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East Usambara Forest Monitoring

A Test of Procedures at Semdoe and Kwamgumi Forest Reserves

Frontier Tanzania

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East Usambara Conservation Area Management Programme

Technical Paper 54

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A test of procedures at Semdoe and Kwamgumi Forest Reserves

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East Usambara Conservation Area Management Programme (EUCAMP)
The East Usambara rain forests are one of the most valuable conservation areas in Africa. Several plant and 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 Conservation Area Management Programme has established the Amani Nature Reserve and aims at protecting water sources; establishing and protecting Forest Reserves; sustaining villager's benefits from the forest; and rehabilitating the Amani Botanical Garden. The programme is implemented by the Forestry and Beekeeping Division of the Ministry of Natural Resources and Tourism with financial support from the Government of Finland, and implementation support from 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 Conservation Area Management Programme (EUCAMP). This survey of selected forests collects baseline biodiversity data and assists the EUCAMP in the management of the East Usambara forests.

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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 have shown that these forests have a unique diversity of flora and fauna, and an exceptionally high degree of endemism. They have gained global recognition as being part of a Biodiversity Hotspot (Conservation International), an Endemic Bird Area (BirdLife), a Centre of Plant Diversity (WWF and IUCN) and a Globally Important Ecoregion (WWF). Since 1990, the East Usambara Conservation Area Management Programme (EUCAMP) (formerly known as the East Usambara Catchment Forest Project (EUCFP)) has worked in the East Usambara Mountains with the mission to protect these natural forests. The project is implemented by 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.

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 in July 1995. The surveys are conducted by Frontier Tanzania, a joint venture between the University of Dar es Salaam and the Society for Environmental Exploration, together with EUCAMP. The aim of the surveys is to provide systematic baseline information on the biological values of different forests as a basis for management planning and long-term monitoring, as well as training forestry staff in the use of biological inventory techniques. They will also help setting 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 EUCAMP, Frontier-Tanzania, University of Dar es Salaam, and Tanzania Forestry Research Institute staff, as well as an international network of taxonomists and other experts. The surveys have become progressively more systematic and quantitative, and have already resulted in the discovery of several previously unknown taxa. This will further raise awareness of the unique conservation values of the East Usambaras. EUCAMP has also commissioned the development of a biodiversity database, work that also contributed the maps of these reports. All data collected during the surveys is entered into this database, which is linked to the national biodiversity database.

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.

Mathias Lema
Project Manager

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Provision of permissions to work within the study areas, logistical and vehicular support, arrangement of game guards at Semdoe forest reserve and project implementation

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Biodiversity Co-ordinator and Botanical collector	Mr. Albert Ntemi Sallu
Foresters:	Mr. Juma Ntogolela, Mr. Mussa Jackson, Mr. Juma Madege, Mr. Gerald Otieno.

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Botanist:	Mr. Ahmed Mndolwa

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Managing Director:	Ms. Eibleis Fanning
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Editorial Comments: Dr. Veli Pohjonen, EUCAMP; Dr. Damon Stanwell-Smith, SEE; Prof. K. Howell, UDSM.

We would like to express gratitude towards the residents of the villages surrounding Kwamgumi and Semdoe Forest Reserves, notably: Kuze and Kwamtili, and the Kwamtili estate managers for their kindness and support.

EXECUTIVE SUMMARY

The East Usambara Biodiversity Surveys (EUBS) aimed to develop a system for monitoring aspects of forest biodiversity in the East Usambara forests. Working in conjunction with the East Usambara Conservation Area Management Programme (EUCAMP), Frontier-Tanzania Forest Research Programme fulfilled this aim by carrying out both fieldwork and deskwork to investigate monitoring options for the East Usambara forests. The baseline biodiversity surveys conducted by EUBS formed the basis for the testing of monitoring procedures. The fieldwork took place between January and March 2001, using Semdoe and Kwamgumi forest reserves as ‘test-sites’.

Semi-permanent vegetation plots established during EUBS were sampled at a range of intensities; 5%, 10%, 15%, 20% and 25% of that during EUBS. Data gathered from these vegetation plots included the status of the vegetation plot, status and dbh (diameter at breast height) of previously marked trees, identity, abundance and dbh of ingrowth trees and the legibility of paint marking on trees. All markings were re-painted (or painted in the case of ingrowth) and the vegetation plot location co-ordinates recorded using a GPS (Global Positioning System). Data were analysed with regard to vegetation plot selection and status, vegetation status and growth, plant species richness and plant species endemism. This also involved the manipulation of data presented within EUBS reports. Summary results are given in Table 1.

Table 1 Summary of results of monitoring work in selected forest reserve test-sites. (All figures were based on only those vegetation plots sampled during monitoring thus c.95% of plots in Semdoe Forest Reserve and c.50% in Kwamgumi Forest Reserve).

