganic fraction is consequently low in available nutrients.

Soils were darker in colour in the surface horizon due to the natural incorporation of surface organic matter. This incorporated organic matter is important in maintaining both the soil structure and nutrient levels, since the Ferralsols have an inherently low nutrient status due to heavy leaching. For the East Usambaras, the nutrient holding capacity of these soils is directly associated with organic matter content (Milne, 1937; Hamilton, 1989). This explains why the level of exchangeable bases decreased markedly on moving down the soil profile.

The organic matter quality of the soils sampled was good. However, Hamilton (1989) states that this apparently high soil fertility is misleading since it is sustained by a very fragile cycling of nutrients between soils and vegetation. Any disruption to this cycle, therefore, will result in the rapid loss of nutrients and lead to soil impoverishment.

5.0 BOTANY

5.1 Introduction

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

5.2 Methods

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

5.2.1 Forest structure

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

5.2.1.1 Quantitative vegetation analysis

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

5.2.1.2 Disturbance transects

Disturbance transects provide an estimate of pole cutting and logging in a forest block. The disturbance transects were based on the 450 m x 450 m grid squares constructed for the vegetation plot analysis. Each transect running north-south was sampled from boundary to boundary. Every self-standing tree and sapling (i.e. not lianas or creepers) above 1 cm dbh was measured within an area 5 m either side of each transect line. Each plant was recorded under one of two categories: cut or naturally fallen and then subdivided to those less than 10 cm dbh or equal to or larger then 10. These divisions represent differences in usage extraction. The smaller are considered poles and the larger are considered timber. The percentages of each category were then calculated to estimate their relative abundance.

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

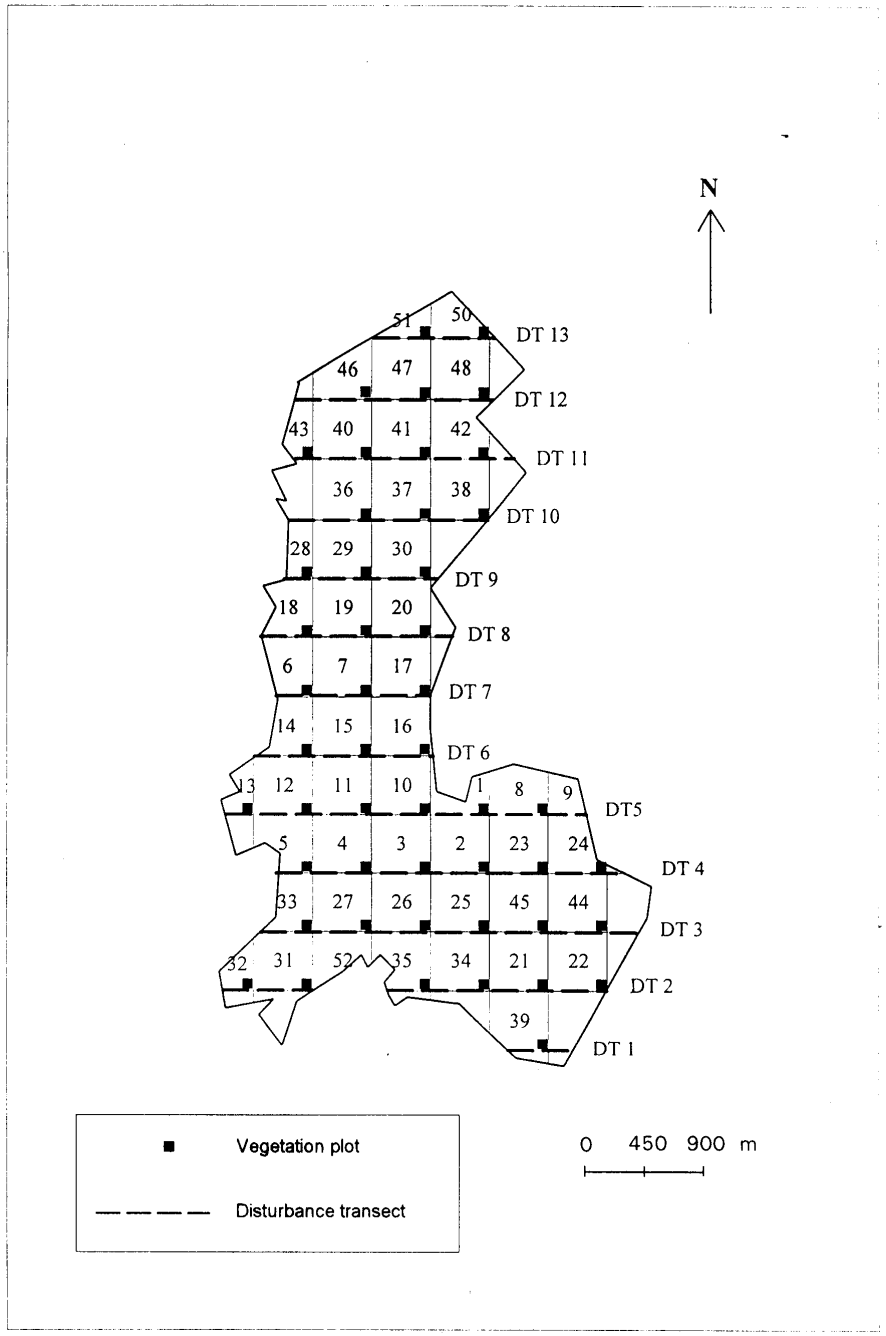

Figure 3. Location of vegetation plots and disturbance transects.

5.3 Results

5.3.1 Quantitative vegetation analysis

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

Table 3. Checklist of trees and shrubs.

Species	Ecological type	Habitat[2]	Endemic status
Anacardiaceae			
Lannea welwitschii	F	L	N
Lannea schweinfurthii stuhlmannii	f		W
Sorindeia madagascariensis	f		W
Annonaceae			
Lettowianthus stellatus	f	L & S	N
Uvariodendron sp.	?		?
5Xylopia parviflora	f	L	W
Mkilua fragrans	F		N
Monodora minor[1]	O		W
Annona senegalensis	f		W
Apocynaceae			
Funtumia africana	F	L & S	W
Rauvolfia caffra	F	L & S	W
Tabernaemontana pachysiphon	F	S	W
Araliaceae			
Cussonia zimmermannii	f	L (forest gaps)	N
Bignoniaceae			
Fernandoa magnifica	f	L	W
Markhamia lutea	f	L & S (forest gaps)	W
Markhamia obtusifolia	O		W
Stereospermum kunthianum	f		W
Bombacaceae			
Bombax rhodognaphalon	f		N
Boraginaceae			
Ehretia cymosa	F		W
Cordia monoica	f		W
Burseraceae			
Commiphora eminii ssp. *zimmermannii*	f	L	W
Commiphora sp.	?		?
Celastraceae			
Maytenus acuminata	F	S	W
Combretaceae			
Combretum schumannii	f	L	W
Combretum molle	O		W
Combretum natalensis[1]	?		?
Pteleopsis myritifolia	f		W
Terminalia sambesiaca	f	L	N

Table 3 (*cont.*)

Species	Ecological type	Habitat[2]	Endemic status
Dracaenaceae			
Dracaena steudneri	f	S (forest gaps)	W
Ebenaceae			
Diospyros mespiliformis	f	L	W
Diospyros natalensis	f	L	W
Diospyros squarrosa[1]	?	L	W
Euphorbiaceae			
Bridelia micrantha	f	L & S	W
Bridelia cathartica melanthesoides	f		W
Cleistanthus polystachyus	f		W
Croton sylivaticus	f	L	W
Drypetes gerrardii	F	S	W
Drypetes natalensis	f	L	W
Drypetes usambarica	f	S	N
Euphorbia candelabrum	O		W
Margaritaria discoidea	f		W
Mildbraedia carpinifolia	f		N
Ricinodendron heudelotii	f	L	N
Sapium ellipticum	f	L & S	W
Suregada zanzibarense	f		W
Flacourtiaceae			
Caloncoba welwitschii	f	S	W
Homalium longistylum	f	S	W
Ludia mauritiana	f		W
Guttiferae			
Allanblackia stuhlmannii	F	S	N
Symphonia globulifera	f	S	W
Hernandiaceae			
Gyrocarpus americanus	f	L	W
Icacinaceae			
Apodytes dimidiata	f	S	W
Lecythidaceae			
Barringtonia racemosa	f	L	W
Leguminosae subfamily: Caesalpiniaceae			
Afzelia quanzensis	f	L	W
Cynometra webberi	f		N
Dialium holtzii	f	L	N
Erythrophleum suaveolens	F		W
Julbernardia magnistipulata	f	L	N
Scorodophloeus fischeri	f	L	N
Senna singueana	O		W
Leguminosae subfamily: Mimosaceae			
Acacia senegalensis[1]	O		W
Albizia glaberrima	f	L	W
Albizia gummifera	f	L	W
Albizia zimmermannii	f	L	W
Albizia schimperana amaniensis	F		N
Albizia versicolor	O		W
Albizia petersiana	f		W
Newtonia paucijuga	F	L	N
Parkia filicoidea	F	L & S	W

Table 3 (*cont.*)

Species	Ecological type	Habitat[2]	Endemic status
Leguminosae subfamily: Papilionaceae			
Angylocalyx braunii	F	L	N
Craibia brevicaudata	f	L	N
Dalbergia melanoxylon	f		W
Erythrina cafra[1]	F		W
Millettia oblata	F		N
Millettia stuhlmannii[1]	O		W
Myroxylon aethiopicum[1]	?		?
Ormocarpum kirkii	O		W
Pterocarpus mildbraedii	F	L	N
Pterocarpus tinctorius	F	S & L	W
Schefflerodendron usambarense	F	S	W
Lonchocarpus bussei	O		W
Melianthaceae			
Bersama abyssinica	f		N
Moraceae			
Antiaris toxicaria	f	L & S	W
Dorstenia kameruniana	f	L	W
Ficus exasperata	f	L & S	W
Ficus lutea	f	L	W
Ficus natalensis	f		W
Ficus scassellattii	f	S	W
Ficus usambarensis	f		N
Ficus vallis-choudae	f	L	W
Mesogyne insignis	F	S	N
Milicia excelsa	f	L & S	W
Morus mesozygia	F	L	W
Trilepisium madagascariense	f		W
Myrtaceae			
Syzygium sp.	?		?
Ochnaceae			
Ochna sp.	?		?
Ochna densicoma[1]	?		?
Olacaceae			
Strombosia scheffleri	F	S	W
Pandanaceae			
Pandanus stuhlmannii	f		W
Pittosporaceae			
Pittosporum viridiflorum	f		W
Rhamnaceae			
Ziziphus mucronata	O	L	W
Rosaceae			
Prunus africana	f		W
Rubiaceae			
Coffea camphora[1]	F		W
Coffea robusta	O		W
Crossopteryx febrifuga	f		W
Galiniera saxifraga	F	S	W
Hallea rubrostipulata	f	S	W
Leptactina platyphylla	f		W
Morinda asteroscepa	f	S (forest gaps)	N
Oxyanthus speciosus	F	S (forest gaps)	W

Table 3 (*cont.*)

Species	Ecological type	Habitat[2]	Endemic status
Rothmannia manganjae	F	L & S	W
Rothmannia urcelliformis	F	L	W
Rytigynia flavida	F		W
Cremaspora triflora	f		W
Tarenna graveolens	O		W
Tricalysia pallens	f		W
Vangueria infausta	f		W
Rutaceae			
Zanthoxylum usambarensis	F	S	W
Teclea nobilis	f	S	W
Teclea simplicifolia	f	S	W
Teclea trichocarpa	f		W
Teclea mespiliformis[1]	?		?
Sapindaceae			
Allophylus melliodorus	f		N
Blighia unijugata	F	L & S	W
Lecaniodiscus fraxinifolius	F	L	W
Placodiscus amaniensis	F		N
Zanha golungensis	F	L & S	W
Sapotaceae			
Bequaertiodendron natalense	f	L & S	W
Chrysophyllum sp.	?		?
Malacantha alnifolia	f	L & S	W
Manilkara obovata	f	S	W
Manilkara sulcata	f	L	W
Mimusops kummel	f	L	W
Pachystela msolo	F	L & S	W
Vincentella passargei	f	L	W
Sterculiaceae			
Cola greenwayi	F		N
Cola microcarpa	F		N
Cola scheffleri	F	L	N
Cola usambarensis	F	S	E (EU)
Cola clavata[1]	F		W
Leptonychia usambarensis	F	L & S	N
Nesogordonia holtzii[1]	?		N
Sterculia appendiculata	F	L	W
Sterculia quinqueloba[1]	?		?
Dombeya shupangae	O		N
Dombeya cincinnata[1]	?		?
Tiliaceae			
Carpodiptera africana	O		W
Grewia goetzeana	f	L	N
Grewia holstii	f		W
Grewia bicolor	O		W
Ulmaceae			
Celtis africana	F	L	W
Celtis gomphophylla	F	L	W
Celtis mildbraedii	F	L & S	W
Celtis wightii	f	S	W
Celtis zenkeri	F	L & S	W

Table 3 (*cont.*)

Species	Ecological type	Habitat[2]	Endemic status
Trema orientalis	f	L & S (forest gaps)	W
Urticaceae			
Obetia radula	O		W
Verbenaceae			
Premna chrysoclada	O	L	N
Vitex amaniensis	f	S & L	N
Violaceae			
Rinorea angustifolia	F		E (EU&WU)
Rinorea ferruginea	F		N

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

KEY TO ABBREVIATIONS FOR TABLE 3

Ecological type (based on Iversen, 1991):
- F - Forest dependent species: This is defined as primary forest only. It does not include forest edge or secondary forest;
- f - Forest dwelling but not forest dependent: Species occurring in primary forest as defined above as well as other vegetation types. Thus these are not forest-dependent species; and
- O - Non-forest species: These are species that do not occur in primary or secondary forest or forest edge.

Habitat: (based on Hamilton, 1989)
- L - Lowland: Species occurring at altitudes of <850 m;
- S - Submontane: Species occurring at altitudes of >850 m.

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

Endemic status: (based on Iversen, 1991):
- E - Endemic: Occurring only in the Usambara mountains;
- N - Near endemic: Species with limited ranges in the Eastern Arc mountains and/or the East African lowlands between Somalia and Mozambique.
- W - Widespread distribution.

EU - Range limited to the East Usambaras ; WU - Range limited to the West Usambaras
? Insufficient data

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

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

Species	Location as previously recorded[1]
Cussonia zimmermannii	Mhinduro and Mtai
Diospyros natalensis	Mhinduro and Mtai
Albizia zimmermannii	Mhinduro and Mtai
Diospyros abyssinica	restricted to the southern end of the East Usambara range
Caloncoba welwitschii	restricted to the southern end of the East Usambara range
Maytenus acuminata	restricted to the southern end of the East Usambara range
Symphonia globulifera	between Kilanga and Lutindi forest reserves and on Mlinga
Gyrocarpus americanus	Fanusi and Kisiwani and on Mhinduro
Allophyllus melliodorus	Lutindi and Mtai forest reserves

Vincentella passargei	Mtai forest reserve

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

Species accumulation rates:

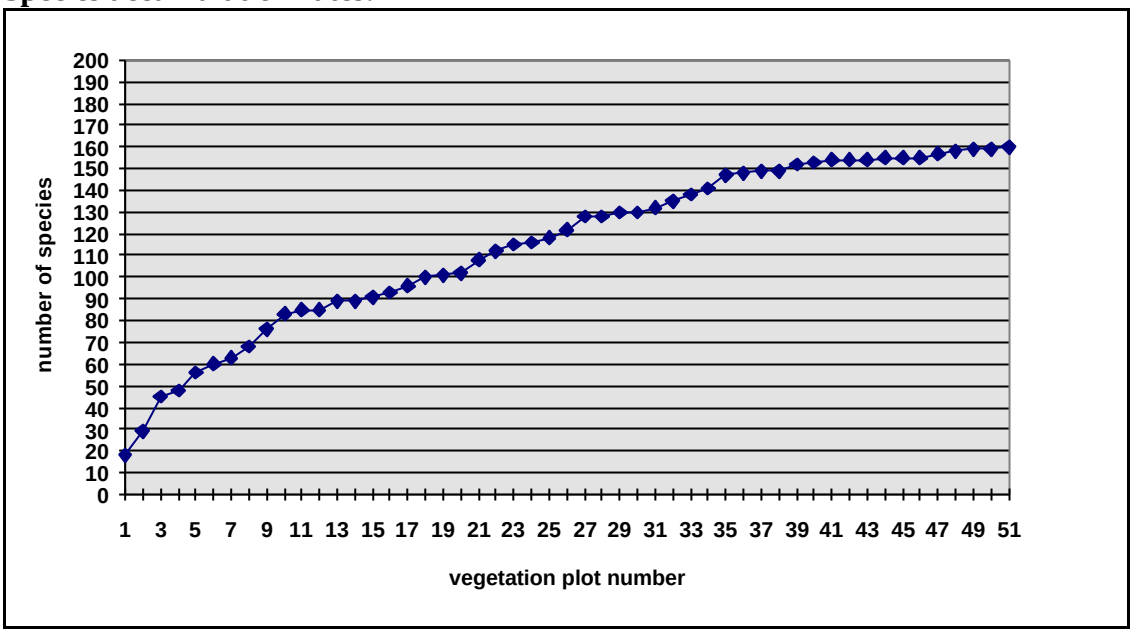

Figure 4. Species accumulation rates of trees and shrubs (10 cm dbh and larger) by vegetation plot.

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

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

Ecological type	Number of species	% of total species
(F) Forest Dependent Species	47	29.0
(f) Forest Non- Dependent Species	84	51.9
(O) Non-Forest Species	18	11.1
Unknown	13	8.0
Total:	**162**	**100.0**

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

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

Habitat	Number of species	% of total species
(L) Lowland Forest Species	60	71.4
(S) Submontane Forest Species	24	28.6
Total:	**84**	**100.0**

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

Species	Altitude (meters)
Dracaena steudneri	200, 400, 600
Diospyros abyssinica	320
Drypetes gerrardii	300
Drypetes usambarica	200, 275, 330, 360, 380, 400, 510
Caloncoba welwitschii	700
Homalium longistylum	700
Allanblackia stuhlmannii	700
Symphonia globulifera	650, 700
Apodytes dimidiata	320
Schefflerodendron usambarense	430
Mesogyne insignis	700
Strombosia scheffleri	700
Galiniera saxifraga	330
Hallea rubrostipulata	550
Morinda asteroscepa	700
Oxyanthus speciosus	380
Zanthoxylum usambarensis	520
Teclea nobilis	300, 600, 650, 700
Teclea simplicifolia	400, 510, 540, 600
Manilkara obovata	350, 390, 400
Ficus scassellattii	330
Maytenus acuminata	380
Tabernaemontana pachysiphon	550
Cola usambarensis	300, 320, 390, 400, 650, 700
Celtis wightii	190, 250, 300, 320, 390, 520, 600

Endemic status (refer to Figures 11,12,13,14)**:**

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

Endemic status	Number of species	% of total species
(E) Endemic	2 (1-EU; 1 EU&WU)*	1.2
(N) Near Endemic	35	21.6
(W) Widespread	113	69.8
Unknown	12	7.4
Total:	**162**	**100.0**

* EU - endemic to the East Usambaras; WU - endemic to the West Usambaras

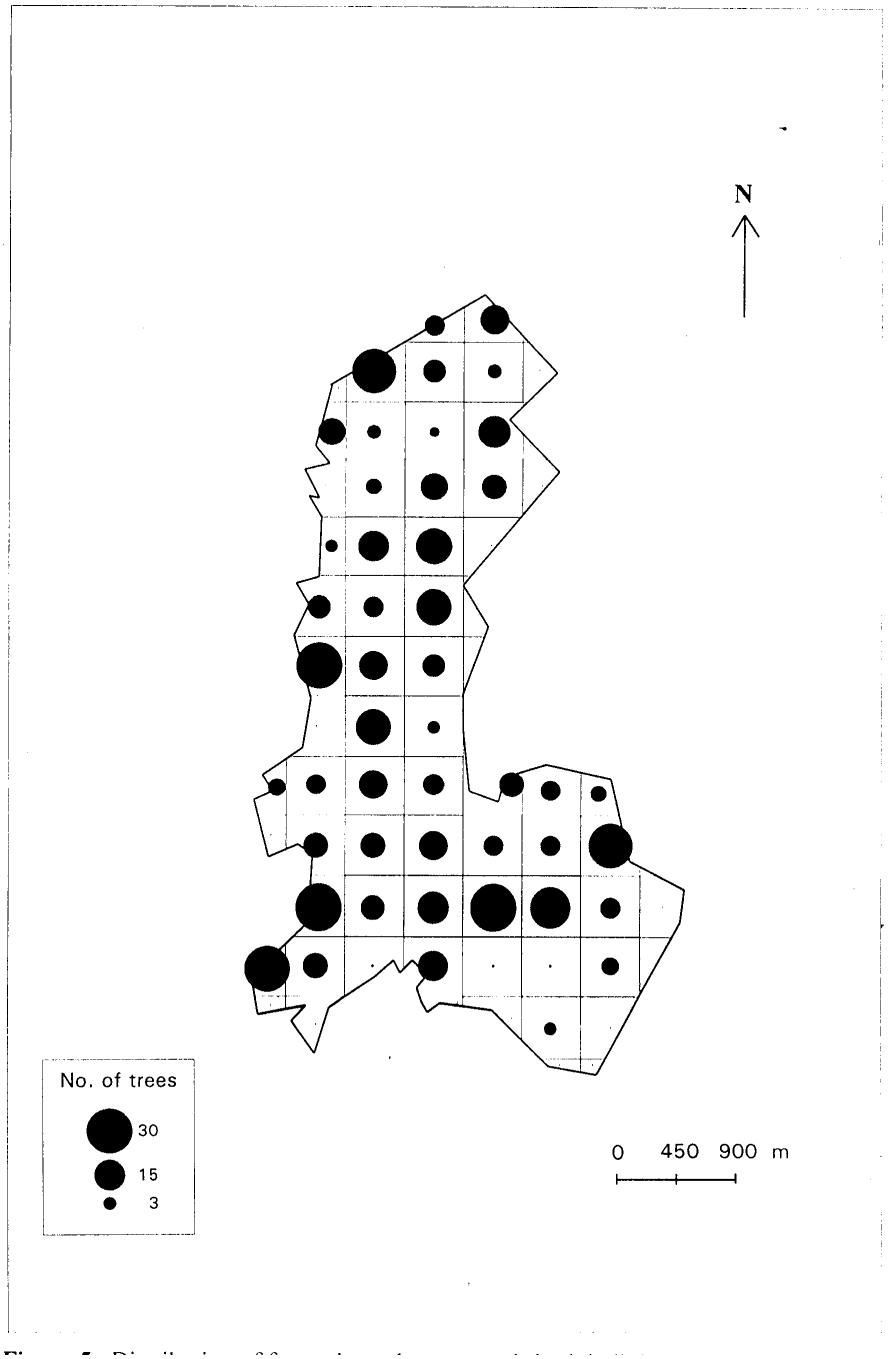

Figure 5. Distribution of forest dependent tree and shrub individuals.