	Semdoe Forest Reserve	**Kwamgumi Forest Reserve**
% of VPs relocated during monitoring (figures are as a % of the number *searched for*, not of all VPs in the reserve)	100%	80%
% of tree (individuals) within VPs that were relocated during monitoring	78.3%	87.4%
% of tree abundance in VPs during EUBS recorded during monitoring (figures are based on the number of relocated live trees and ingrowth recorded during monitoring)	95%	91%
% of tree markings painted during EUBS that were still legible during monitoring (figures based on paint markings of live trees relocated during monitoring)	98.5%	97.1%
Total number of plant species recorded during EUBS (in VPs only)	79	134
Total number of plant species recorded during monitoring (in VPs only)	75	124
Number of restricted range species recorded during EUBS (in VPs only)	23	36
Number of restricted range species recorded during monitoring (in VPs only)	23	33

Abbreviations: EUBS – East Usambara Biodiversity Surveys, VPs – vegetation plots, Restricted range – endemic to the Usambara mountains or endemic to the Eastern Arc mountains, coastal and lowland East African forests

An overall increase in the dbh of trees and shrubs previously recorded in vegetation plots was noted. Average increases of dbh of trees from both forest reserves was ascertained to be 0.64 cm. The species accumulation curves of all species and species of restricted range within both FRs were found to have changed little between the baseline survey and monitoring. Based on data manipulated from EUBS reports, the number of predicted and recorded species at each sampling-intensity were at higher sampling-intensities. A relationship between the number of species predicted and the species richness, size and altitudinal range of the FR was found to exist. Larger sampling-intensities were also found to give a truer representation of the state of restricted range species with regard to the number recorded during both periods.

Various aspects of the monitoring procedures tested during the study were discussed and an interpretation with regard to the findings of Semdoe and Kwamgumi FRs presented. Species richness, species accumulation and the richness of endemic and near-endemic species in particular had remained fairly similar between EUBS and monitoring work in both Semdoe and Kwamgumi FR. Based on these results, it was deemed that the current state of these FRs were not of great cause for concern with regards to these factors.

The culmination of this study was the recommendation of a set of biodiversity monitoring options for the East Usambara forests. These were based on the methods, results and discussion of both fieldwork and deskwork. Recommendations for the monitoring of trees and shrubs ≥10cm dbh and regeneration were given with regards to objectives, methods, analysis, interpretation, action, review, data storage and management and personnel. Brief ideas for the monitoring of *Maesopsis eminii* and defunct logging roads were presented, along with brief information on the use of GIS and remote sensing in monitoring.

In addition to work concerned with forest monitoring, selected fauna groups were studied within each forest reserve test-site. Bats were sampled using mist-nets whilst reptiles and amphibians were recorded through opportunistic collection. This work provided additional species for the species lists compiled during the EUBS survey of each forest reserve. Within Semdoe forest reserve an additional 13 bat, two reptile and five amphibian species were recorded, these included four forest-dependent species and two species of restricted range. Within Kwamgumi forest reserve an additional four bat, one reptile and seven amphibian species were recorded, these included eight forest-dependent species and six species of restricted range.

Syncerus caffer, the African buffalo was recorded in Semdoe forest reserve. Two individuals were observed on first entering the forest. No problems were encountered with the buffalo during the monitoring work. Semdoe forest is thought to be on an old migration route. It is the first record of this IUCN 'Lower Risk/ Conservation Dependent' (LR/cd) listed species (Hamilton-Taylor 2000) since the 1930s in the east Usambara forests.

It should be re-iterated that the emphasis of this work was to test monitoring procedures regarding the state of vegetation and to make recommendations for potential future monitoring programmes with regard to monitoring vegetation. This study has thus concentrated on the analysis of data from vegetation plots established during EUBS in selected forest reserves. No attempt was made to monitor disturbance or threat within the forests or to quantitatively relate this to change detected in vegetation within the vegetation plots. However, monitoring activities to detect disturbance and threat within the East Usambara forests are needed. It is recommended that these should be run in conjunction with vegetation monitoring activities.

1.0 INTRODUCTION

1.1 THE EAST USAMBARAS AND FOREST BIODIVERSITY

The East Usambara mountains are situated in north-eastern Tanzania within 40 km of the coastal town of Tanga, between 4^{o} 48'- 5^{o} 13'S and 38^{o} 32'- 38^{o} 48'E. These mountains form part of a chain known as the Eastern Arc, that stretches down East Africa from southern Kenya to southern Tanzania. This is a chain of isolated mountains composed of Precambrian rock exposed by block faulting and slow uprising (Griffiths 1993). Being adjacent to the Indian Ocean, considerable orographic rainfall occurs in this area. The rainfall distribution is bi-modal, peaking between March and May and between September and December. The dry seasons are from June to August and January to March. 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 higher altitudes. Due to topographic and climatic interactions, the west-facing slopes of the mountains are drier compared to the east-facing slopes. Due to their age, isolation and their role as condensers of moisture from the Indian Ocean, the East Usambara mountains support ancient and unique forests, rich in endemic species (Hamilton 1989).

Research in the East Usambara mountains began in the late 1890s with substantial botanical collections being undertaken. Later, in 1928, surveys were undertaken on amphibians and by the 1930s detailed ornithological work had begun. Since these early studies, biological research in the mountains has steadily increased, however most was concentrated on the Amani area. More recent work has also included an attempt to understand the drainage and catchment value of the mountain's forests (Bruen 1989, Litterick 1989).

The East Usambara forests have been likened to the African equivalent of the Galapagos Islands in terms of their endemism and biodiversity (Rodgers and Homewood 1982, Howell 1989). They are considered to be one of the most important forest blocks in Africa (Tye 1994). Currently, at least 3,450 species of vascular plants have been recorded in the Usambara mountains of which it is suggested that over one quarter are endemic or near-endemic (Iversen 1991a). Many are threatened (Rodgers 1996). The forests of the East Usambara mountains are recognised as part of a *Biodiversity Hotspot* (Mittermeier *et al*, 1999), an *Endemic Bird Area* (ICBP 1992), a *Centre of Plant Diversity* (WWF and IUCN) and a *Globally Important Ecoregion* (WWF).

The forests of the East Usambara mountains are not only important for their biodiversity, they also play an important role in maintaining the hydrological cycle that feeds the Sigi River. This river is a vital water source for the local communities as well as supplying water for the large coastal town of Tanga. Deforestation in the area can lead to increased soil erosion, particularly from the steeper slopes. Soil erosion is liable to result in a more irregular run off and deterioration in water quality due to siltation.

The latest survey of the East Usambara mountains, conducted by Johansson and Sandy (1996) shows that approximately 45,137 ha of the East Usambara Mountains remain as natural forest. This can be divided into two types: submontane rain forest and lowland forest. Altitude is the factor differentiating these two forest types (Hamilton 1989), with submontane forest generally occurring above 850m. The area recorded as forest in the East Usambara mountains according to these categories is described in Table 2.

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

Forest type	Area (ha)	% of area
Lowland forest	29,497.4	62.9
Submontane forest	12,916.6	30.6
Forest plantation	2,723.6	6.5
Total	**45,137.6**	**100 %**

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

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

The forest avifauna of the East Usambara mountains has a high diversity with at least 110 species (Stuart 1989). Six species occurring in the lowland forests are categorised as threatened with global extinction by IUCN, specifically: Sokoke Scops owl, *Otus irenea;,* Banded green sunbird, *Anthreptes pallidigaster* [Endangered]; the Usambara eagle owl, *Bubo vosseleri*; Swynnerton's robin, *Swynnertonia swynnertoni*; East coast akalat, *Sheppardia gunningi*; and the Amani sunbird, *Anthreptes rubritorques* [Vunerable](Hamilton-Taylor 2000).

The East Usambara mountains are essentially forest 'islands' (Lovett 1989). There has been natural forest in the area for several million years. The Usambara mountains harbour many species that have been geographically separated from their closest relatives for long periods. They also serve as a refuge for formerly widespread flora and fauna that have become extinct over much of their former area (Iversen 1991).

These forests have been under continuous exploitative human pressure for at least 2,000 years, serving as a principle water catchment area and as a source of fuel-wood and medicinal plants (Schmidt 1989). Until recently, especially before the past 50 years (Kikula 1989), this pressure was sustainable. Growing human population in the area is leading to increased pressure on the remaining natural forest, and represents the main threat to their survival. The forests of the East Usambara mountains have been reduced to fragments within a matrix of agricultural land. Little forest remains outside of the gazetted forest reserves. For those species that are forest dependent, the forest reserves now provide almost the only available habitat. There are differences in the perceived value of the forests between the villagers and the Forest and Beekeeping Division. Alternative sources of building material and fuel are required in order to meet the needs of surrounding villages while ensuring the protection of the forests.

1.2 EAST USAMBARA BIODIVERSITY SURVEYS

Since July 1994, the Frontier-Tanzania Forest Research Programme (FT FRP) has been working in collaboration with the East Usambara Conservation Area Management Programme (EUCAMP) under the title of East Usambara Biodiversity Surveys (EUBS). To date, baseline biodiversity surveys of 12 Forest Reserves, one Nature Reserve and one Village Forest Reserve within the East Usambara mountains have been conducted (see Table 3). Six forest areas have yet to be surveyed at the time of this monitoring work. These reserves are as follow: Bombo East I Forest Reserve, Bombo East II Forest Reserve, Derema proposed Forest Reserve, Handei Village Forest Reserve, Mgambo Forest Reserve and Mlinga Forest Reserve and are all scheduled for completed survey and report by December 2002. The fieldwork of EUBS provides training for EUCAMP foresters in survey techniques and results are used to assist EUCAMP with the management of the East Usambara forests.