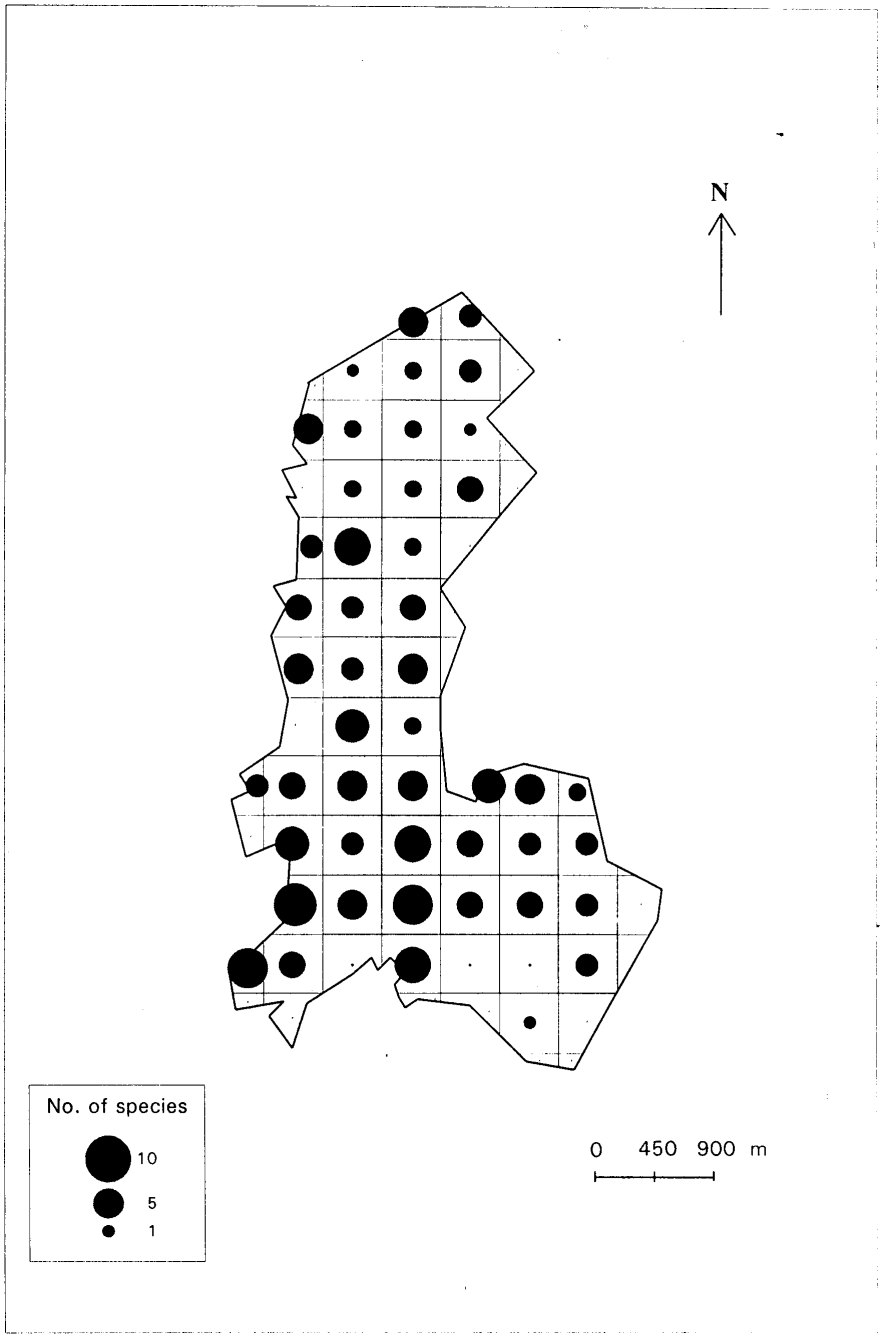

Figure 6. Distribution of forest dependent tree and shrub species.

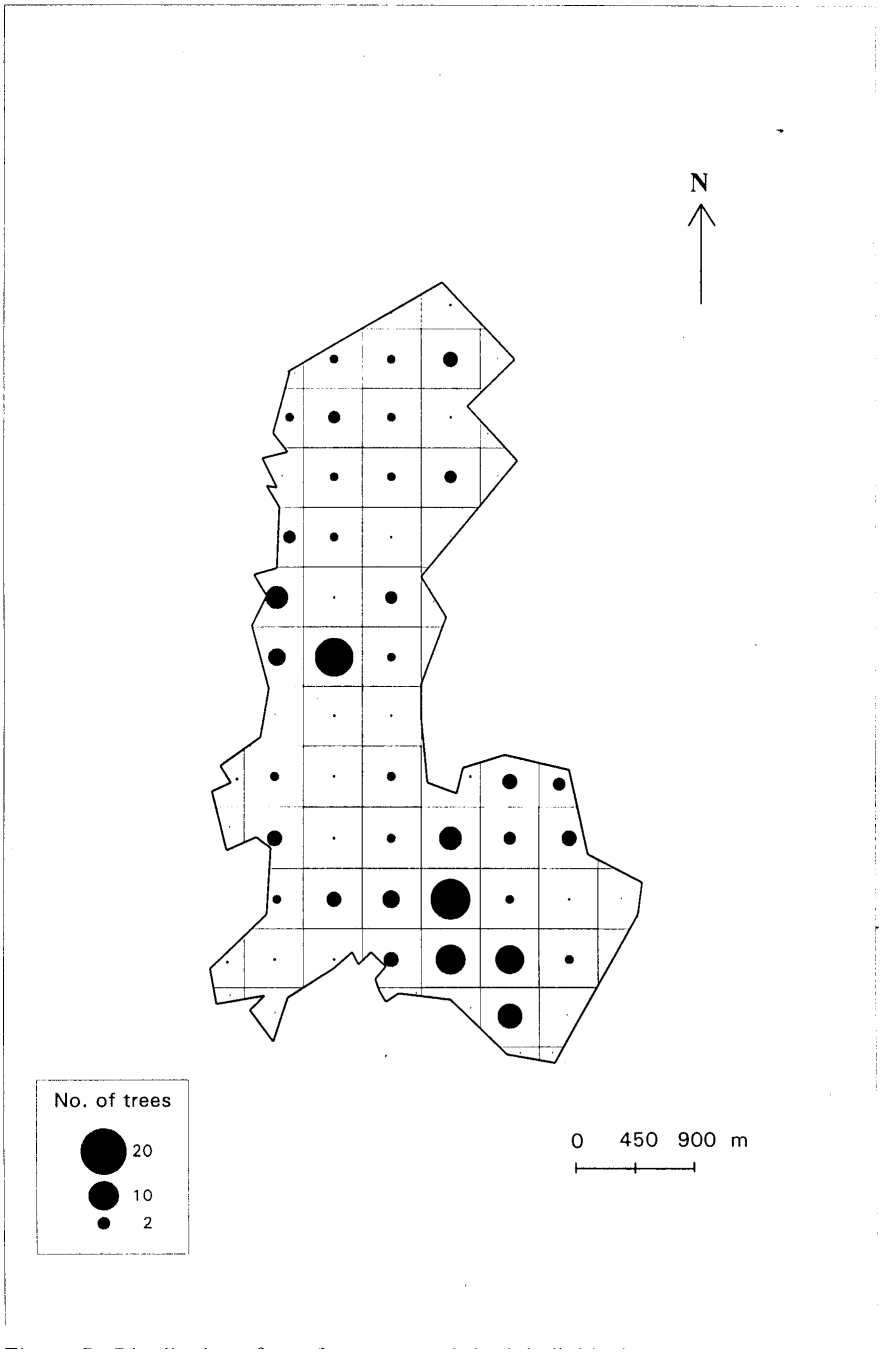

Figure 7. Distribution of non-forest tree and shrub individuals.

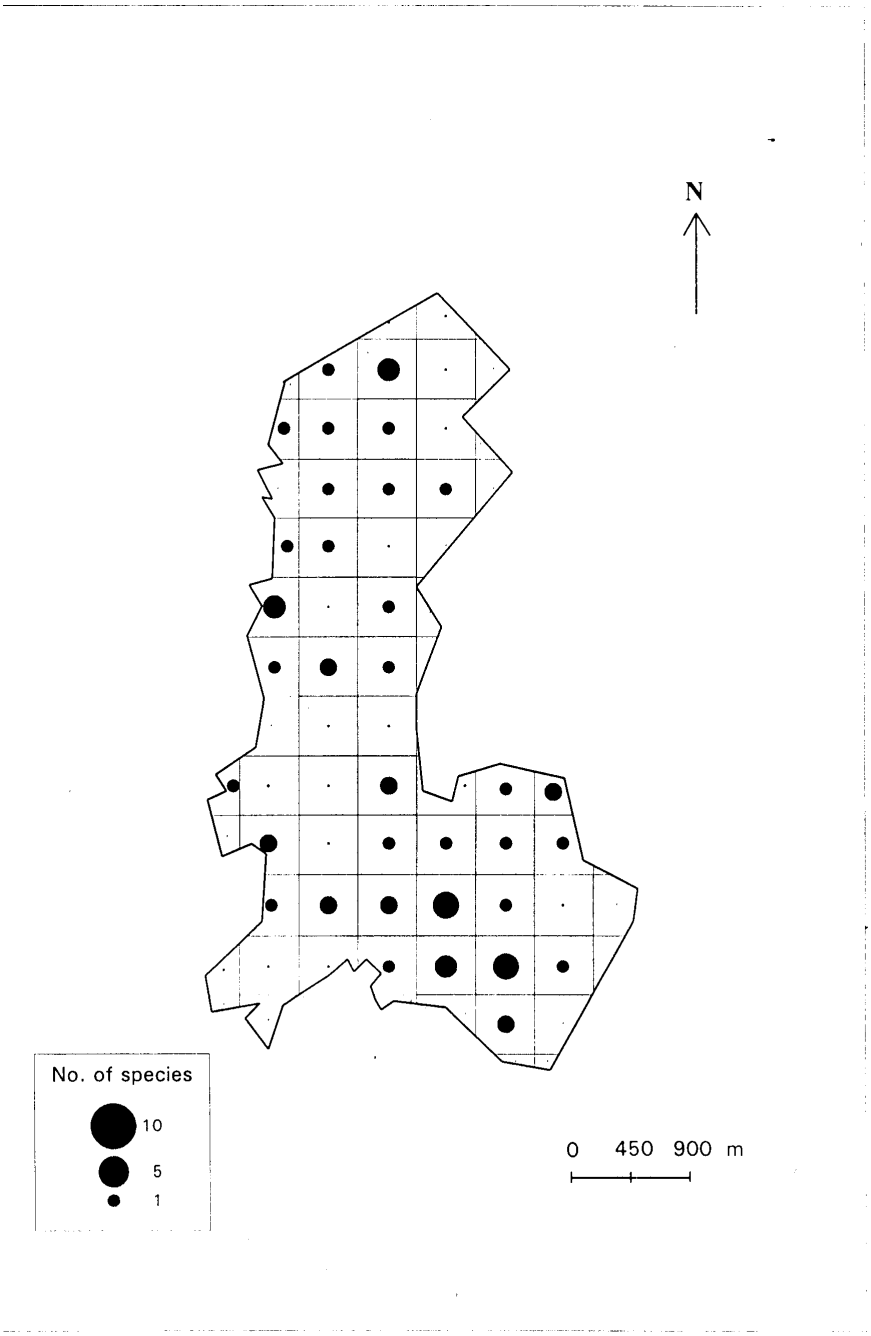

Figure 8. Distribution of non-forest tree and shrub species.

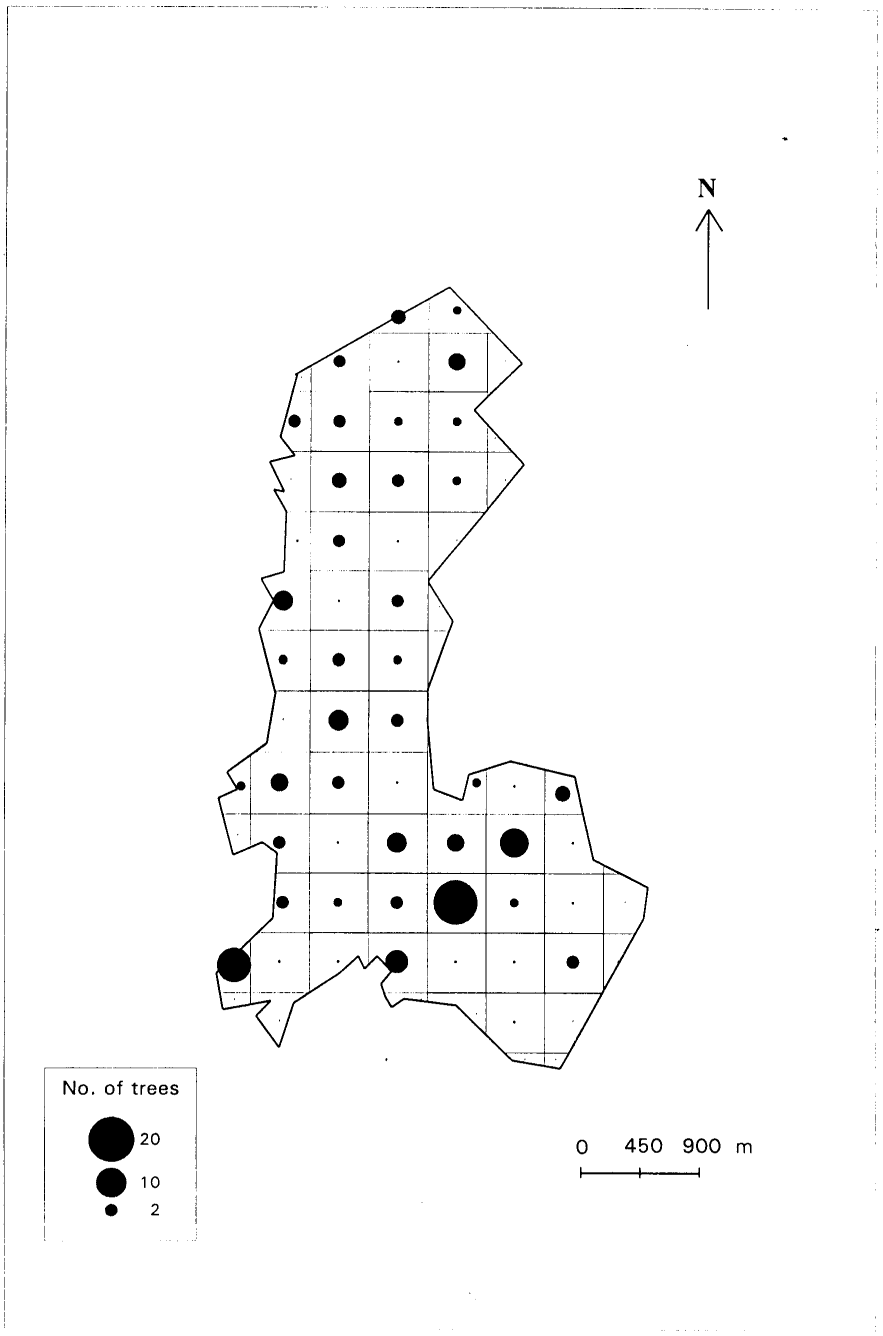

Figure 9. Distribution of submontane tree and shrub individuals.

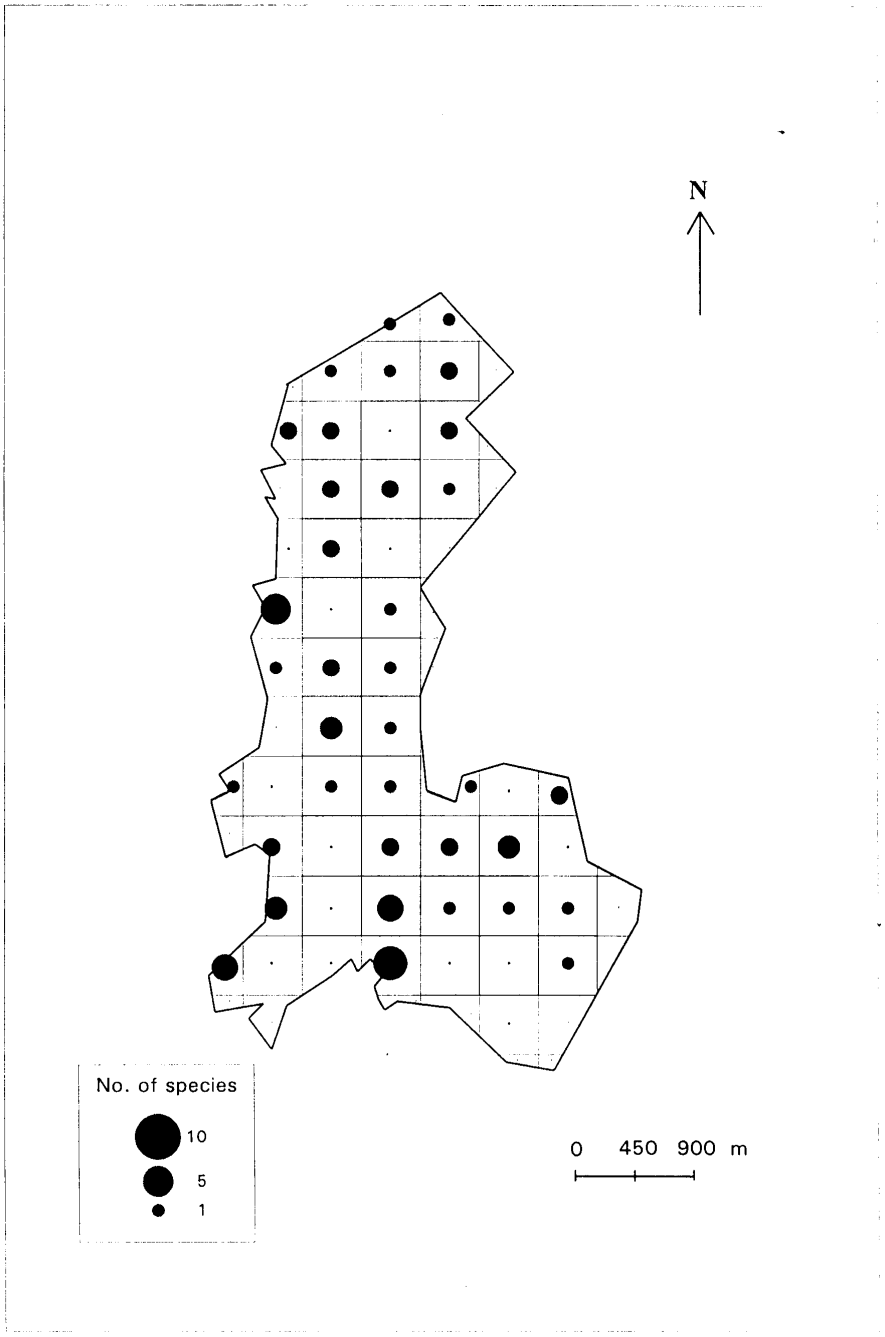

Figure 10. Distribution of submontane tree and shrub species.