The specific aims of EUBS as outlined in the Terms of Reference between FT FRP and EUCAMP 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.
- to train EUCAMP personnel in biological field techniques.

Furthermore, the aims of the survey methods applied are:

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

By using standardised and repeatable methods these surveys provide an assessment of the biodiversity value of the forests, enabling their importance to be determined and their biodiversity value to be monitored in future. For detailed research aims, objectives and methodologies employed during EUBS, refer to *Methodologies Report* (SEE 1998).

Three criteria are used in EUBS reports to analyse the uniqueness of the biodiversity of a reserve and vulnerability to disturbance. They are as follows:

Ecological requirement

- **Forest dependent species (F)**: Species dependent on primary forest only. This category does not include forest edge or secondary forest species.
- **Forest non-dependent species (f)**: Forest dwelling but not dependent on primary forest: species occurring in primary forest as defined above as well as other vegetation types. It should be emphasised

that many of these species are still dependent on a forest habitat albeit forest edge or disturbed forest. Most species in this category will still be adversely affected by forest destruction.

- **Non-forest species (O)**: These are species that do not normally occur in primary or secondary forest or forest edge.

Endemic Status

- **Endemic (E):** Occurring only in the Usambara Mountains.
- **Near-endemic (N):** Species with ranges restricted to the Eastern Arc Mountains and / or the East African lowland forests.
- **Widespread (W):** Species with ranges extending beyond the Eastern Arc and East African lowland forests.

Habitat (of plant species)

- **Lowland (L):** Species occurring at altitudes of <849 m above sea level (a.s.l.).
- **Submontane (S):** Species occurring at altitudes of >850 –1,249 m a.s.l..
- **Montane (M):** Species occurring at altitudes of 1250 m + a.s.l..

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

The categories are based on information from various sources. For plants the ecological type and endemic status are primarily based on Iversen (1991a). Forest dependent species refers to those species listed as being exclusively associated with Iversen's categories 1a (wet evergreen forest), 1b (dry evergreen forest) and / or 1c (riverine forest). Forest dwelling also includes other habitats. Habitat type is based on Hamilton (1989) and the List of East African Plants (LEAP) (Knox 2000). For those species not listed by Iversen or Hamilton, the information is taken from the Flora of Tropical East Africa and/ or the List of East African Plants database (LEAP) (Knox 2000).

EUCAMP data are stored in a Microsoft Access (version Windows 2000) database stored at the EUCAMP with copies distributed to FT FRP and SEE offices to name two locations. It is planned that parts of it will be available on the Internet. Zoological data are also stored on the National Biodiversity Database (NBD) at the Department of Zoology and Marine Biology, University of Dar es Salaam (UDSM), also in a Microsoft Access 2000 database. The data are geographically referenced and so can be used as a baseline for biodiversity monitoring.

The results of EUBS have proven to be very interesting. To date, new species have been discovered, range extensions have been recorded, new records of species for Tanzania have been documented and many endemic and near-endemic species have been confirmed within various forests of the East Usambara mountains (Table 3).

Table 3 Summary of Forest Reserves surveyed by EUBS and the highlights from each.

Forest Reserve	Number of species		Notes
Amani Nature Reserve			
Size: 8,380 ha 190-1130m a.s.l. EUBS: 1999/2000	Trees/shrubs* Mammals** Reptiles Amphibians Butterflies	264 59 (16) 49 27 112	Usambara endemic animal species: chameleon *Chameleo spinosus*, frog species *Hoplophryne rogersi* and *Phrynobatrachus kreffti*. East Usambara endemic trees species *Cola scheffleri* and *C. usambarensis* were recorded. Three species of African violet recorded: *Saintpaulia confusa, S. difficilis, S. grotei.*
Bamba Ridge			
Size: 1,109 ha 150-1,065 m a.s.l. EUBS: 1995	Trees/shrubs Mammals Reptiles Amphibians Butterflies	169 28 (14) 26 23 -	First record in East Usamabaras of bat *Miniopterus m.minor*. New species of Leaf chameleon *Rhampholeon* sp. nov. found. Usambara endemic ground frog *Hoplophryne rogersi* found at extended elevation. East Usambara endemic trees species *Cola scheffleri* and *C. usambarensis* were recorded.
Kambai			
Size: 1,046 ha 200-870 m a.s.l. EUBS: 1996	Trees/shrubs Mammals Reptiles Amphibians Butterflies	162 36 (16) 18 15 -	EU endemic *Cola usamberensis* and Usambara endemic *Rinorea angustifolia* found. Previously recorded only from coastal forests, tree species *Manodora minor* and *Nesogordonia holtzii* . First record of bat *Scotophicus nucella* in Tanzania. Second specimen and first female of gecko *Lygodactylus kimhowelli* found.
Kwamarimba			
Size: 802 ha 95-445 m a.s.l. EUBS: 1995	Trees/shrubs Mammals Reptiles Amphibians Butterflies	165 16 (7) 17 11 -	Records of the endemic to Usambaras *Cynometra brachyrhachis*, *C. longipedicellata* and *Cola usambarensis*, and *Sapium armatum* and *Nesogordonia holtzii*, previously recorded as coastal endemics. First record in Tanzania of the blind snake *Typhlops pallidus*.
Kwamgumi			
Size: 1,708 ha 150-915 m a.s.l. EUBS: 1996	Trees/shrubs Mammals Reptiles Amphibians Butterflies	192 47 (17) 27 24 31	Endemic tree species *Cynometra longipedicellata* and *Cola usambarensis* were recorded. First record of the recently described snake, *Prosymna semifasciata*. *Stephopaedes usambarae* frog species recorded. Zanj elephant shrew and Four toed elephant shrew were present.
Longuza (N)			
Size: 1,580 ha 95-345 m a.s.l. EUBS: 1995	Trees/shrubs Mammals Reptiles Amphibians Butterflies	106 10 (5) 9 1 -	Tree species *Nesogordonia holtzii* recorded. First record in Tanzania of the Serotine bat *Eptesicus flavescens*, previous records were from Angola and Burundi.
Magrotto			
Size: 591 ha 600-900 m a.s.l. EUBS: 1994	Trees/shrubs Mammals Reptiles Amphibians	109 27 (9) 29 29	Endemic plant species to the Usambaras *Saintpaulia magungensis, Dolichometra leucantha* and *Rinorea scheffleri* were recorded. Third record for Tanzania of the Mops free tailed bat *Tadarida brachyptera* and first record for the East Usambaras. Zanj elephant shrew present.

Table 3 continued.

Forest Reserve	Number of species		Notes
Manga			
Size: 1,616 ha	Trees/shrubs	115	The reserve provides a corridor effect with other central lowland reserves. Usambara plant endemics *Chassalia albiflora, Sericantha odoratissima* and *Uvariodendron oligocarpum* were recorded. Particularly high butterfly diversity, with new species of *Euthecta* sp., discovered. Zany elephant shrew and the gecko *Lygodactylus kimhowelli* were recorded.
120-360 m a.s.l.	Mammals	30 (10)	
EUBS: 1997	Reptiles	26	
	Amphibians	22	
	Butterflies	102	
Mlungui			
Size: 200 ha	Trees/shrubs	56	First record of *Dichapetalum macrocarpum* and a range extension for *D. stuhlmannii*. *Olax gambecola* (previous records Uganda)and *Tricalysia pedicellata* (previous records Pwani and Morogoro regions, Tanzania) show a range extension here. Second specimen of snake *Prosymna semifasciata* collected.
200-450 m a.s.l.	Mammals	5 (0)	
EUBS: 1996	Reptiles	9	
	Amphibians	3	
	Butterflies	-	
Mtai			
Size: 3,107 ha	Trees/shrubs	146	East Usambara endemic plant species *Cola usambarensis*, *Rinorea scheffleri* and *Saintpaulia grotei* recorded. Exceptional diversity of herpetofauna including recently described snake *Prosymna semifasciata* and endemic chameleon *Chameleo spinosus*.
180-1,016 m a.s.l.	Mammals	31 (13)	
EUBS: 1996/97	Reptiles	34	
	Amphibians	27	
	Butterflies	55	
Nilo			
Size: 6,025 ha	Trees/shrubs	207	East Usambara plant endemic species, *Cynometra brachyrrahchis, C. longipedicellata, Placodiscus amaniensis*. Usambara plant endemics, *Uvariodendron oligocarpum, U. pycnophyllum.* seven species of African Violet including *Saintpaulia grotei* and *S. magungensis.* Zanj elephant shrew present. First record for the East Usambaras of the skink species *Proscelotes eggeli*. Frog species records of Usambara endemic *Hoplophryne rogersi* and *Phrynobatrachus kreffti*.
400-1,506 m a.s.l.	Mammals	47 (15)	
EUBS 2000/01	Reptiles	41	
	Amphibians	35	
	Butterflies	121	
Segoma			
Size: 1,934 ha	Trees/shrubs	148	East Usambara endemic tree species *Cola schefferi* and Usambara endemic tree species *Rinorea angustifolia* were recorded. Zany elephant shrew and Four-toed elephant shrew recorded. Snake species *Prosymna semifasciata* recorded. Frog species *Stephopaedes usambarae* recorded.
80-920 m a.s.l.	Mammals	31 (6)	
EUBS: 1998	Reptiles	29	
	Amphibians	19	
	Butterflies	-	
Semdoe			
Size: 950 ha	Trees/shrubs	81	Endemic tree *Uvariodendron oligocarpum* recorded. The Eastern Arc gecko species *Cnemaspis barbouri* was recorded .
160-520 m a.s.l.	Mammals	17 (0)	
EUBS: 1997	Reptiles	17	
	Amphibians	11	
	Butterflies	68	

Note: * Number of tree and .shrub species are from the systematic plots only.
** Number in brackets after the number of mammals are the number of species of bat recorded. For example Amani NR: a total of 59 mammal species were recorded including 26 species of bat.