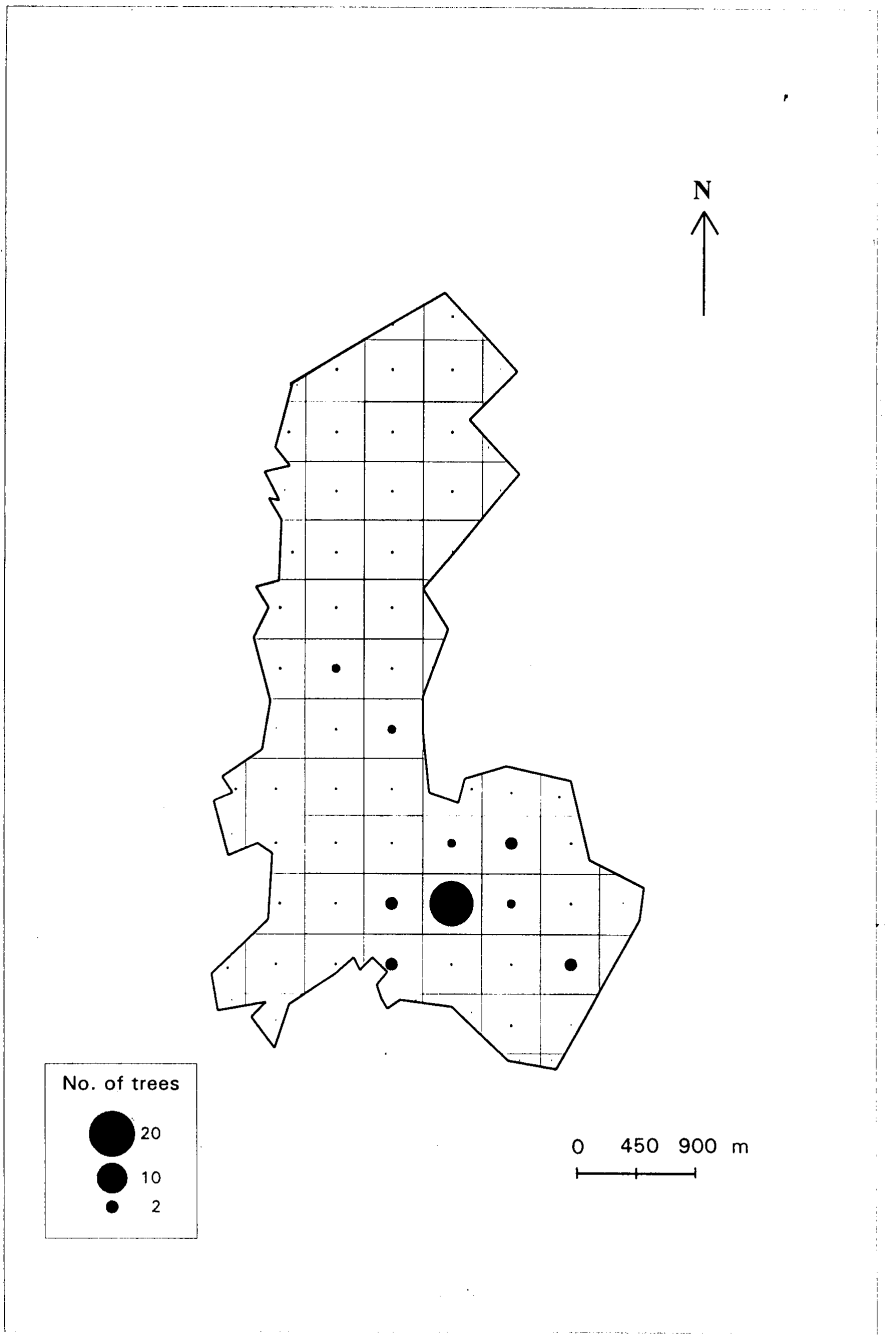

Figure 11. Distribution of endemic tree and shrub individuals.

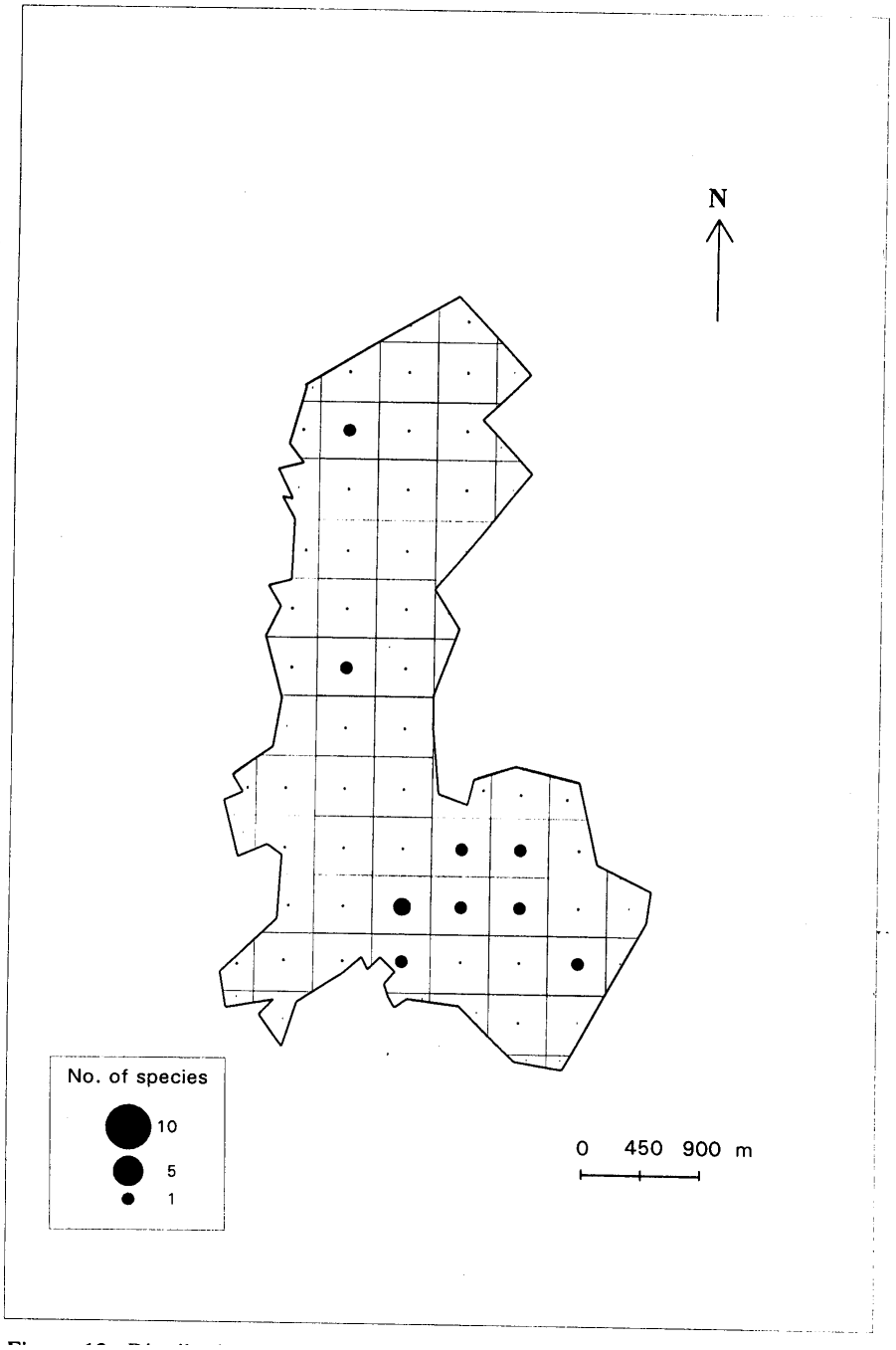

Figure 12. Distribution of endemic tree and shrub species.

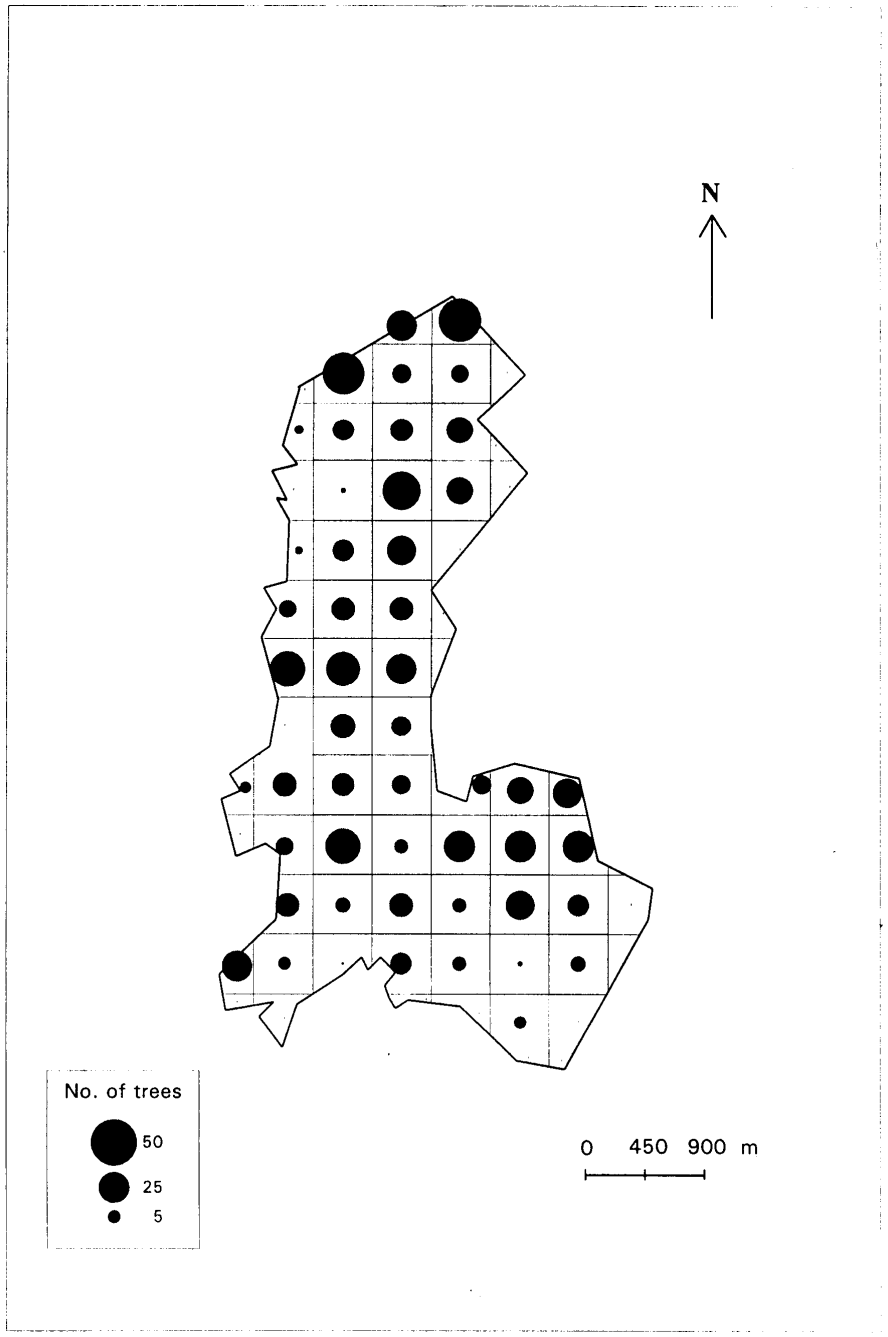

Figure 13. Distribution of near-endemic tree and shrub individuals.

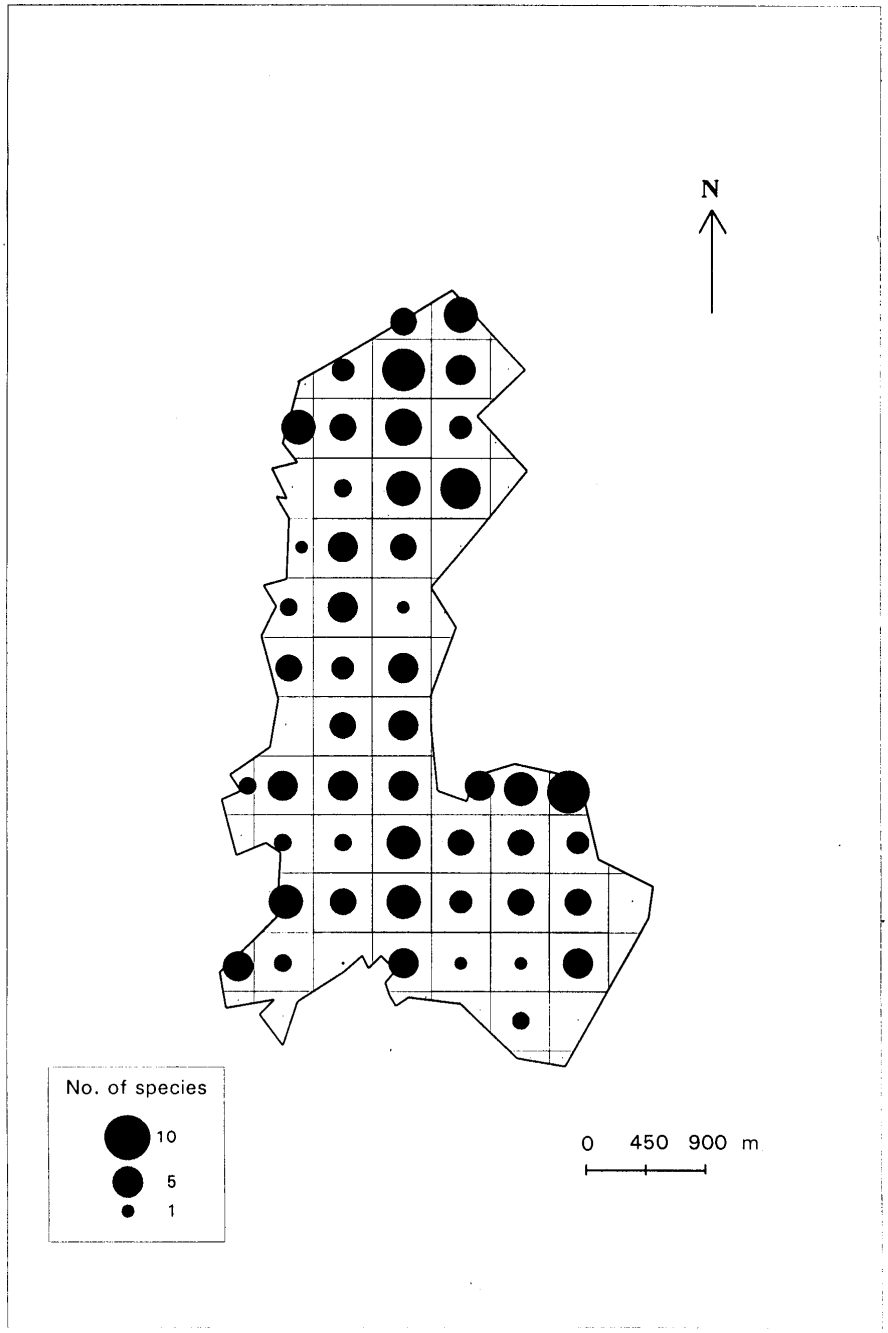

Figure 14. Distribution of near-endemic tree and shrub species.

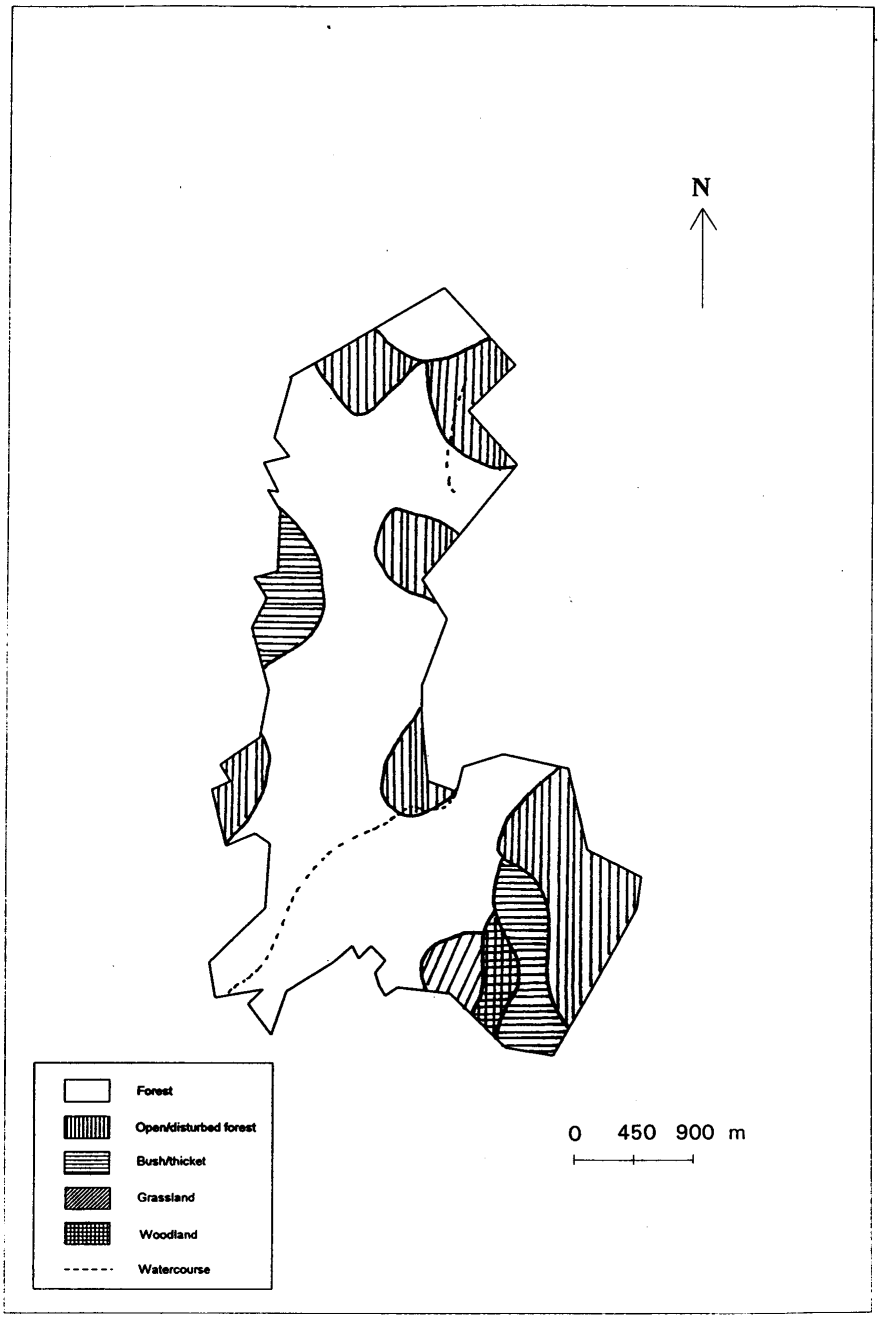

Figure 15. Vegetation of Kambai forest reserve.

5.3.2 Disturbance transects

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

Table 9. Disturbance transect results for pole counts.

Transect number	Length of transect (m)	Total poles sampled	Cut poles	Average per 100 metres	Naturally fallen poles	Average per 100 metres
1	100	99	21	**21.0**	78	**78.0**
2	2025	438	139	**6.9**	299	**14.8**
3	2650	397	64	**2.4**	333	**12.6**
4	2600	370	26	**1.0**	344	**13.2**
5	2800	306	168	**6.0**	138	**4.9**
6	1000	253	152	**15.2**	101	**10.1**
7	1150	359	98	**8.5**	261	**23.0**
8	1250	826	50	**4.0**	776	**62.1**
9	1200	459	247	**20.6**	212	**17.7**
10	1300	473	276	**21.2**	197	**15.2**
11	1550	394	85	**5.5**	309	**19.9**
12	1300	29	6	**0.5**	23	**1.8**
13	1000	521	194	**19.4**	327	**32.7**

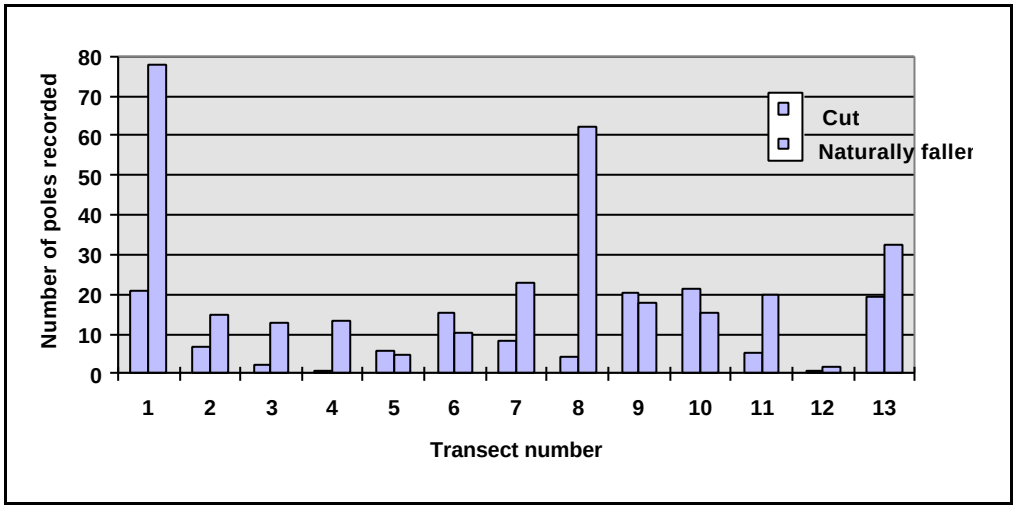

Figure 16. Cut and naturally fallen poles recorded per 100 metres by transect.