1.3 MONITORING

Monitoring is a process that aims to detect changes in managed and unmanaged populations, communities and ecological systems over time (Sutter 1996). Although the term is often used indiscriminately, the repetition of measurement over time for the purpose of quantifying change distinguishes monitoring from inventory (MacDonald 1991). Another two words that are sometimes used interchangeably with monitoring are survey and surveillance. The former (very much like inventory), aims to make a set of observations with no preconceived ideas as to the findings, the latter is an extended programme of surveys taken in order to provide a time series, still with no preconceived idea of the findings (Hellawell 1991). Monitoring may provide information for management decisions and is an essential component of conservation (Sutter 1996). It can be used to assess the effectiveness of policy or legislation, perform a regulatory role or detect incipient change (Hellawell 1991).

According to Sutter (1996) monitoring techniques need to meet four criteria:

1. The data must have a known and acceptable level of precision, and detect real changes with a level of accuracy that the investigators find acceptable. Guiding factors include the extent of change expected, the variability inherent within the study area and the time and funding available.
2. Data collection techniques need to be repeatable over years and across personnel.
3. Data must be collected over a long enough time period to capture important natural processes and responses to management (Likens 1983, 1989, Magnuson 1990).
4. Efficiency must be considered an integral component of monitoring, i.e. the program should be feasible, realistic and inexpensive enough to be maintained over the long term.

Whilst there remain differences in opinion as to what makes a ‘good’ monitoring programme (Goldsmith 1991, Hellawell 1991, Usher 1991, Sutter 1996), there is general agreement as to the need for clearly defined objectives, in the absence of which, monitoring becomes merely surveillance (Goldsmith 1991). Sutter (1996) proposes that objectives have the following characteristics; be specific and quantifiable, provide the framework for defining specific tasks, specify the variables to be measured and the frequency of measurements, specify how success or failure will be assessed and help communicate and justify the project and provide a historical record of the project. Goldsmith (1991) would appear to agree with the need to measure the success or failure of a project and considers that all projects need a cut-off or at least review built into them. Usher (1991) argues the need for setting limits, however arbitrary, in order that a situation is defined at which the monitoring would reveal the need for action. This becomes especially important if the results of a monitoring programme are to be fed directly into management decision making. Such limits or standards should however not be irrevocable and should instead allow for change if experience shows them to be in error (Usher 1991). This ties in with the need for review in all monitoring programmes.

The sampling design is of utmost importance in any monitoring programme. A well thought out methodology maximises the ability of any monitoring programme to distinguish real changes, trends or cycles from random variation (Sutter 1996). Sutter (1996) considers the major considerations in sampling design to be; the sampling universe (the collection of individuals or area from which data is to be collected), the placement of sampling units in the sampling universe, the selection of sampling units, the selection of permanent or temporary sampling units, the sampling frequency and the number of samples. The analysis and interpretation of results from a monitoring programme will be rather more case-specific, reflecting the desired format of results, the importance of the project to management and the personnel and resources available. The personnel and resources available to a project will of course be of major importance to the whole programme. The personnel available to administer, co-ordinate, carry out fieldwork and file, analyse and interpret results will have a direct effect on the ‘success’ of a project. The resources available will largely dictate the monitoring equipment, the intensity of sampling, the interval between monitoring, the length of monitoring project and its sustainability.

A number of points should be made with regards to specifically monitoring forest biodiversity in areas managed for conservation. Firstly, to believe that areas set aside for conservation do not need management is a misconception (Alder & Synnott 1992). Most gazetted forests are fragments of former more widespread forests and many are now subject to a variety of edge-effects in the form of encroachment by shifting agriculture and the gathering of non-timber products. Few are in a state of equilibrium and thus most require active management, into which monitoring can feed. The monitoring of these areas may also provide valuable 'control' information in the monitoring of exploited forests (Alder & Synnott 1992). The second point is that the range of techniques and methods available for monitoring the biodiversity contained within forest environments is almost endless, thus to list all here is unfortunately beyond the scope of the current report. For further information consult the following references; Goldsmith (1991), Spellerberg (1991), Sutter (1996) and Dallmeier and Comiskey (c.1996).

1.4 REPORT STRUCTURE

This report starts with introduction, methods, results and discussion surrounding the testing of monitoring techniques. The recommendations for monitoring vegetation within East Usambara forest reserves that culminated from the testing of techniques are then presented. These recommendations were considered to be the main focus of the project and the most useful information for the managers; EUCAMP and ultimately Forestry and Bee Keeping Division (FBD) of the Ministry of Natural Resources and Tourism, Tanzania.

1.5 DATA AND MONITORING

Monitoring data will be to be stored in a Microsoft Access (version Windows 2000) database managed by East Usambara Conservation Area Management Programme. New fields for the database have yet to be developed to include the vegetation monitoring and vegetation plot GPS data but this is an aim for the EUCAMP database. Zoological data are also stored on the National Biodiversity Database at the Department of Zoology and Marine Biology, University of Dar es Salaam, as EUBS. This is also a Microsoft Access database. The data are geographically referenced and so can be used as a baseline for biodiversity monitoring.

1.6 SURVEY PERIOD AND PERSONNEL

The monitoring work carried out in Semdoe and Kwamgumi Forest Reserves was conducted between January 2001 and March 2001 for a total of 65 research days. The survey was conducted by Frontier-Tanzania staff, EUCAMP foresters, expatriate volunteers and utilised invaluable local knowledge from locally employed Field Assistants.

2.0 AIMS AND OBJECTIVES

2.1 AIMS

To investigate options for monitoring biodiversity within the East Usambara forests.

To use the methods, results and discussions of baseline biodiversity surveys conducted by the East Usamabara Biodiversity Surveys (EUBS) as a basis for this investigation.

2.2 OBJECTIVES

- To revisit semi-permanent vegetation plots established during EUBS in a number of selected forest reserves (test-sites) and gather data relevant to the monitoring of vegetation.
- To analyse the results in order to obtain information regarding change within vegetation plots and test analytical techniques available for long-term monitoring programmes.
- To provide information with regard to the current status of the selected forest reserves.
- To obtain longitude and latitude co-ordinates for all vegetation plots revisited using a GPS (Global Positioning System).
- To supplement fieldwork with literature based investigation.
- To recommend a set of options for the monitoring of forest biodiversity in the East Usambara mountains.
- To supplement EUBS species lists of the selected forest reserves by opportunistic collection of certain animal groups during fieldwork.

3.0 DESCRIPTION OF THE FORESTS

A brief introduction to the East Usambara mountains and the work of EUBS is presented in section 1.1 and 1.2 respectively. Two forest reserves within the East Usambara mountains previously surveyed by EUBS were chosen and re-visited for the purposes of monitoring fieldwork activities. These were Semdoe and Kwamgumi forest reserves. The following descriptions are taken from the relevant EUBS technical reports for each forest reserve, Frontier Tanzania. (2001a) & Frontier Tanzania (1999b) respectively.

3.1 SEMDOE FOREST RESERVE

3.1.1 Site Description

Name:	Semdoe Forest Reserve Muheza District, Tanga Region, Tanzania.
Area:	980 ha; 9.8km^2
Status:	Central Government Forest Reserve Gazetted 1999 Gazettement Notice 547 (1999)
Maps:	Ordnance Survey topographic maps Y742 (DOS 422) Sheet 110/3 'Hemagoma'. Forest Division map: JB.2261
Year of baseline survey	1997

3.1.2 Location

Grid reference:	38°41'E - 38°43'E, 4°56' - 4°58' S
Elevation	95 – 520 m a.s.l.

Semdoe Forest Reserve is situated in the centre of the East Usambaras forest reserves (Figure 1). Semdoe Forest Reserve is contiguous on its western border with Kambai Forest Reserve. In the east the reserve is divided from Segoma Forest Reserve by a narrow strip of public land around the Muzi River. The northern border of the reserve is the Semdoe River. To the south there is agricultural land. The southern border was poorly marked at the time of the survey.

3.1.3 Land use

The latest survey of the area was carried out by Hyytiäinen (1995), and updated by Johansson & Sandy (1996). The results for Semdoe Forest Reserve are summarised in Table 4 below. Semdoe Forest Reserve was described as entirely consisting of cultivation under lowland forest. However this was not the finding of the current survey and many areas appear to be lowland forest without cultivation.

Table 4. Land use distribution in Semdoe Forest Reserve (Johansson & Sandy 1996).

Semdoe Forest Reserve	Area (ha)	Percent (%)
Cultivation under lowland forest	970	100
Total for the reserve:	**970**	**100.0**

3.1.4 Topography

Semdoe Forest Reserve lies in the Sigi-Muzi river valley. Three tributaries of the Muzi River flow through the reserve. Along the northern border flows the Semdoe river, further south the Mazingara river runs north-eastwards and the most southerly tributary flows parallel to the Mazingara. The elevation of the reserve rises gently from east to west, the steepest slopes being along the western border. The highest point, at Semdoe Peak in the north-west of the reserve rises to 520m a.s.l..