Table 10. Disturbance transect results for timber counts.

Transect number	Length of transect (m)	Total timber sampled	Cut timber	Average per 100 metres	Naturally fallen timber	Average per 100 metres
1	100	16	1	**16.0**	15	**15.0**
2	2025	73	6	**0.3**	67	**3.3**
3	2650	97	1	**0.04**	96	**3.6**
4	2600	163	13	**0.5**	150	**5.8**
5	2800	94	15	**0.5**	89	**3.2**
6	1000	86	12	**1.2**	74	**7.4**
7	1150	116	1	**0.09**	115	**10.0**
8	1250	240	1	**0.08**	239	**19.1**
9	1200	62	16	**1.3**	48	**4.0**
10	1300	140	32	**2.5**	108	**8.3**
11	1550	206	3	**0.2**	203	**13.1**
12	1300	36	1	**0.08**	35	**2.7**
13	1000	118	10	**1.0**	108	**10.8**

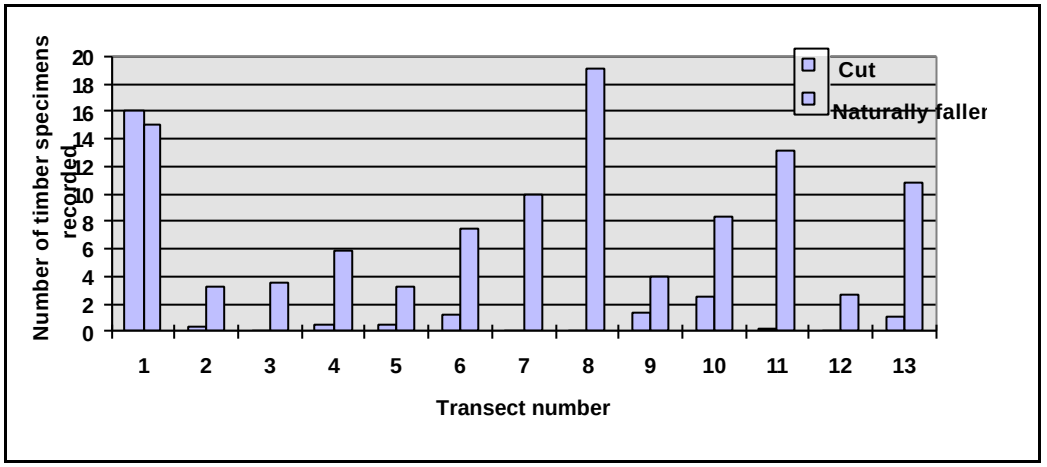

Figure 17. Cut and naturally fallen timber recorded per 100 metres by transect.

Table 11. Other human disturbance recorded in the forest on an *ad lib.* basis other than pole and timber cutting.

Transect no.	Disturbance
1	fire
2	fire (plot 34); previously cultivated (plot 31); cassava plants; pitsaw; traps
3	traps (plot 33); previously cultivated (plot 33); fire (plot 45); gun shot & dogs heard
4	none recorded
5	logging (plot 13); gun shots heard
6	none recorded
7	none recorded
8	none recorded
9	previously cultivated (plot 28, 29); fire-not recent (plot 30)
10	trap (plot 38);camp site
11	none recorded
12	logging (plot 48)
13	none recorded

5.4 Summary

Kambai forest reserve covers an area of 1046.3 ha with altitudes ranging from 200 to 870 m. From the survey, 2,080 trees and shrubs were recorded, representing 162 species from 38 families.

Of the 49 plots systematically surveyed, 32 (65.3%) were recorded as mature mixed forest, 11 (22.5%) as colonising, poorly stocked forest or formerly disturbed, 1 (2.0%) as open woodland, 4 (8.2%) as bushland/thicket, and 1 (2.0%) as grassland.

Species Accumulation Rates

The species accumulation rate appears to be approaching a plateau indicating that the majority of the vascular plants of the size 10 cm dbh and larger were identified in Kambai forest reserve.

Ecological Type

Forest dependent species, defined as limited to primary forest only, were recorded 611 times. This represents 29.4% of all specimens recorded. Forest dependent individuals are distributed throughout the reserve except in the south-east corner an area characterised by scrub and thicket. The most common forest dependent tree is *Millettia oblata.* Seventeen of the forest dependent species are also endemic or near-endemic to the Usambaras.

Eighteen non-forest species were recorded in 73.5% of the plots (36 plots). *Millettia stuhlmannii* is the most common non-forest species.

Habitat

Approximately two-thirds of the tree species surveyed with known altitude characteristics are considered to be typical of lowland forest and one-third are considered typical of submontane forest. Submontane species are found throughout the reserve occurring in 74% of the plots surveyed in the lowland forest. This data serves to further clarify the ecological requirements and niches of these submontane species.

Endemic Status

Of the plant species recorded, 112 (69.6%) have widespread distributions. Near-endemics contribute 35 species (21.7%) from 16 families to the floristic composition of the reserve. These near-endemics are found throughout the reserve occurring in every plot surveyed and account for 819 of the surveyed specimens or 39.4% of all recorded trees and shrubs in the reserve. Of the 50 plots surveyed, 34 (68.0%) have >10 near-endemics. The most common near-endemics in the reserve are *Millettia oblata* and *Scorodophloeus fischeri*. Of these 35 near-endemic species, 15 species are also considered to be forest dependent.

Only two of the species surveyed are endemic to the Usambaras. These endemics are: *Cola usambarensis*, found only in the East Usambaras and *Rinorea angustifolia* found in

the East and West Usambaras. The former is a submontane species represented by 33 individuals from 10 plots and the latter is a lowland species represented by only one individual. Both are forest dependent species (Iversen, 1991).

Range Extensions

The record of *Monodora minor* in Kambai forest reserve represents a range extension (Flora of Tropical East Africa, FTEA). It previously was considered restricted within the coastal forests (Hawthorne, 1993).

Nesogordonia holtzii is a coastal endemic (Hawthorne, 1993). This species may also represent a range extension however the FTEA has not yet been published for this family.

Disturbance

Disturbance by pole and timber extraction was recorded at lower rates than naturally fallen trees. Other disturbances, such as fire, traps and cultivation were recorded on about half the transects in the reserve. For the reserve as a whole, rate of pole cutting occurred between 0.5 and 21.2 per 100 m and for timber cutting, 0.04 to 16.0 per 100 m.

The highest concentration of pole and timber disturbance occurred on the southern end of the reserve, transect 1. This transect is located 450 m from the forest boundary and is an area of scrubland/thicket. Cleared areas and evidence of fire were observed frequently. This area therefore presents no apparent threat to the integrity of the forest as few near-endemics and forest dependent trees and shrubs were recorded there.

Transect 6 and 10, recorded a higher than the average reserve rate of both timber and pole extraction. Both transects are characterised by dense forest.

Transect 9 and 13 were recorded with higher than the average rate of pole extraction. Transect 13 is the most northerly transect of the reserve. It has a relatively high number of near-endemics and an average number of forest dependent trees and shrubs. It is characterised by dense forest. Transect 9 is an area that was previously disturbed and is now open forest.

Endemic species are found almost exclusively in areas that are considered lower in disturbance (see Figures 18 and 19) whereas near-endemics are found in areas of high and low disturbance (see Figures 20 and 21).

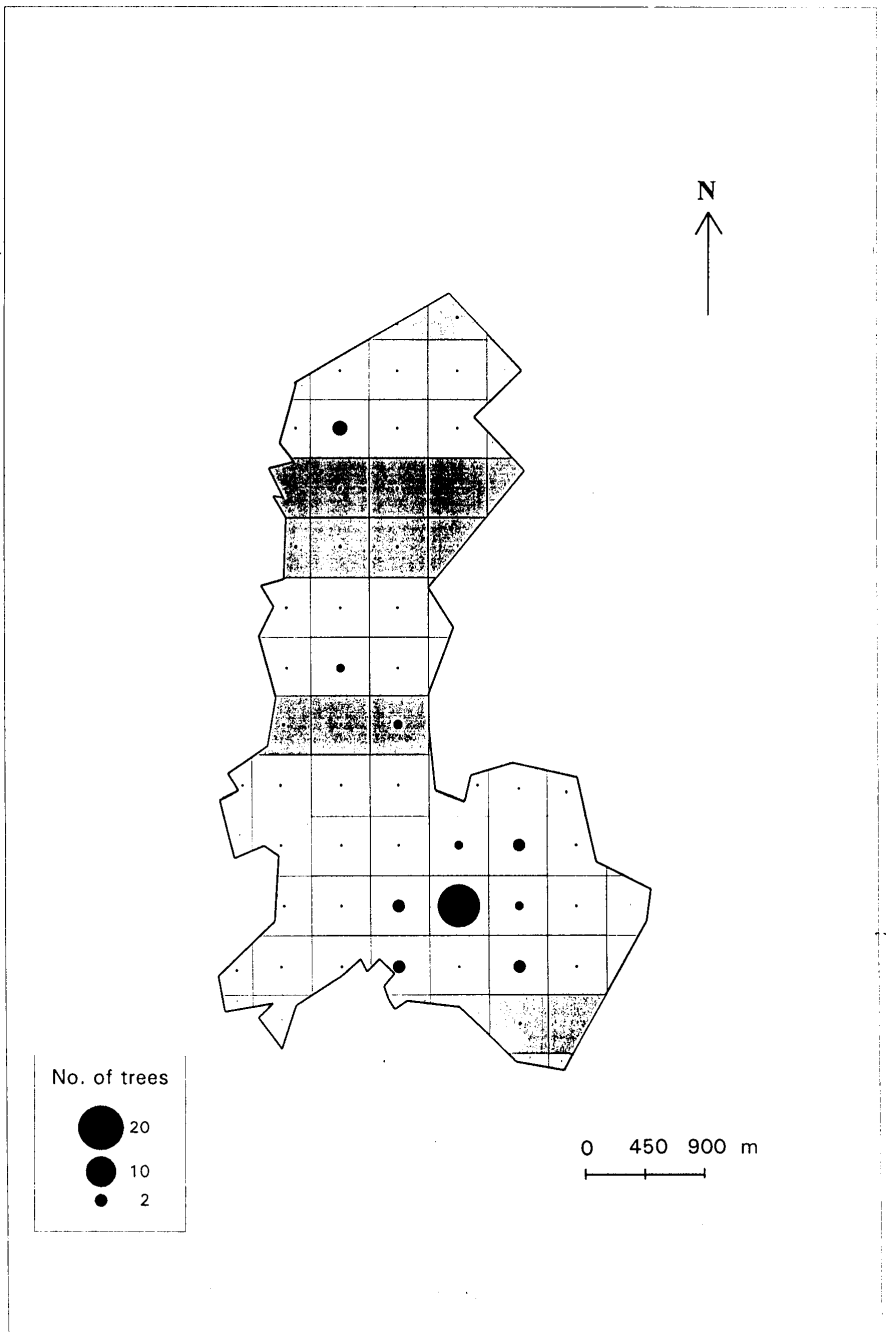

Figure 18. Areas of highest disturbance in relation to the distribution of tree and shrub individuals that are both forest dependent and endemic.

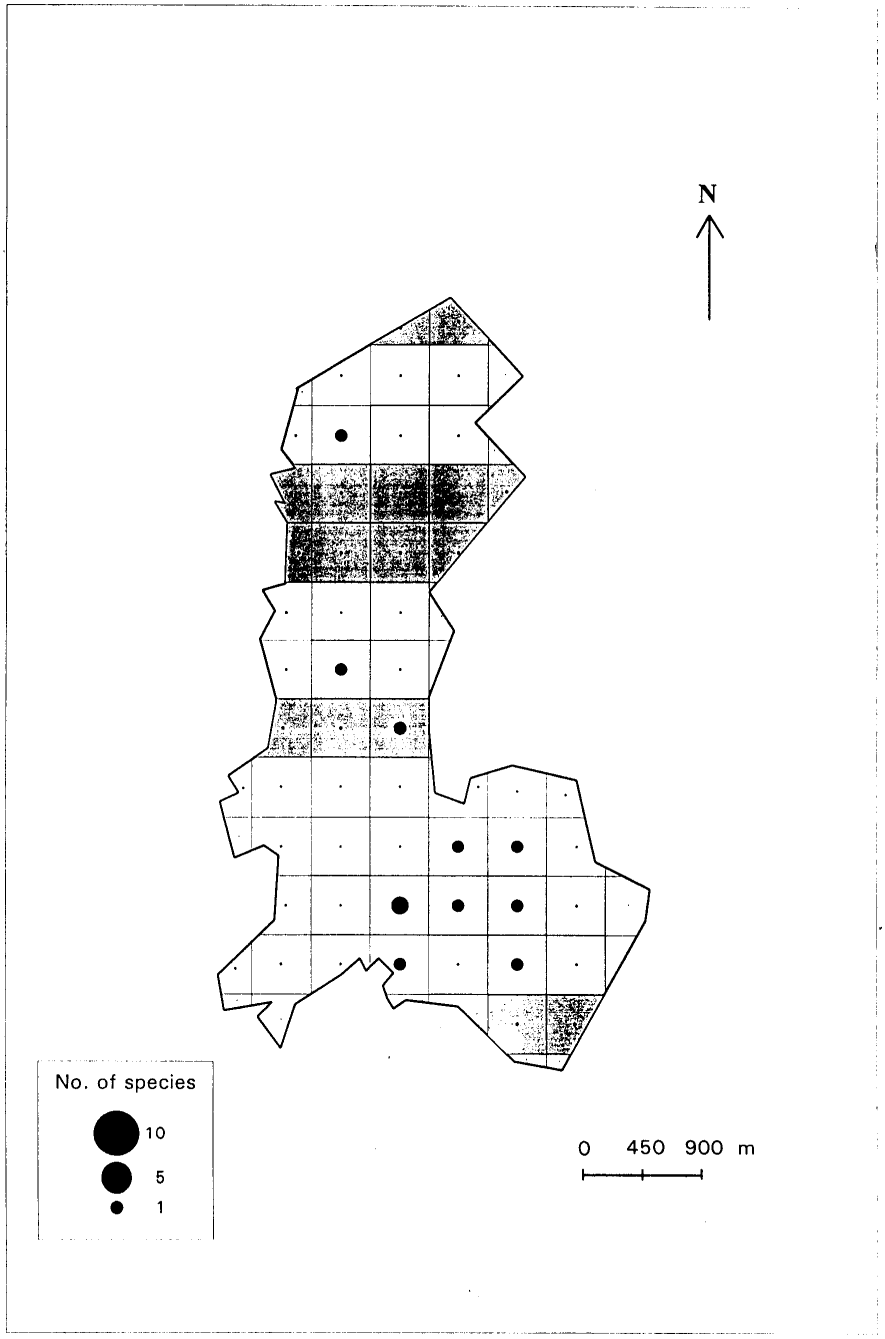

Figure 19. Areas of highest disturbance in relation to the distribution of tree and shrub species that are both forest dependent and endemic.

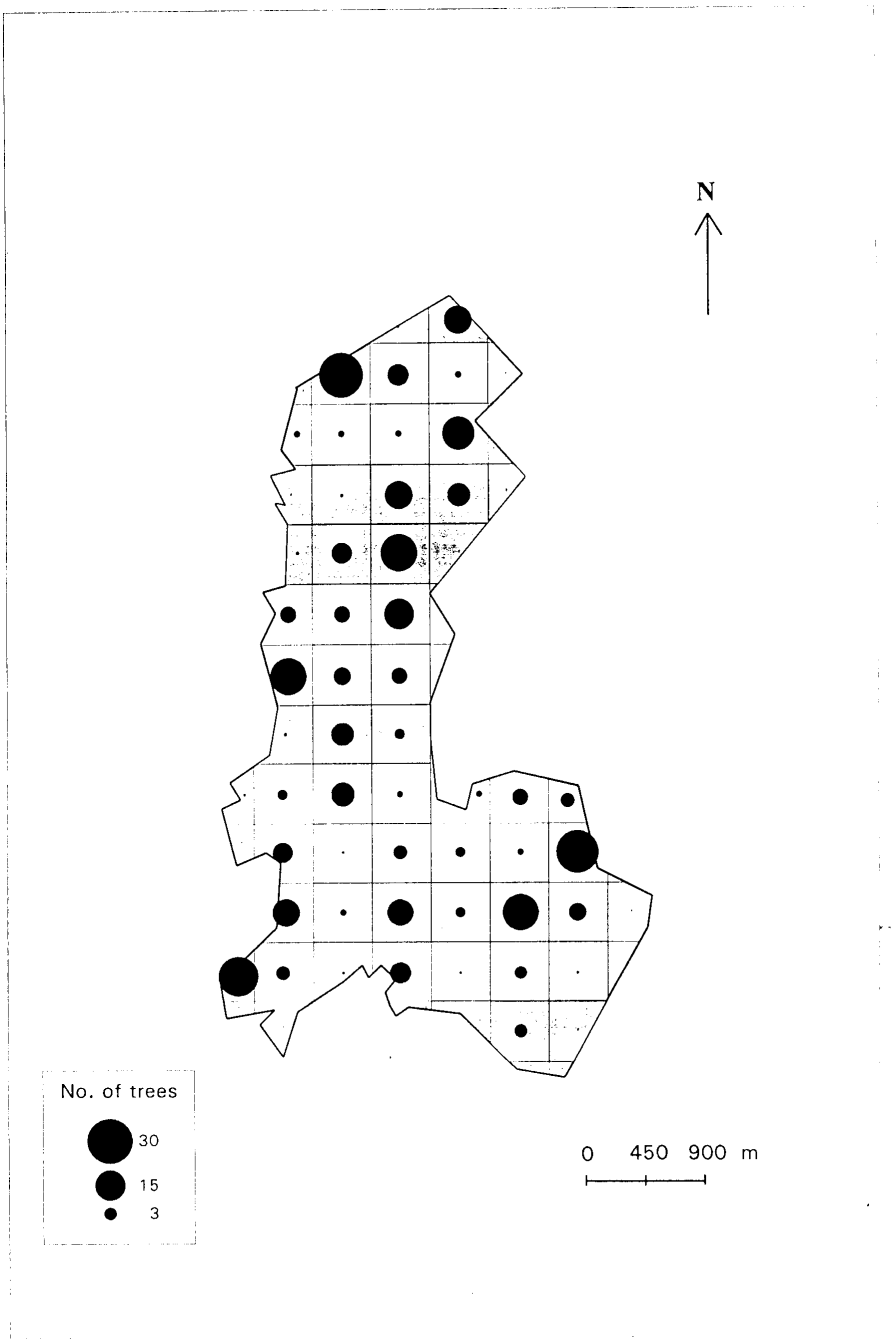

Figure 20. Areas of highest disturbance in relation to the distribution of tree and shrub individuals that are both forest dependent and near-endemic.

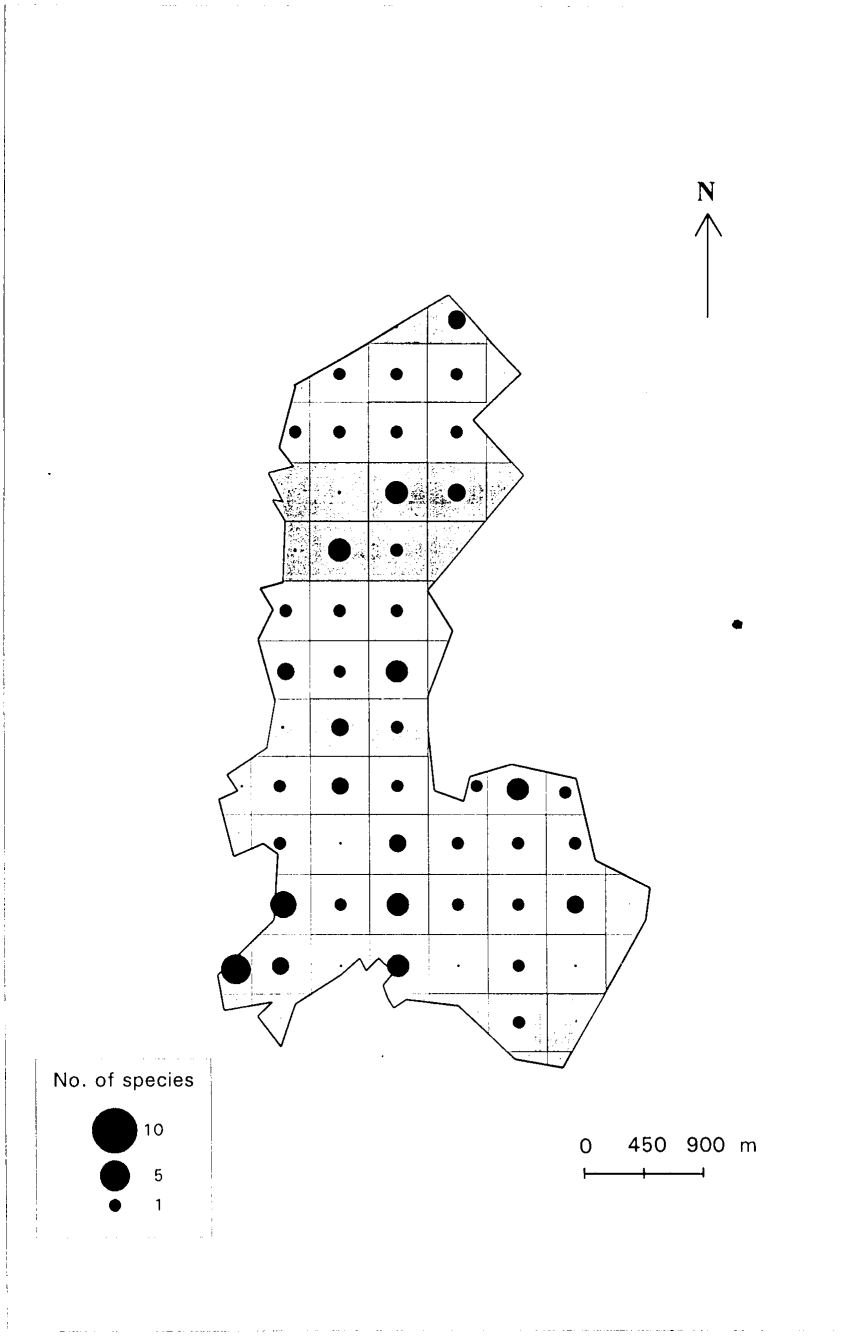

Figure 21. Areas of highest disturbance in relation to the distribution of tree and shrub species that are both forest dependent and near-endemic.

6.0 ZOOLOGY

6.1 Introduction

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

6.2 Methods

Five plots were chosen as trapping sites. In each plot standardised methods were used. These methods are outlined in detail in the FR FRP methodologies report (SEE, 1996). A brief description is presented below. The location of trap sites are presented in Figure 22.

6.2.1 Mammals

Four methods were used to sample the mammal community within Kambai forest reserve: (1) snap trap lines, (2) bucket pitfalls, (3) bat netting and (4) opportunistic observations.

6.2.1.1 Snap-trap lines

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

6.2.1.2 Bucket pitfall trapping

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

6.2.1.3 Bat netting

Bat mist netting was used to collect and study a representative sample of the forest bat community, and also provide data on species' ranges. Mist nets were placed near potential

roosts sites and across obvious flight "corridors", such as paths and rivers. Nets were set up at dusk, observed continuously throughout the night and closed shortly before dawn. Each bat caught was weighed and measured at the netting site. Trapping and biometric information was recorded on standardised data sheets. Unless otherwise indicated, taxonomic identification was made by Prof. K. Howell or Dr. Dieter Kock (see Appendix 2).

6.2.1.4 Mammal observations

Other vertebrate species were recorded opportunistically throughout the survey.

6.2.2 Birds

The aim of this study was to provide information concerning the presence of endemic and near-endemic birds of the reserve. However, as an experienced ornithologist was not present during the survey period, the results of an avifaunal survey conducted by the Cambridge-Tanzania Rainforest Project (1994), are presented here.

6.2.3 Reptiles

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

6.2.4 Amphibians

The aim of this study was to collect and identify a representative sample of the forest amphibian community. The community of ground-dwelling amphibians was sampled using the bucket pitfall method (see 6.2.1.2 above). Opportunistic captures were also conducted, especially in reference to tree frog collections since they are often beyond capture with the bucket pitfalls. After rain, typical amphibian habitats were targeted for sampling. Unless otherwise indicated, taxonomic identifications were made by Prof. Kim Howell or by Prof. John Poynton (see Appendix 2).

6.2.5 Invertebrates

Two methods were employed to sample the invertebrate community within the study site: (1) invertebrate pitfall trapping; (2) malaise trapping.

6.2.5.1 Invertebrate pitfall trapping

This method was used to sample the invertebrate ground (forest floor) dwelling community. Four 1.5 litre pots were sunk flush with the level of the ground. Plastic sheeting was erected between the pots using wood stakes to keep the plastic sheeting perpendicular to the ground surface. A lip of plastic sheeting was kept on the ground on to which soil and leaf litter was placed. The pots were placed in a star arrangement with one central pot and the other three set so that the plastic sheeting was positioned at an angle of 120^{o} from the next line of plastic sheeting. Each length of plastic sheeting was 2.5 m. Approximately 1/4 litre of 10% formalin is put in each pot. A few drops of washing-up liquid was added to reduce surface

water tension. The trap was then left for 5 days before collection. Specimens were identified and sorted to order level in the field. These specimens were sent for curation at the Zoological Museum, University of Copenhagen. Specific groups will then be sent on to individual taxonomists.

6.2.5.2 Malaise trapping

This method was used to sample the flying invertebrate community. Sites for trap placement were selected at natural flyways, such as wet or dry watercourses and paths. The malaise trap was raised into the tree canopy thereby sampling the flying invertebrate forest community. Approximately 1/4 litre of 10% formalin was used in the collecting pot of the trap. The trap was then left for approximately 10 days before collection. Specimens were identified and sorted to order level in the field. These specimens were sent for curation at the Zoological Museum, University of Copenhagen. Specific groups will then be sent on to individual taxonomists.

6.3 Trapping sites and sampling intensity

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

Table 12. Summary descriptions of trapping sites.

Plot number	Vegetation type	Altitude (metres)	Topography	Slope (degrees)
1	lowland forest (riverine)	220	lower slope	5
8	lowland forest (riverine; rocky outcrops; *Pandanus*)	205	bottom of hill	0
15	lowland forest (mature mixed forest)	355	mid-slope	20
30	lowland forest (open forest)	475	mid-slope	25
52	lowland forest (grassy understory)	595	mid-slope	31

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

Trapping method	Plot 1	Plot 15	Plot 52	Plot 8	Plot 30
Date	**Jan 28-Feb 6**	**Feb 7-16**	**Feb 17-26**	**Feb 27-Mar 7**	**Mar 9-18**
small snap traps	234	225	250	250	246
large snap traps	788	725	500	497	500
live traps**	24	0	8	72	32
bucket pitfall	340	330	330	330	330
invertebrate pitfall	10	10	10	10	10
malaise	0	10	10	10	10

*Differences in sampling intensity are due to broken or lost equipment, or delay due to weather conditions.

** No captures were made with any of the live traps.

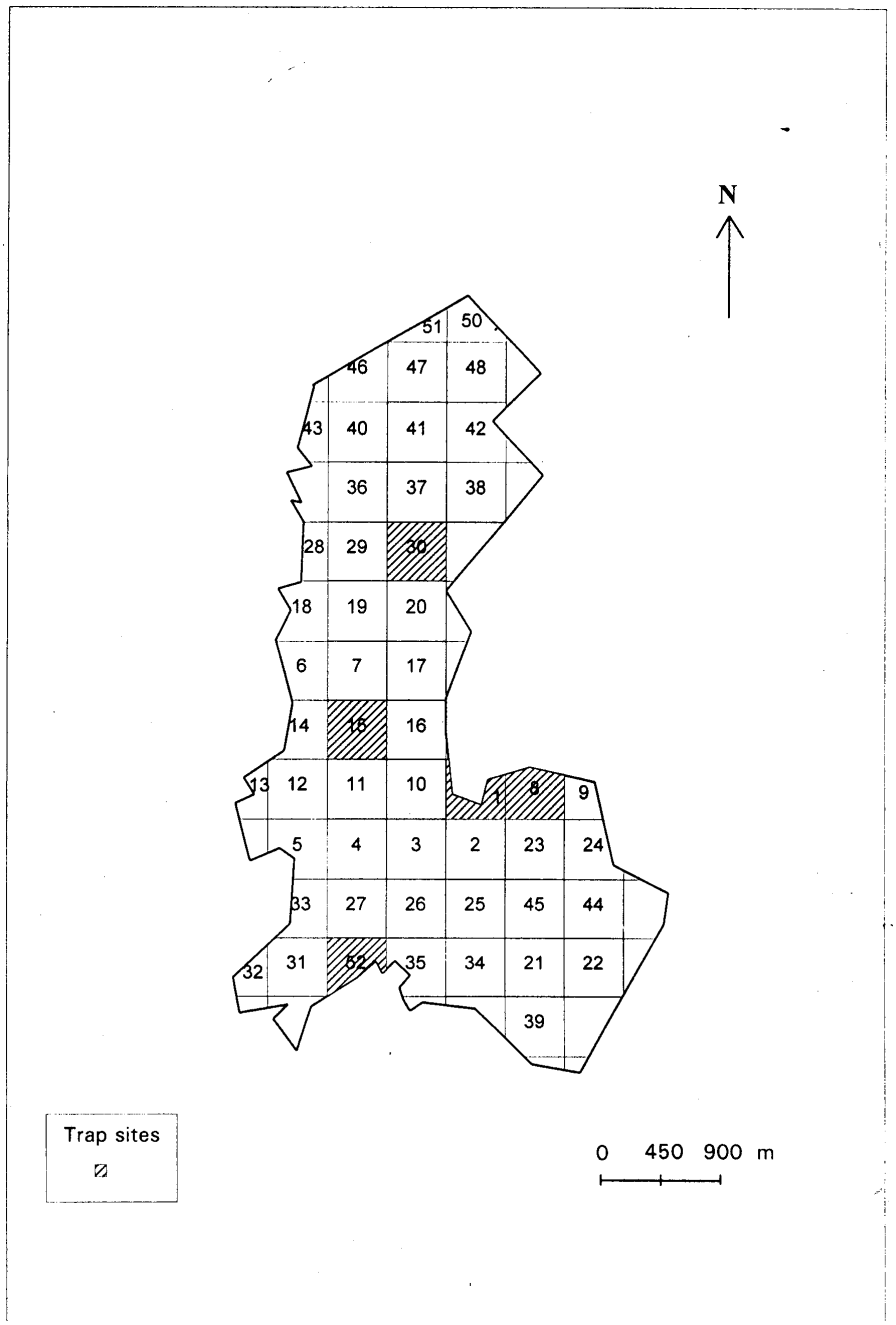

Figure 22. Location of trapping sites.

6.4 Results

6.4.1 Mammals

6.4.1.1 Mammals (non-bats)

A total of 21 specimens were retained for taxonomic purposes. These represent nine species from four families. Ecological type, endemic status and IUCN status were compiled from the National Biodiversity Database (UDSM, 1997) and Kingdon (1989).

Table 14. Summary of mammals (non-bats).

Species	Ecological type	Endemic status	IUCN status	Capture location by plot & number collected					
				1	**8**	**15**	**30**	**52**	**Total**
Soricidae									
Crocidura nanilla	O	W		1	1		1	1	**4**
Crocidura luna	f	W		5			1		**6**
Crocidura xantippe	?	N	E	1					**1**
Crocidura occidentalis martiensseni	?	W				1		1	**2**
Crocidura jacksoni	?	W						1	**1**
Cricetidae									
Beamys hindei	f	N	DD		1	1		1	**3**
Muridae									
Hylomyscus denniae	F	W		1					**1**
Rattus rattus	O	W			1	1			**2**
Myoxidae									
Graphiurus murinus	f	W			1				**1**

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

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

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

IUCN status:
- E - Endangered
- V - Vulnerable

6.4.1.2 Opportunistic Observations

A total of 11 species from eight families were observed but not retained for taxonomic purposes. Ecological type, endemic status and IUCN status were compiled from the National Biodiversity Database (UDSM, 1997) and Kingdon (1989).

Table 15. Summary of mammal observations.

Species	Certainty	Ecological type	Endemic status	IUCN status	Observation location by plot
Galagonidae					
Galago zanzibaricus	definite	f	W	NT	16
Cercopithecidae					
Cercopithecus mitis	definite	f	W		1,2,13,16,20,23,27,29 ,42,43,44,45,48,49,50 , 52
Cercopithecus aethiops	definite	f	W		4,13,26,52
Papio cynocephalus	definite	f	W		OR
Colobus angolensis	definite	F	W		1,2,7,25
Viverridae					
Genetta sp.	definite	?	?		OR
Procaviidae					
Dendrohyrax validus	definite	f	W	V	?
Suidae					
Potamochoerus porcus	probable	f	W		?
Cricetidae					
Cricetomys gambianus	definite	O	W		1
Thryonomyidae					
Thryonomys sp.	probable	f	W		OR
Macroscelididae					
Petrodromus tetradactylus	definite	f	W		1

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

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

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

IUCN status:
- V- Vulnerable
- NT - Near-threatened

OR: Refers to observations outside but in proximity to the reserve to be considered associated to it.
?: No data available
Certainty: Indicates the probability of the correctness of the identity of the species observed;
Definite: Can be regarded as occurring in the reserve.
Probable: Identification is likely but requires confirmation before placing on the reserve's species list.

6.4.1.3 Bats

A total of 20 specimens were retained for taxonomic purposes. These represent 16 species from five families. Ecological type and endemic status were compiled from the National Biodiversity Database (UDSM, 1997), Howell (1993) and Kingdon (1989).

Table 16. Summary of bats.

Species	Ecological type	Endemic status	Number collected[1]
Rhinolophidae			
Rhinolophus eloquens	?	W	**1**
Rhinolophus deckenii	f	W	**1**
Rhinolophus swinnyi	F	N	**1**
Nycteridae			
Nycteris hispida	f	W	**1**
Nycteris thebaica	f	W	**1**
Nycteris macrotis	f	W	**1**
Hipposideridae			
Hipposideros ruber	f	W	**1**
Hipposideros caffer	?	W	**1**
Vespertilionidae			
Myotis bocagei spp. *hildegardeae*	f	W	**1**
Scotophilus nucella	f	W	**1**
Pipistrellus flavescens	?	?	**4**
Miniopterus m. minor	f	W	**2**
Kerivoula argentata	f	W	**1**
Pteropodidae			
Rousettus aegyptiacus spp. *leachi*	f	W	**1**
Lissonycteris angolensis	F	W	**1**
Epomophorus wahlbergi	F	W	**1**

[1] Capture sites not available

KEY TO ABBREVIATIONS FOR TABLE 16 (Definitions based on those described in the botanical section of this report).

Ecological type:

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

Endemic status:

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

Table 17. Ranges of near-endemic mammal species recorded (National Biodiversity Database, UDSM, 1997).

Near-endemic species	Range
Crocidura xantippe	Usambara Mts.; Nyiru; Voi; Tsavo
Beamys hindei	coastal forests, Tanzania; S.E. Kenya

Rhinolophus swinnyi	Usambaras; Zanzibar

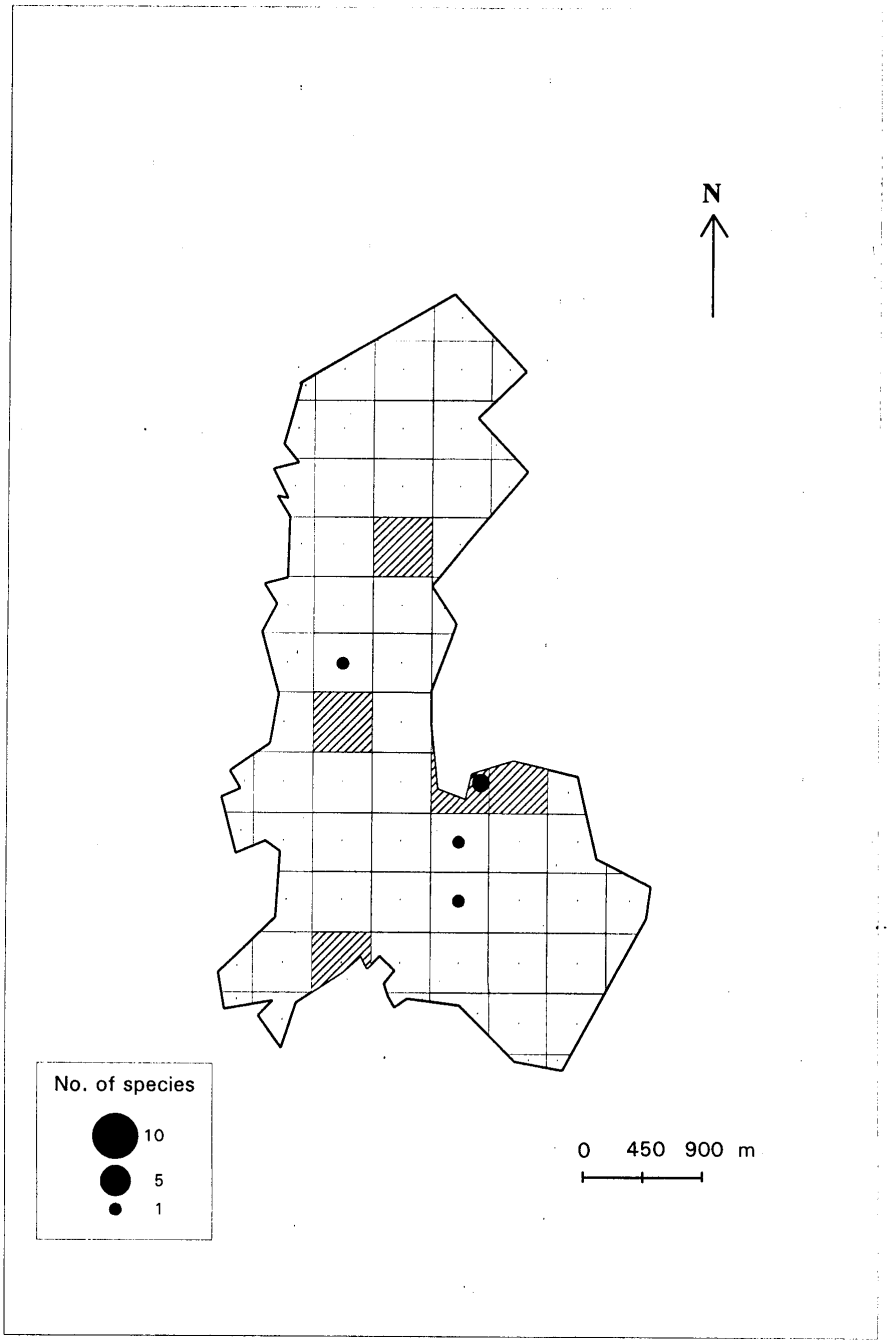

Figure 23. Distribution of forest dependent mammal species.

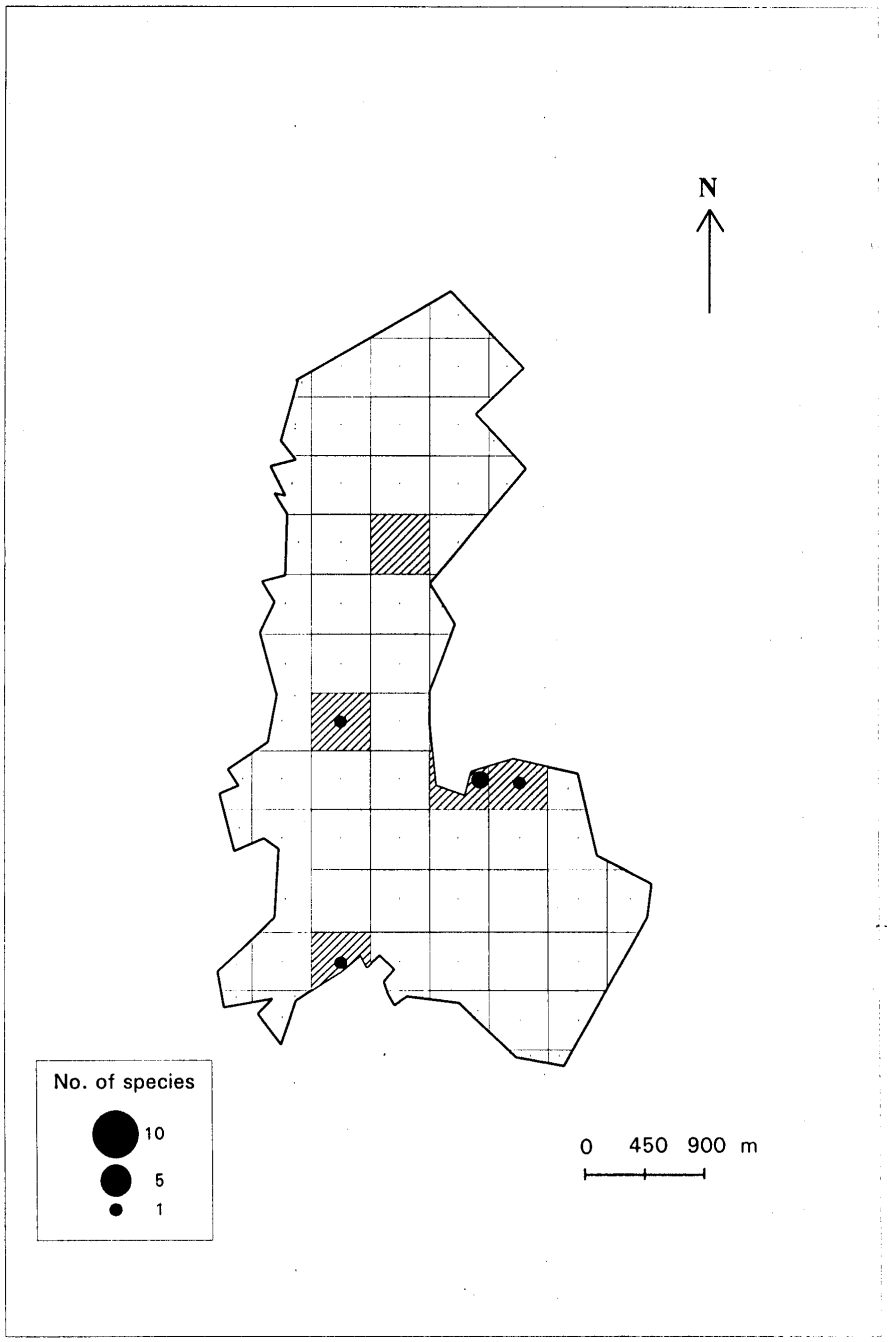

Figure 24. Distribution of near-endemic mammal species.

6.4.2 Birds

There was not an ornithologist present for the survey, however, as birds are a valuable indicator of habitat quality and biodiversity measures, we include here a summary of important or interesting birds recorded in Kambai forest reserve during the Cambridge-Tanzania Rainforest Project (1994). These specimens represent eleven species from nine families. Ecological type, endemic status and IUCN status were compiled from the National Biodiversity Database (1997) and Zimmerman *et al.* (1996).

Table 18. Summary of birds.

Species	Common name	Ecological type	Endemic status	IUCN status
Columbidae				
Columba delgorguei	Bronze-naped pigeon	F	W	
Strigidae				
Bubo vosseleri	Usambara eagle owl	F	E	V (CITES II)
Otus irenae	Sokoke scops owl	F	N	E (CITES II)
Picidae				
Campethera mombassica/abingoni	Mombasa/Golden-tailed woodpecker	f	W	
Turdidae				
Sheppardia gunningi	East coast akalat	F	N	V
Swynnertonia swynnertoni	Swynnerton's forest robin	F	N	NT
Sylviidae				
Hyliota australis spp. *usambarae*	Southern hyliota	F	E	
Nectariniidae				
Anthreptes neglectus	Uluguru violet-backed sunbird	F	W	
Anthreptes pallidigaster	Amani sunbird	F	N	NT
Anthreptes reichenowi	Plain-backed sunbird	F	W	
Estrildidae				
Spermophaga ruficapilla	Red-headed bluebill	F	W	

KEY TO ABBREVIATIONS FOR TABLE 18 (Definitions based on those described in the botanical section of this report).

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

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

IUCN status:
- E - Endangered
- V - Vulnerable
- NT - Near-threatened

Table 19. Ranges of endemic and near-endemic bird species recorded (Zimmerman, 1996).

Endemic Species	**Range**
Bubo vosseleri	Usambara Mts.
Hyliota australis spp. *usambarae*	Usambara Mts.
Near-endemic Species	**Range**
Otus irenae	East Usambara; coastal forest
Sheppardia gunningi	coastal forests; Kenya; Malawi; Mozambique
Swynnertonia swynnertoni	East Usambara; Udzungwa; Zimbabwe; Mozambique
Anthreptes pallidigaster	East Usambara Mts. Sokoke forest, Kenya

6.4.3 Reptiles

A total of 48 specimens were retained for taxonomic purposes and two species were observed. These represent 18 species from seven families. Ecological type, endemic status and IUCN status were compiled from the National Biodiversity Database (UDSM, 1997), Broadley and Howell (unpubl.); Howell (1993); and Branch (1994).

Table 20. Summary of reptiles.

Species	**Ecological type**	**Endemic status**	**IUCN status**	**Capture location by plot and number collected**								
				1	**8**	**15**	**30**	**52**	**Alt. (m) ***	**OR**	**UK**	**Total**
Leptotyphlops												
Leptotyphlops macrops	?	?	V	1								**1**
Colubridae												
Lycophidion capense spp *loveridgei*	F	W							250			**1**
Natriciteres olivacea	f	W							200			**1**
Aparallactus werneri	F	N	V			1		1				**2**
Philothamnus macrops	F	N	V						200, 335	1		**3**
Philothamnus punctatus	f	W								1		**1**
Crotaphopeltis tornieri	F	W	V		1		1		200			**3**
Cordylidae												
Cordylus t. tropidosternum	f	W				1	3					**4**
Scincidae												
Melanoseps loveridgei	F	N						1				**1**
Mabuya m. maculilabris	f	W	V	2	1	1		2		1		**7**
Agamidae												
Agama mossambica	f	W								1	1	**2**
Chamaeleonidae												
Rhampholeon brevicaudatus	F	N	V	2			1					**3**
Gekkonidae												
Hemidactylus mabouia	f	W		3	1					1		**5**
Hemidactylus platycephalus	f	W		1						1	2	**2**
Cnemaspis barbouri	F	N	E	1	1		2	1	200 700		7	**7**
Lygodactylus kimhowelli	F	N	E							1	1	**1**

Table 21. Summary of reptile observations.

Species	Certainty	Ecological type	Endemic status	Observation location
Colubridae				
Thelotornis capensis	definite	f	W	plot 30
Varanidae				
Varanus niloticus	definite	f	W (CITES II)	OR

KEY TO ABBREVIATIONS FOR TABLE 20 & 21 (Definitions based on those described in the botanical section of this report).

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

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

IUCN status:
- E - Endangered
- V - Vulnerable

OR - Refers to observations outside but in proximity to the reserve to be considered associated to it.
? - Insufficient data
UK - Unknown capture location.
* In cases where the plot number is unknown, the altitude in metres is given. Each altitude represents one specimen captured.
Certainty: Indicates the probability of the correctness of the identity of the species observed;
Definite: Can be regarded as occurring in the reserve.
Probable: Identification is likely but requires further information before being considered on the reserve's species list.

Table 22. Ranges of near-endemic reptile species recorded (Howell, 1993).

Near-endemic species	Range
Aparallactus werneri	East Usambara; West Usambara; Uluguru; Coastal forest
Philothamnus macrops	East Usambara; Zanzibar; Rondo Plateau
Melanoseps loveridgei	East Usambara; Kiwengoma forest reserve
Rhampholeon brevicaudatus	East Usambara; Uluguru; Uzungwa; Coastal forest
Cnemaspis barbouri	East Usambara; Uluguru
Lygodactylus kimhowelli	East Usambara; Amboni Caves Forest

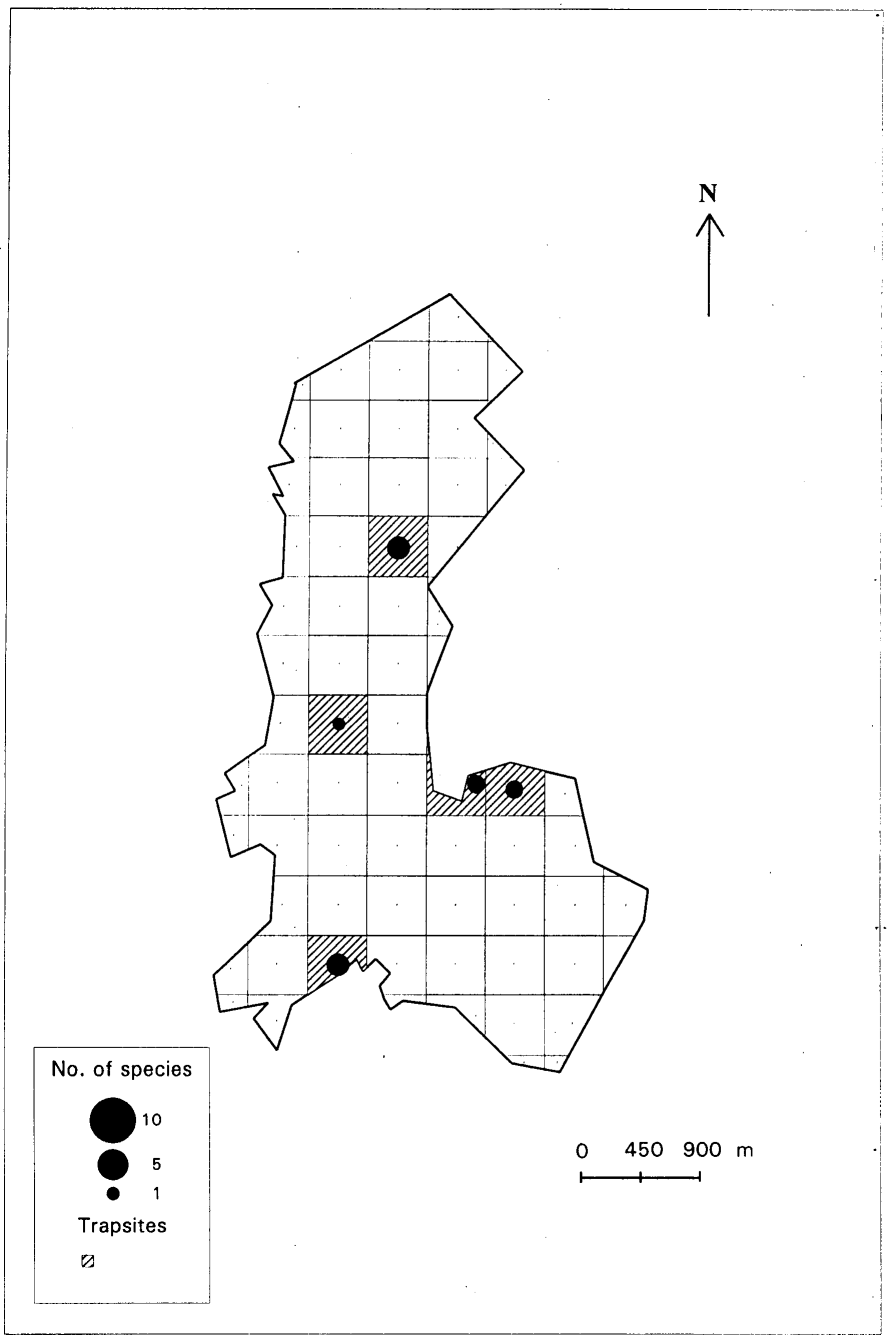

Figure 25. Distribution of forest dependent reptile species.

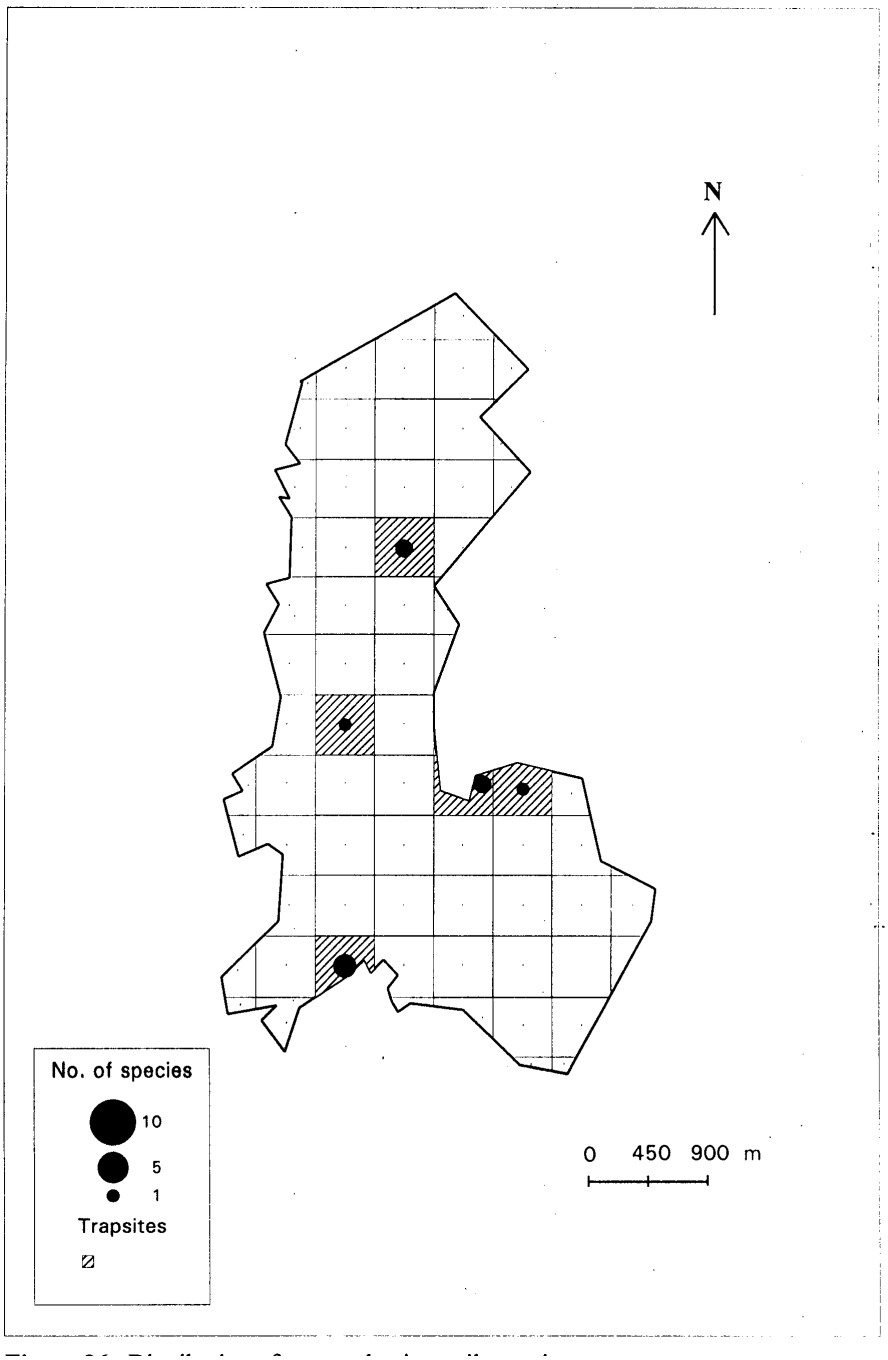

Figure 26. Distribution of near-endemic reptile species.

6.4.4 Amphibians

A total of 58 specimens were retained for taxonomic purposes. Those that have been identified to date are presented below. These represent 15 species from seven families. Ecological type, endemic status and IUCN status were compiled from the National Biodiversity Database (UDSM, 1997), Howell (1993); Poynton and Broadley (1991); and Poynton (unpubl.).

Table 23. Summary of amphibians.

Species	Ecol. type	End. status	IUCN status	Capture location by plot and number collected								
				1	7	8	15	30	52	OR	UK	Total
Arthroleptidae												
Arthroleptis stenodactylus	f	W					1		1	1		**3**
Arthroleptis xenodactyloides	f	W					1					**1**
Bufonidae												
Bufo brauni	F	N	V	4								**4**
Bufo gutturalis	f	W		1								**1**
Mertensophryne micranotis	F	N	E		1		1	1				**3**
Hemisidae												
Hemisus marmoratus spp. *marmoratus*	f	W				2			1			**3**
Hyperoliidae												
Leptopelis barbouri	F	N	V							1		**1**
Leptopelis flavomaculatus	F	W								7		**7**
Leptopelis uluguruensis	F	N	V								1	**1**
Leptopelis vermiculatus	F	N	NT							1		**1**
Hyperolius argus	f	W									1	**1**
Hyperolius mitchelli	F	W								1		**1**
Microhylidae												
Hoplophryne rogersi	F	E	V				1					**1**
Ranidae												**2**
Arthroleptides martiensseni	F	N	V							2		
Caeciliidae												
Boulengerula boulengeri	F	E	V	1				1	1			**3**

KEY TO ABBREVIATIONS FOR TABLE 23 (Definitions based on those described in the botanical section of this report).

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

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

IUCN status:
- E - Endangered
- V - Vulnerable

OR - Captured outside the reserve boundaries.
UK - Unknown capture location

- NT - Near-threatened

Table 24. Ranges of endemic and near-endemic amphibian species recorded (Howell 1993).

Endemic Species	**Range**
Hoplophryne rogersi	East Usambara; West Usambara
Boulengerula boulengeri	East Usambara; West Usambara
Near-endemic Species	**Range**
Bufo brauni	East Usambara; West Usambara; Uluguru; Uzungwa
Mertensophryne micranotis	East Usambara; Coastal forest
Leptopelis barbouri	East Usambara; Uzungwa mountains
Leptopelis uluguruensis	East Usambara; West Usambara; Uluguru; Uzungwa
Leptopelis vermiculatus	East Usambara; West Usambara; Southern Highlands
Arthroleptides martiensseni	East Usambara; West Usambara; Uluguru; Uzungwas

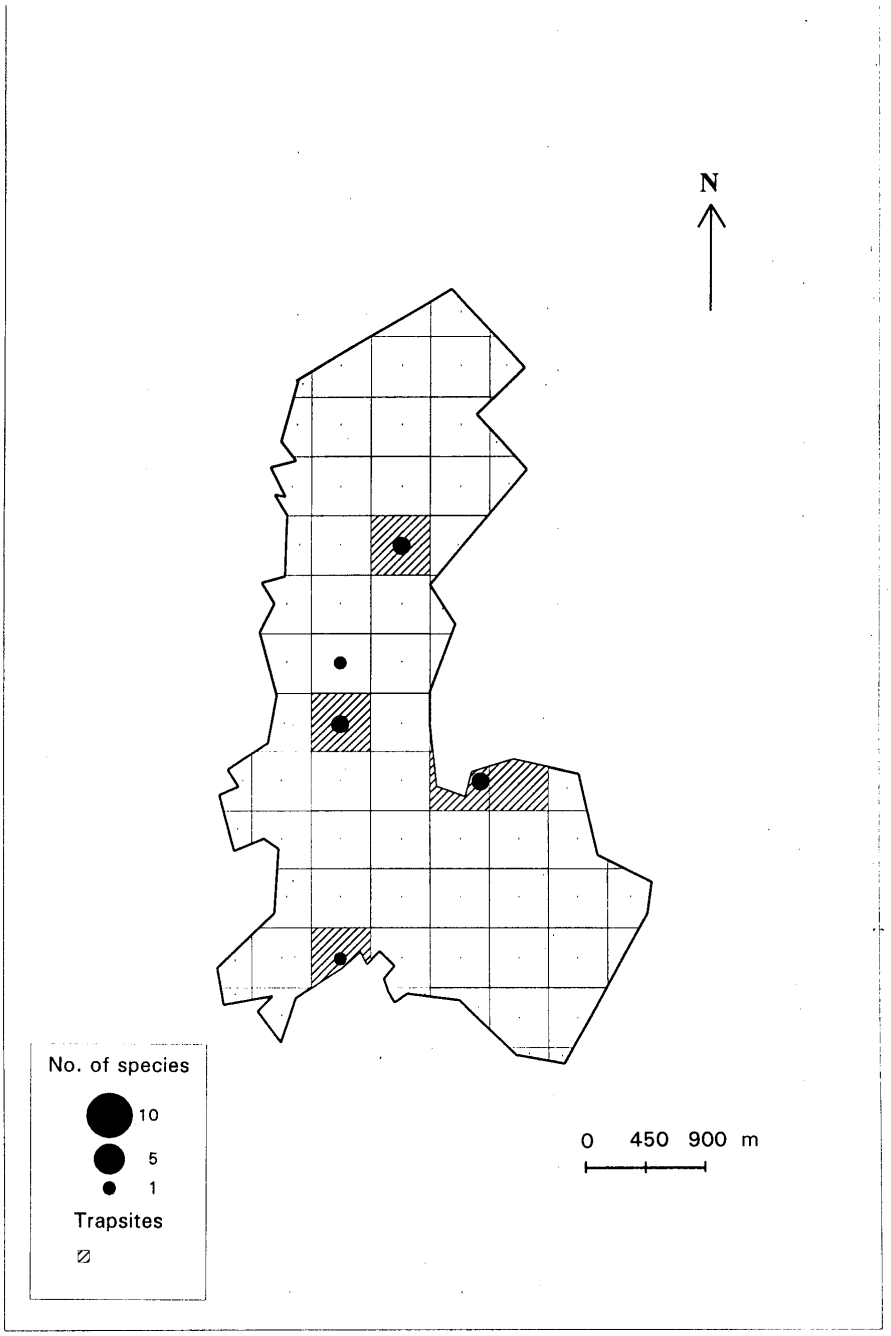

Figure 27. Distribution of forest dependent amphibian species.

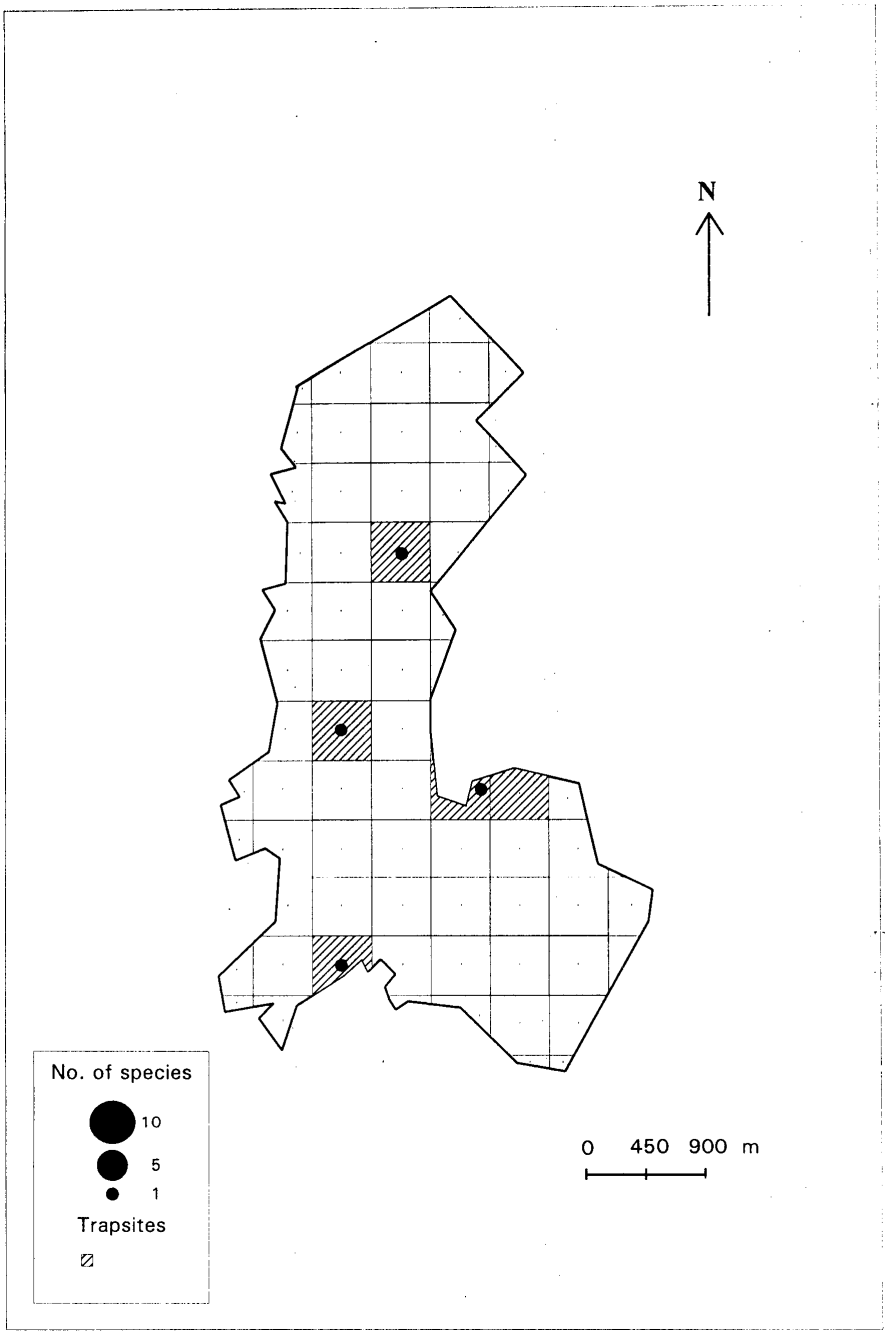

Figure 28. Distribution of endemic amphibian species.

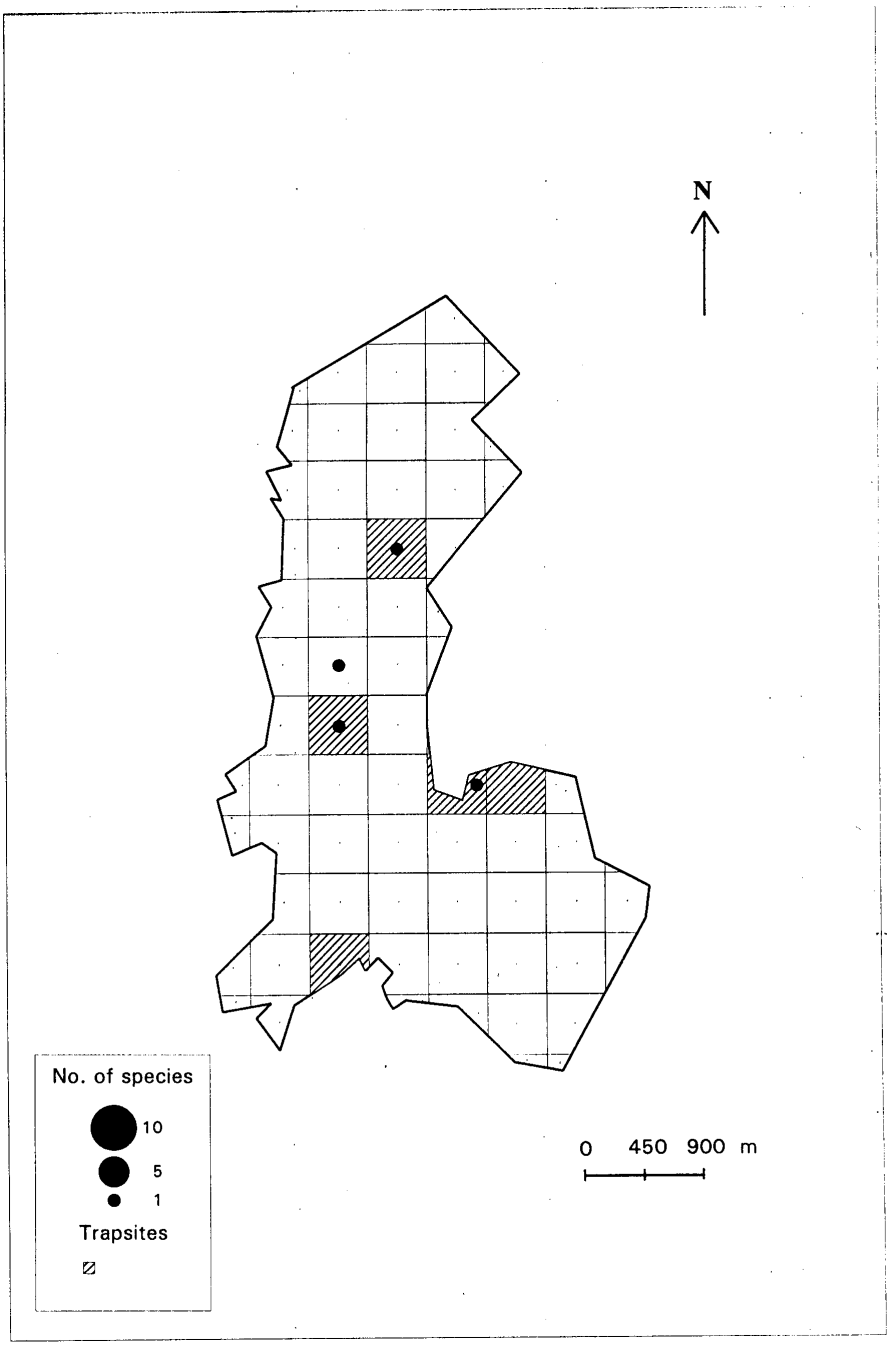

Figure 29. Distribution of near-endemic amphibian species.

6.4.5 Invertebrate sampling

6.4.5.1 Invertebrate pitfall trapping

Preliminary identifications to order level are provided in Table 25.

Table 25. Summary of ground-dwelling invertebrates.

Order	Common name	Plot 1	Plot 8	Plot 15	Plot 30	Plot 52
Araneae	spiders	61	70	56	30	27
Acari	mites	0	0	5	0	2
Anoplura	sucking lice	0	5	0	32	0
Blatteria	cockroaches	2	15	18	3	23
Chilopoda	centipedes	2	1	0	0	16
Coleoptera	beetles	24	41	41	97	86
Collembola	springtails	1	5	1	40	7
Dermaptera	earwigs	1	4	0	0	1
Diplopoda	millipedes	2	10	0	28	1
Diptera	flies	2	1	15	12	17
Heteroptera	true bugs	15	13	29	11	4
Homoptera	true bugs	3	6	4	3	2
Hymenoptera	bees, wasps, ants etc.	100	1162	310	182	269
Isoptera	termites	0	2	5	0	3
Isopoda	wood lice	2	2	2	2	14
Mantodea	mantids	1	0	1	0	0
Opiliones	harvestman	0	12	0	1	12
Orthoptera	crickets & grasshoppers	42	67	26	26	106
Pseudoscorpiones	pseudoscorpions	0	1	1	0	0
Scorpiones	scorpions	1	1	1	0	0
Symphylan	symphylids	0	0	1	0	0
Thysanoptera	bristletails	2	1	0	0	17

6.4.5.2 Malaise trapping

Preliminary identifications to order level are provided in Table 26.

Table 26. Summary of malaise captured invertebrates.

Order	Common name	Plot 8	Plot 15	Plot 30	Plot 52
Araneae	spiders	0	4	0	3
Blatteria	cockroaches	0	0	1	0
Coleoptera	beetles	36	16	23	24
Diptera	flies	293	19	81	39
Ephemeroptera	mayflies	1	0	0	0
Heteroptera	true bugs	0	1	1	1
Homoptera	true bugs	33	3	17	27
Hymenoptera	bees, wasps, ants etc.	85	14	40	14
Lepidoptera	butterflies & moths	50	22	17	20
Orthoptera	crickets & grasshoppers	4	0	2	0
Plecoptera	stoneflies	21	0	0	0

6.4.5.3 Molluscs

Eight specimens were retained for taxonomic purposes. These represent eight species from six families. Remarks were compiled from Verdcourt (*pers. comm.*); Seddon (*et al.* 1996) and IUCN (1996).

Table 27. Summary of molluscs.

Species	Remarks
Urocyclidae	
Urocyclus kirkii	slug: possible northern range extension
Trichotoxon hegnemanni	slug
Elisolimax sp.	slug: possibly colour form of *E. rufescens* describe from Nderema, near Amani.
Ampullariidae	
Lanistes farleri	water snail: IUCN Endangered
Thiaridae	
Cleopatra africana	water snail
Achatinidae	
Achatina fulica	giant land snail
Subulinidae	
Pseudoglessula cf. P. obtusa	snail
Ariophantidae	
Sitala leroyi	snail

6.5 Summary

Species Richness

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

Mammals:

Crocidura luna was the most abundant mammal recorded. It was found almost exclusively in one locale on the forest edge near the Miembeni river. *Crocidura nanilla* was also commonly recorded. This species was found in a variety of habitats, in four of the five trapping sites. The most common bat is *Pipistrellus flavescens*, however this likely reflects the collection method rather than differences in species richness.

Reptiles:

The two most common reptile species are *Cnemaspis barbouri* and *Mabuya maculilabris*. The former is a near-endemic forest dependent gecko and the latter is a widespread, forest non-dependent skink. Each was recorded seven times indicating that they are abundant species.

Amphibians:

For tree frogs, the most commonly caught species was *Leptopelis flavomaculatus*. The majority of these specimens were caught by hand in one night and may reflect a temporal or spatial distribution. Other amphibians that appear locally common are *Bufo brauni* and *Arthroleptis stenodactylus*, each recorded four times.

Endemics and near-endemics:

Of the 23 faunal endemics and near-endemics of the Usambaras recorded, five appear to be locally common as they were recorded at least three times during the survey. These are: *Beamys hindei; Philothamnus macrops*; *Cnemaspis barbouri*; *Mertensophryne micranotis;* and *Boulengerula boulengeri.*

Forest dependent species:

Of the 22 forest dependent species with adequate information available, nine appear to be locally common these are: *Colobus angolensis, Philothamnus macrops*; *Crotaphopeltis tornieri*; *Rhampholeon brevicaudatus*; *Cnemaspis barbouri*; *Bufo brauni*; *Mertensophryne micranotis*; *Leptopelis flavomaculatus* and *Boulengerula boulengeri*.

High risk species:

Assuming that the number captured reflects relative population size, the locally uncommon species that are both forest dependent and near-endemic or endemic species may well be of high conservation concern due to their low population density. These species are: *Rhinolophus swinnyi; Aparallactus werneri*; *Melanoseps loveridgei*; *Lygodactylus kimhowelli*; *Leptopelis barbouri*; *Leptopelis uluguruensis*; *Leptopelis vermiculatus*; *Hoplophryne rogersi*; and *Arthroleptides martiensseni*.

Table 28. Summary of faunal families and species (identified to date).

Taxon	Number of families	Number of species
mammals	15	36
birds	9	11
reptiles	7	18
amphibians	7	15
molluscs	6	8

Table 29. Summary of capture locations of faunal species.

Taxon	Plot 1	Plot 7	Plot 8	Plot 15	Plot 16	Plot 30	Plot 52	lowland altitude (plot unknown)	Outside reserve	Unknown capture location
mammals*	6	0	4	3	1	2	4	0	2	2
reptiles	6	0	4	3	0	7	4	7	8	1
amphibians	3	1	1	4	0	2	3	0	6	2

*bats excluded due to insufficient data; Cercopithecines excluded due to their large ranges.

Ecological type

Of the forest dependent species, five are mammals, ten are birds, eight are reptiles and ten are amphibians. Forest dependent mammals were recorded in only one of the trapping sites, plot 1. They were however observed in several other plots. Forest dependent reptiles were recorded in all five trapping sites. Forest dependent amphibians were captured in all trapping sites except plot 8 trapping site.

Three invasive species are established in the reserve. These are: *Rattus rattus, Crocidura nanilla* and *Cricetomys gambianus. Rattus rattus* was collected in primary forest as well as an area of *Pandanus* forest. *Cricetomys gambianus* was collected in forest edge. *Crocidura nanilla* is a shrew typical of savannah habitats. It was captured in all the trapping sites but one. It was the most commonly recorded non-forest species.

Table 30. Summary of ecological type of faunal species.

Ecological type*	No. of species	% of total species recorded
(F) Forest dependent	33	41.3
(f) Forest dwelling but not forest dependent	36	45.0
(O) Non-forest species	3	3.7
Unknown	8	10.0
Total	**80**	**100.0**

***** Not including molluscs.

Endemic Status

The three species and one subspecies that are endemic to the Usambara mountains are: *Hoplophryne rogersi*, *Boulengerula boulengeri*, *Hyliota australis* spp. *usambarae*, and *Bubo vosseleri*. *Hoplophryne rogersi* was recorded in a mature mixed forest whereas *Boulengerula boulengeri* was found in a variety of habitats: riverine, open forest, and mature mixed forest. The two species of birds were recorded previously by another survey.

Endemic species were found in all trapping sites suggesting that endemics are found throughout the reserve in and outside disturbed areas.

Table 31. Summary of endemic status of faunal species.

Endemic status*	No. of species	% of total species recorded
(E) Endemic to the Usambara Mountains	4	5.0
(N) Near-Endemic: ranges in restricted locations	19	23.7
(W) Widespread	54	67.5
Unknown	3	3.8
Total	**80**	**100.0**

***** Not including molluscs.

Range Extensions

Mammals:
The bat, *Scotophilus nucella*, is a first record for Tanzania (Kock, *pers. comm.*). This specimen was captured in riverine forest on the forest edge.

Reptiles:
The second specimen, and the first female was collected of *Lygodactylus kimhowelli*. This is a new range extension (Broadley, *pers comm.*). The only other collecting site of this species is the Amboni Caves forest, outside the town of Tanga.

Melanoseps loveridgei, a forest-dwelling fossorial skink, was collected at an altitude of 580 m. The area is characterised by mature forest with the site of capture having good canopy cover with some grassy ground cover of *Olyra latifolia*. This collection represents a north-eastern range extension (Broadley, *pers. comm.*). Previously this specimen is known only from the Kiwengoma forest reserve of the coastal forests.

Amphibians:
The East Usambara endemic ground frog, *Hoplophryne rogersi*, was collected in Kambai forest reserve. Previously known only from the Amani area, Bamba Ridge forest reserve and Magoroto forest. This is a range extension (Poynton, *pers. comm.*). In Bamba Ridge, the specimen was found in an *Achatina* sp. shell at an altitude of 750 m (Cunneyworth & Stubblefield., 1996b).

Molluscs:
The slug specimen, *Urocyclus kirkii*, represents a possible northern range extension.

CITES

Otus irenae and *Bubo vosseleri* are CITES Appendix II bird species.

The Nile monitor lizard, *Varanus niloticus,* as are all Varanidae, is a CITES Appendix II species. These reptiles have encountered high hunting pressure for their meat and skin and are now protected (Branch, 1994).

IUCN Status (National Biodiversity Database, 1997)

Crocidura xantippe, Otus irenae and *Lanistes farleri* are listed as 'Endangered'.

Dendrohyrax validus, Bubo vosseleri and *Sheppardia gunningi* are listed as 'Vulnerable'.

Swynnertonia swynnertoni, Anthreptes pallidigaster and *Galago zanzibaricus* are listed as 'Near-threatened'.

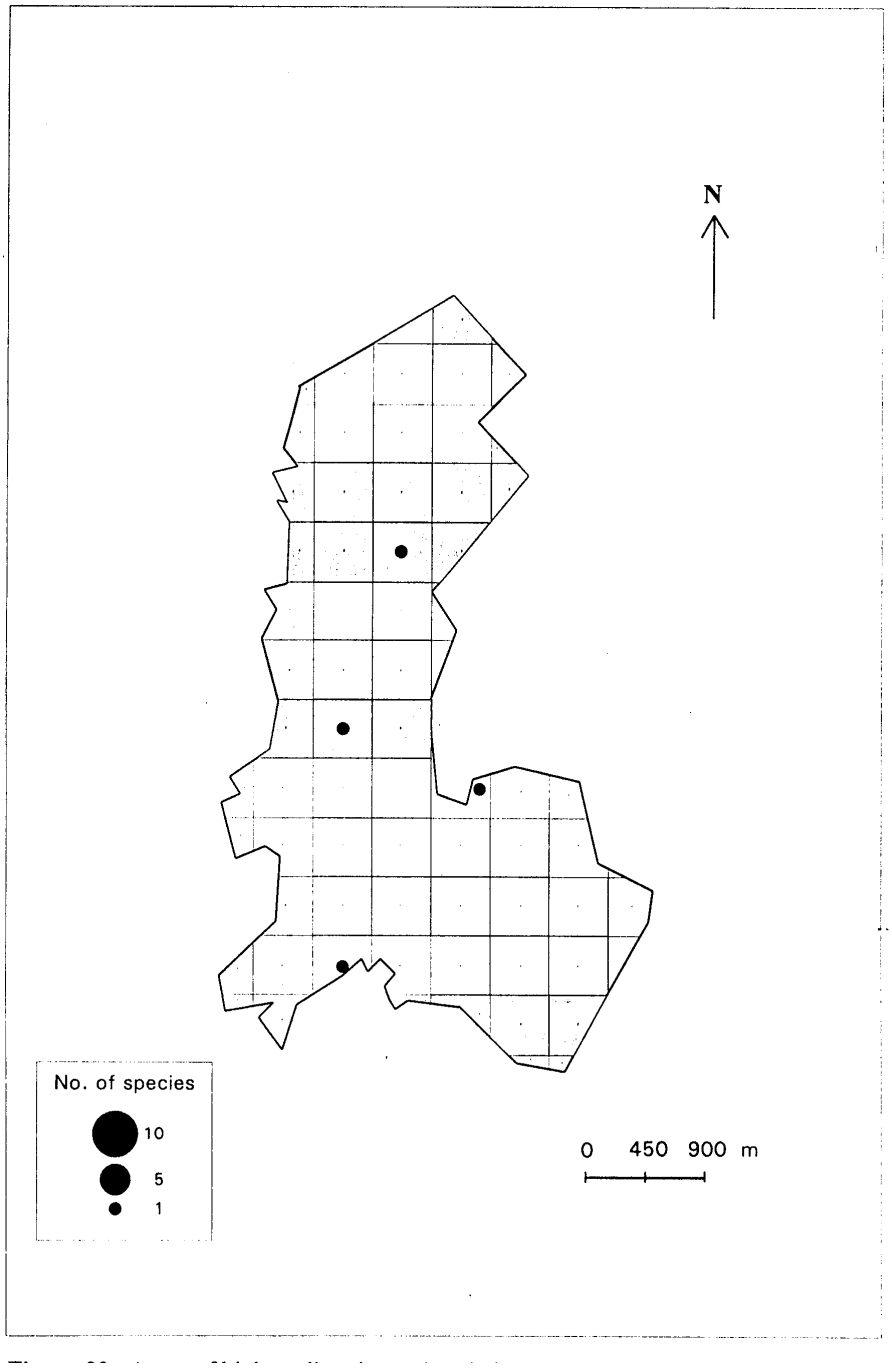

Figure 30. Areas of highest disturbance in relation to the distribution of animal species that are both forest dependent and endemic.

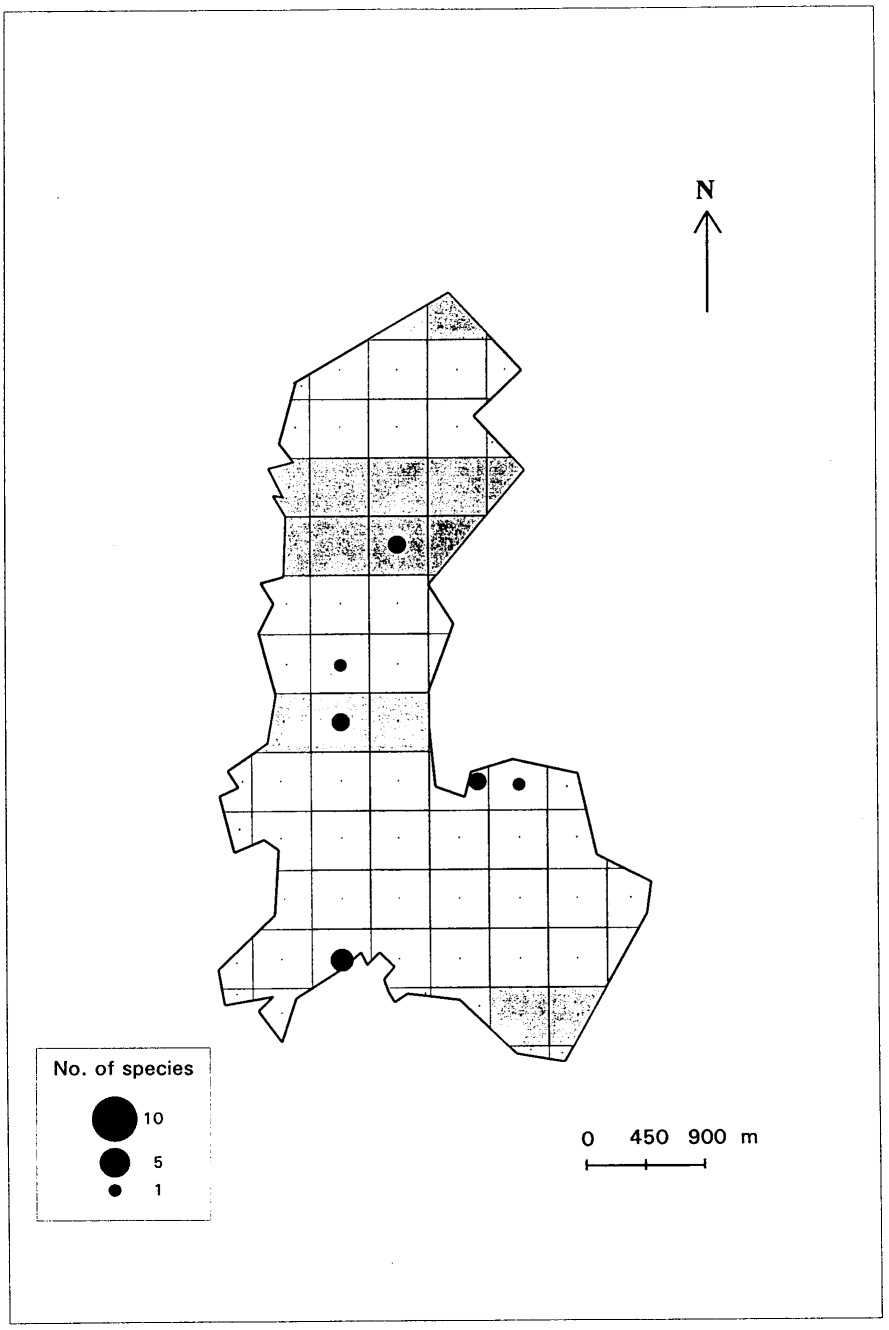

Figure 31. Areas of highest disturbance in relation to the distribution of animal species that are both forest dependent and near-endemic.

7.0 SOCIO-ECONOMICS

7.1 Introduction

A socio-economic study was conducted in villages surrounding Kambai forest reserve to assess the resource use of the reserve and to what extent that this is carried out. In addition, attitudes and problems concerning the reserve were recorded.

7.2 Methodology

The techniques utilised were largely those from Participatory Rural Appraisal (PRA): group meetings, participatory mapping, preference ranking and historical time lines.

participatory mapping: mapping village resources to show how agricultural and forestry systems interconnect.
time lines or chronologies of events, listing major remembered events in a village with approximate dates. Every community has a heritage of experience and environmental knowledge that influences present attitudes and behaviour (NES Government of Kenya, 1990). Time lines may be prepared through discussions with small groups of local residents, with emphasis on community elders. These discussions aim at stimulating exchanges about problems and achievements in agricultural and forest resource management as far back as the oldest member can remember or were told by their parents and grandparents.
scoring and ranking: useful when discussing the importance of different forest products and preferences for tree species for different uses. This may help to identify gender differences in forest utilisation and also tree species which are important.

7.3 Results

7.3.1 The villages and the population

Kambai village and its sub villages of Msige, Miembeni, Kweboha, and Msakazi are located in the lowlands between Kambai forest reserve and Semdoe proposed forest reserve. Kwezitu village is located on the western ridge of Kambai forest reserve and Seluka and Magati which are sub villages of Kuze village are located on the northern boundary of the proposed Semdoe reserve.

Kambai has a heterogeneous population of approximately 2,000, including its four subvillages of Kweboha, Msige, Miembeni and Msakazi. Kambai village is a relatively new village, established in 1968 as a Julius Nyereres' Ujamaa villagisation programme. Previous to this, the population was limited to only a small number of families farming in the area. In addition to farming, many of the local people were also workers at the Sigi-Miembeni Sisal Estate or the Mgambo Sawmills. Many immigrants came to work on the estate and the sawmills and remained in the area after the closure of these work places. Hence the population is made up of a great mixture of tribes; locals of the Wasambaa and Wabondei tribes, Wangoni from Songea region, Wabena from Iringa, Wakinga from Mbeya, Makonde

from Mozambique and Warundi from Burundi and Waganda, Wasukuma, Wangoni and Waha.

7.3.2 Economic activity

Livelihood is based on subsistence farming with income generated through cash crops and of minor sales of local alcohol, woven baskets and mats. Few people have paid work. The main cash crops for the lowland villages of Kambai, Seluka and Magati are maize, cassava, oranges, sugarcane, and groundnuts. The main cash crop for Kwezitu is cardamom.

The farming method employed is that of shifting cultivation. Traditionally, farmers work an area of land for three to five years and then move to 'fresh' land when crop yields decline. The area is slashed and burned, the residue being left. However due to the lack of available land, this fallow period has been reduced to between one and two years. All farming techniques are learned through knowledge passed down from one generation to the next. All members of the household help with farm work and only the wealthier farmers employ labourers at harvest time or when preparing the land for planting. Roads are in poor condition and therefore access to markets for surplus crops is limited.

Decisions concerning land use are usually made jointly by both the male and female heads of household. However, because the land is usually owned by the man, he will have more control over the farm. In addition, land disputes are usually solved by stating that whomever has planted the trees or permanent crops on the land, owned the land. As is often the case, tree and crop planting is largely carried out by the man, consequently, it is he who holds the rights of the land and decides on its use. This system has changed recently in some families. In these instances, the man of the household will give his wife an area of land on which to farm and of which she has control.

7.3.3 Land tenure

On average each farmer has between two and four ha of land. In general, women do not own land but are given farmland by their fathers, husbands or brothers. Traditionally, it is said that should a woman become widowed the land on which she has farmed would return to her husband's family. Nowadays, should a woman become widowed the land will be passed on to her children.

Those people who settled in the area at the time of Ujamaa each received approximately 0.4 hectare (1 acre) of land near their home on which to farm. Those who came later were given land by the village government. As the population grew, people were advised by village elders to take land from the SHUWIMU area, owned by a government parastatal company. Those villagers who decided to settle in Kweboha and Msakazi also took land from the SHUWIMU area and those in Msige, farmed land in the forest before it was a reserve. The situation at present has now changed. When land is required, it must either be passed on through a family line or it must be bought. In Seluka and Magati villages, immigrants must request land from the village authorities, but no payment is needed. Land pressure is great as Kambai village is landlocked by forest reserve and SHUWIMU land thus there is no land available for agricultural expansion.

7.3.4 Forest resource utilisation

Tables 32 and 33 illustrates where villagers extract natural resources and consequently where the land pressure is the greatest. '0' is defined as resource not taken from that land; '*l*' is defined as low levels of resource extraction; '*ll*' is defined as moderate levels of resource extraction; '*lll*' is defined as high levels of resource extraction. These are quoted as per village agreement.

Table 32. Results of Kambai, Miembeni and Msige subvillage meeting.

Resource	Kambai Forest Reserve	Public Land	SHUWIMU
Agricultural land	*l**	*lll*	*ll*
Building poles	*lll*	*l*	*ll*
Firewood	0	*lll*	*l*
Timber	0	0	0
Medicine	*lll*	*l*	*ll*
Ropes	*lll*	*l*	*ll*
Roofing material	0	*lll*	*ll*
Vegetables	0	*lll*	*ll*
Meat	*lll*	*l*	*ll*
TOTAL	**13**	**16**	**15**
PERCENT	**30**	**36**	**34**

* Agricultural land was taken from the forest before it was made a forest reserve.

Table 33. Results of Kweboha and Msakazi subvillage meeting.

Resource	Kambai Forest Reserve	Public Land	SHUWIMU
Agricultural land	0*	0	*lll*
Building poles	0	0	*lll*
Firewood	0	0	*lll*
Timber	0	0	0
Medicine	0	0	*lll*
Ropes	0	0	*lll*
Roofing material	0	0	*lll*
Vegetables	0	0	*lll*
Meat	0	0	*lll*
TOTAL	**0**	**0**	**24**
PERCENT	**0**	**0**	**100**

* Agricultural land was taken from the forest before it was made a forest reserve.

Tables 32 and 33 clearly show the differences within Kambai village. Kweboha and Msakazi sub villagers get 100% of their resource needs from SHUWIMU land where they live and farm. There are still large areas which are not under agriculture and hence over the last twenty years, since Sikh Sawmills left the area, forest has been allowed to regenerate. Kambai villagers however, obtain their resource needs equally between forest reserve (30%), public land (36%) and SHUWIMU land (34%).

Although the data show that pitsawing has not occurred in the forest reserves, public land or SHUWIMU land, the researchers are aware of two separate cases of illegal pitsawing which have occurred on SHUWIMU land over the last year. At the end of 1995 Kambai

village was granted a licence to obtain timber for building a bridge for the Kambai-Longuza road.

Magati villagers told us that they obtain their subsistence needs, such as firewood, medicine and building poles from Segoma (Kwamgumi) forest reserve rather than Semdoe because it is nearer to them. Villagers know they are allowed to enter the forest only on one day per week (Wednesday) to collect their subsistence needs, but the fact that they had difficulty in remembering which day suggested that they did not obey this rule. They also commented that one day was not enough and that two would be better.

7.3.5 Attitudes toward the forest reserve

Since many farmers in Kambai originate from other areas they are often aware of the consequences of cutting down the forest. For example, one farmer who originates from Iringa told us that; "the farmers cut all the trees down until there were none left which resulted in little rain and hot winds. Because of this, the government has forced people to plant trees and now there are many trees on farms again." Other farmers come from areas such as Mwanza and Tabora where the situation is similar. Farmers have told us about the land becoming infertile and eroded and women having to walk long distances for firewood.

Many of the interviewees were former pit sawers. One farmer said that he does not continue pitsawing because most of the good timber species have already been removed from the public land and because it is illegal to go inside the forest reserve. He said, "one would need three eyes to get away with it. It is good to reserve forest otherwise it would be finished." He continued, "for example, in Iringa people are suffering because there is not enough rain and few trees are left for their uses." However, he concluded, that even though many people know why they should not encroach on the forest, they still would if the EUCFP guards were not there. The reason being; "it is simply a matter of money".

Often farmers see both the advantages and disadvantages of forest conservation. They may know the advantage of forest for water catchment, but they feel that the need for agricultural land and their subsistence and cash needs are more important than conservation. One farmer felt disappointed in the government because he feels they are preventing his development, since he has no more land on which to clear and farm.

One farmer suggested that fifty percent of farmers still do not know the value of the forest and would still encroach on the forest if there were no EUCFP guards. Many have admitted that they would cut down the forest tomorrow if they could, since they do not know the value of conserving the forest. However, when one old man was asked how he felt about the forest reserves, his reply was, "it is best to have EUCFP people guarding the forest, because villagers here are only interested in making money rather than conserving." He could not envisage the day when communities would manage and conserve the forests for themselves without outside help.

Kwezitu villagers are beginning to be affected by deforestation and have reported their concerns on soil erosion to EUCFP. Due to this, they have noted the need and requested assistance to plant trees on their farms.

7.3.6 Development

The Kambai Forest Conservation Programme (KFCP) started work in Kambai village in August 1994. Since this time KFCP have been assisting farmers with tree raising and planting activities on their farms and with vegetable nurseries. To date, approximately sixty farmers have been involved in the programme.

Many farmers retain at least a few trees on their land whilst farm clearing for planting. The most commonly retained are those which have good timber and building poles, such as Mvule (*Milicia excelsa*) and Mtalawanda (*Markhamia hildebrantii*). Farmers are also aware that it is illegal to cut Mvule without a permit. Other trees which may be retained are fruit trees and water retaining trees, such as Mkuyu (*Ficus sp.*). Farmers have also started to plant trees on their land, especially over the last five years. One farmer from Kweboha, is now reaping the benefits from teak he planted five years ago. He is now thinning his teak woodlot and from each pole he hopes to make 1000 tshs. Other farmers have followed his example. With the assistance of KFCP, farmers have also planted Mkabela (*Grevillea robusta*), around their farm boundaries and intercropped with their maize and some have planted indigenous species such as, Mbambakofi (*Afzelia quanzensis*), Mpingo (*Dalbergia melanoxylon*), and Mshai (*Albizia schimperana*).

In Seluka and Magati, farmers have retained some tree species on their farms, but because much of the land was previously under sisal, there were few remaining. Farmers have not been greatly involved in tree planting activities here, but EUCFP will shortly be starting a tree nursery in Kuze village. Seluka villages commented that because Kuze is quite a distance away, it would be better for Seluka to have its own tree and vegetable nursery.

Gonja, a sub village of Kwezitu have also requested assistance with tree planting activities. They shall plant trees on their land this rainy season and have requested assistance with starting their own tree and vegetable nurseries.

Villagers say that since talking with an agriculturist at Sokoine University, Morogoro who originates from Kwezitu, they have become convinced that tree planting is a good way to prevent soil erosion on their farms. They also feel that if they do not start looking after their environment by planting trees, that more land will be taken from them and planted up as forest reserve.

7.4 DISCUSSION

The people living around Kambai forest reserve are mainly farmers with an average of between two and four ha of land per family. The agricultural method employed is that of shifting cultivation. Traditionally, farmers work an area of land for three to five years and then move to 'fresh' land when crop yields decline. The area is slashed and burned with the being residue left. In recent years, Kambai village has become landlocked between Kambai forest reserve, Semdoe proposed forest reserve and SHUWIMU land. The lack of available land for the expansion of farms has reduced the fallow period to between one and two years. The agricultural products are for subsistence only as roads are in poor condition and therefore access to markets for surplus crops is limited.

Few people recognise that there are advantages of a forest reserve. Thus without active conservation efforts, the exploitation of the forest would be devastating as the lack of education concerning the importance of the forest is patently evident. Therefore, education is essential. There are however a few people who have begun to plant trees as an alternative resource acquisition practice and for marketing the surplus. These actions on a greater scale may help reduce the pressure on the forest in future years. These actions at the present time are limited and it is too early to establish the actual effects that they may have.

The forest reserve resources are used by the people of Kambai village. The resources, as stated by the villagers, are building poles, ropes, medicine and meat. Timber, although not stated as a forest product, is known to be removed from the reserve. Kweboha and Msakazi sub villagers state that they do not rely on the reserve but obtain all their resource needs from SHUWIMU land near to where they live and farm. Magati villages obtained their forest products from Kwamgumi forest rather than Kambai as the former is closer to where they live. Kambai village rather than Kweboha, Msakazi or Magati, thus appears to require education and alternatives to using forest products in the conservation efforts related to Kambai forest reserve.

8.0 CONCLUSION

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

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

Kambai forest, gazetted as a forest reserve in 1994, covers an area of 1046.3 ha in the central area of the East Usambara range. With altitudes between 200 m and 870 m, it consists of approximately 65.3% mature forest, 22.5% previously disturbed, colonising or poorly stocked forest, 2.0% woodland, 8.2% bushland/thicket, 2.0% grassland.

Disturbance

Higher rates in the reserve of pole and timber extraction were found to occur in three areas of dense forest, one area of bushland/thicket and one area of open forest. All but the bushland/thicket area should be considered of conservation concern as these areas have high numbers of near-endemic and forest dependent trees and shrubs and also endemic and near-endemic mammals, reptiles and amphibians.

Species Richness

The forest reserve was found to contain a minimum of 162 species of trees and shrubs; 36 mammal, 11 bird, 18 reptile and 15 species of amphibian.

Flora

Two tree species were recorded which are endemic to the Usambara mountains and 35 have restricted ranges limited to the Eastern Arc and/or East African lowland forests. Forty-seven species are dependent only on primary forest, and of these species, 17 are also endemic or near endemic to the Usambara mountains. Eighteen non-forest tree and shrub species are established within the reserve boundaries.

Fauna

Four faunal species were recorded which are endemic to the Usambara mountains and nineteen species were recorded as near-endemics, having restricted ranges limited to the Eastern Arc and/or East African lowland forests. Thirty-three species are considered dependent only on primary forest, and of these species, 21 are also endemic or near endemic to the Usambara mountains. Three non-forest species are established in the reserve.

Table 34. Summary of biodiversity of taxa surveyed.

Taxon:	Total no. of species	% forest dependent	No. of non-forest species	No. of endemics	No. of near-endemics	No. of forest dependent endemics and near-endemics
trees and shrubs	162	29.0	18	2	35	**17**
mammals	36	13.9	3	0	3	**1**
birds*	11	90.9	0	2	4	**6**
reptiles	18	44.4	0	0	6	**6**
amphibians	15	66.7	0	2	6	**8**
Total	**242**	--	**21**	**6**	**54**	**38**

* This does not represent an inventory. This information is limited to the important species discussed.

Conservation

The East Usambara mountains are important due to their floral and faunal diversity and to their water catchment value. The forests also provide an important source of fuelwood, poles, timber, food and medicinal plants for the local people. Differences in the perceived values of the forests have caused and still causes a conflict of interest between the villagers and the Catchment authorities. The remaining forests of the East Usambara mountains are now only small refuges of what was present just one hundred years ago as a result of human exploitation (Hamilton, 1989). The area continues to be vulnerable because as the local populations increase, there will be a need for access to new agricultural land. The major concern of the people is that Kambai village is landlocked between Kambai forest reserve, Semdoe proposed forest reserve and SHUWIMU land.

As has been documented many times before, the problem of resource exploitation of the forest is that the forest is a fragile ecosystem. The soils are highly susceptible to soil erosion once the land has been cleared. Due to the tight nutrient recycling in the forest, once the land has been cleared the soil quickly loses fertility (Hamilton, 1989). Soil erosion increases dramatically with the removal of the canopy cover, causing increased siltation of the rivers (Bruen, 1989). This is of great concern considering that the East Usambaras are a major water catchment site. This water is critical for the local people and also the Sigi river is the main source of water for the coastal town of Tanga. In addition, the possible long-term effect of deforestation is the apparent decrease in rainfall and the greater unpredictability of the rainy seasons (Hamilton, 1989).

A number of the species encountered are at risk of local extinction as they are uncommon, forest dependent, endemic and near-endemics. Degradation and fragmentation of Kambai forest will inevitably cause local extinctions of populations of these vulnerable species further limiting their ability to sustain viable populations. The loss of the forest may also have devastating effects on the water catchment of the area.

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Appendix 1:

General Plot Information

Plot Number	Topography	Altitude (metres)	Slope (degrees)	Vegetation Condition	Canopy Height (metres)
1	SL	190	30	M	>30
2	M	300	25	M	20-30
3	M	320	25	M	20-30
4	SG	350	30	M	>30
5	GU	520	15	M	10-20
6	M	650	25	M	10-20
7	M	400	25	M	10-20
8	FV	220	5	M	20-30
9	SU	330	30	P	10-20
10	GL	250	10	EC	20-30
11	SU	400	5	M	<10
12	SU	500	25	M	20-30
13	SU	700	45	EC	20-30
14	missed plot				
15	M	380	15	M	20-30
16	FV	250	10	M	10-20
17	SL	330	15	M	20-30
18	SU	600	25	B	<10
19	SL	410	25	M	20-30
20	GL	320	15	M	20-30
21	SU	440	20	W	<10
22	SU	390	25	EC	<10
23	M	320	25	EC	10-20
24	SL	280	30	EC	10-20
25	SU	650	20	M	10-20
26	M	650	25	M	20-30
27	M	650	30	M	10-20
28	SU	640	20	B	10-20
29	M	510	25	M	10-20
30	M	410	30	P	<10
31	R	700	20	M	20-30
32	SU	700	30	M	>30
33	GU	550	20	M	10-20
34	SU	565	25	G	<10
35	SU	700	25	M	10-20
36	M	540	20	M	10-20
37	M	390	25	M	10-20
38	GL	360	?	M	20-30
39	M	400	20	B	<10
40	M	400	20	M	10-20
41	GL	260	25	M	20-30
42	GL	320	15	P	10-20
43	GU	600	20	M	10-20
44	GU	330	15	EC	10-20
45	M	400	30	B	<10
46	R	400	40	P	10-20
47	M	330	30	M	20-30

Plot Number	Topography	Altitude (metres)	Slope (degrees)	Vegetation Condition	Canopy Height (metres)
48	FV	200	5	EC	>30
49	GL	275	20	M	20-30
50	SU	350	25	M	10-20
51	M	430	30	M	10-20
52*	M	595	?	M	10-20

KEY TO ABBREVIATIONS

Topography

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

Vegetation Condition

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

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

Appendix 2:

Taxonomic Verification

BOTANY

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All other invertebrates:

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