3.1.5 History and Status

It was first proposed to gazette Semdoe as a Catchment Forest in 1994. Prior to this, the area was a part of the Kambai Public Lands. It was recognised by the EUCAMP that Semdoe is an important corridor between the Kwamgumi-Segoma forest block and the forests further west such as Kambai. The forest was therefore gazetted during the second phase of the EUCAMP.

As public land, the forest was highly disturbed primarily for fuel collection. A small area under cultivation was incorporated into the reserve and the family relocated.

Formerly a road passed through the reserve allowing access between Kwamtili and Kambai. This road was passable until 1996. It is now overgrown and impassable by vehicle having deteriorated significantly during the heavy rains of 1997.

Other research conducted in the reserve includes a visit by the Cambridge-Tanzania Rainforest Project (1994).

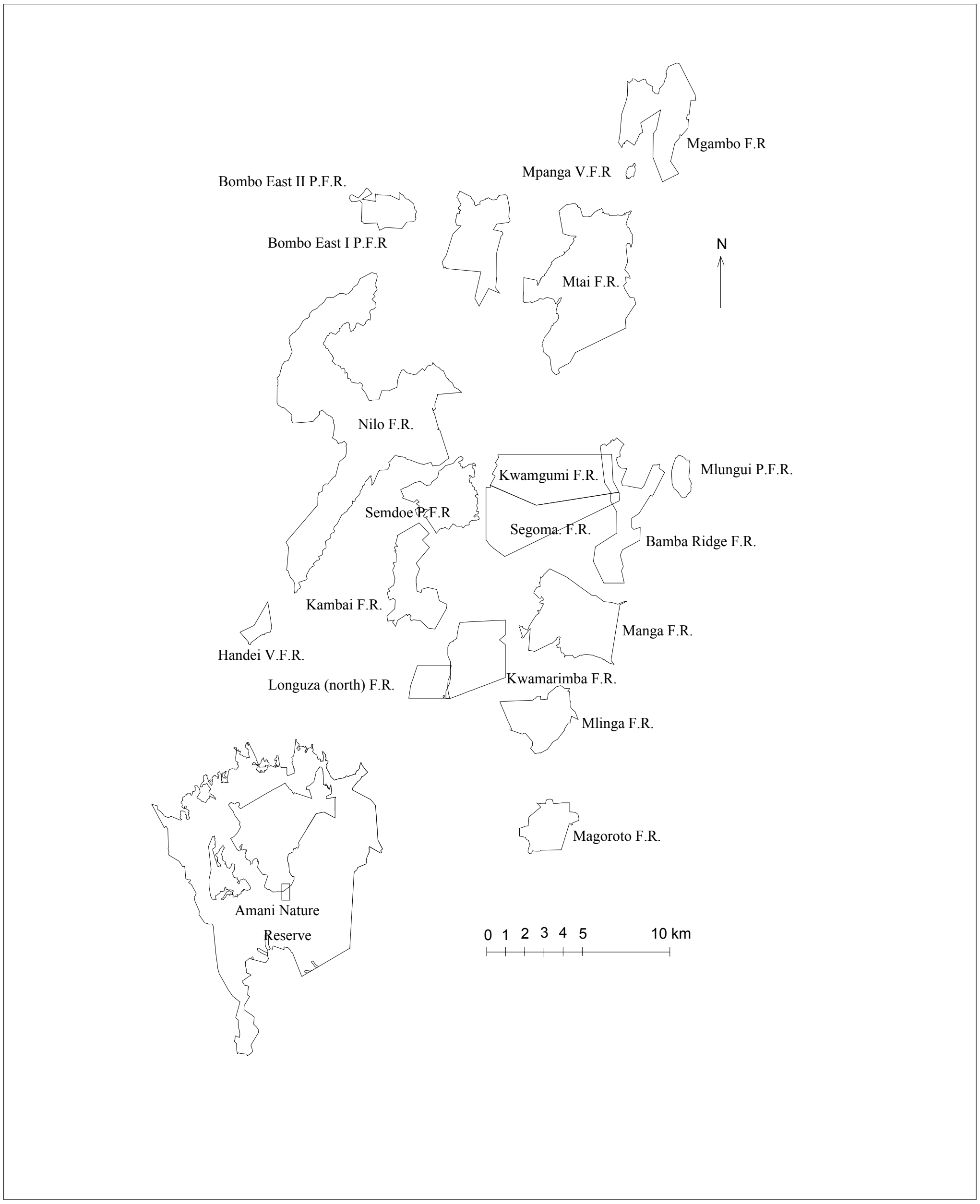


Figure 1. The location of Semdoe Forest Reserve in relation to other East Usambara forests.

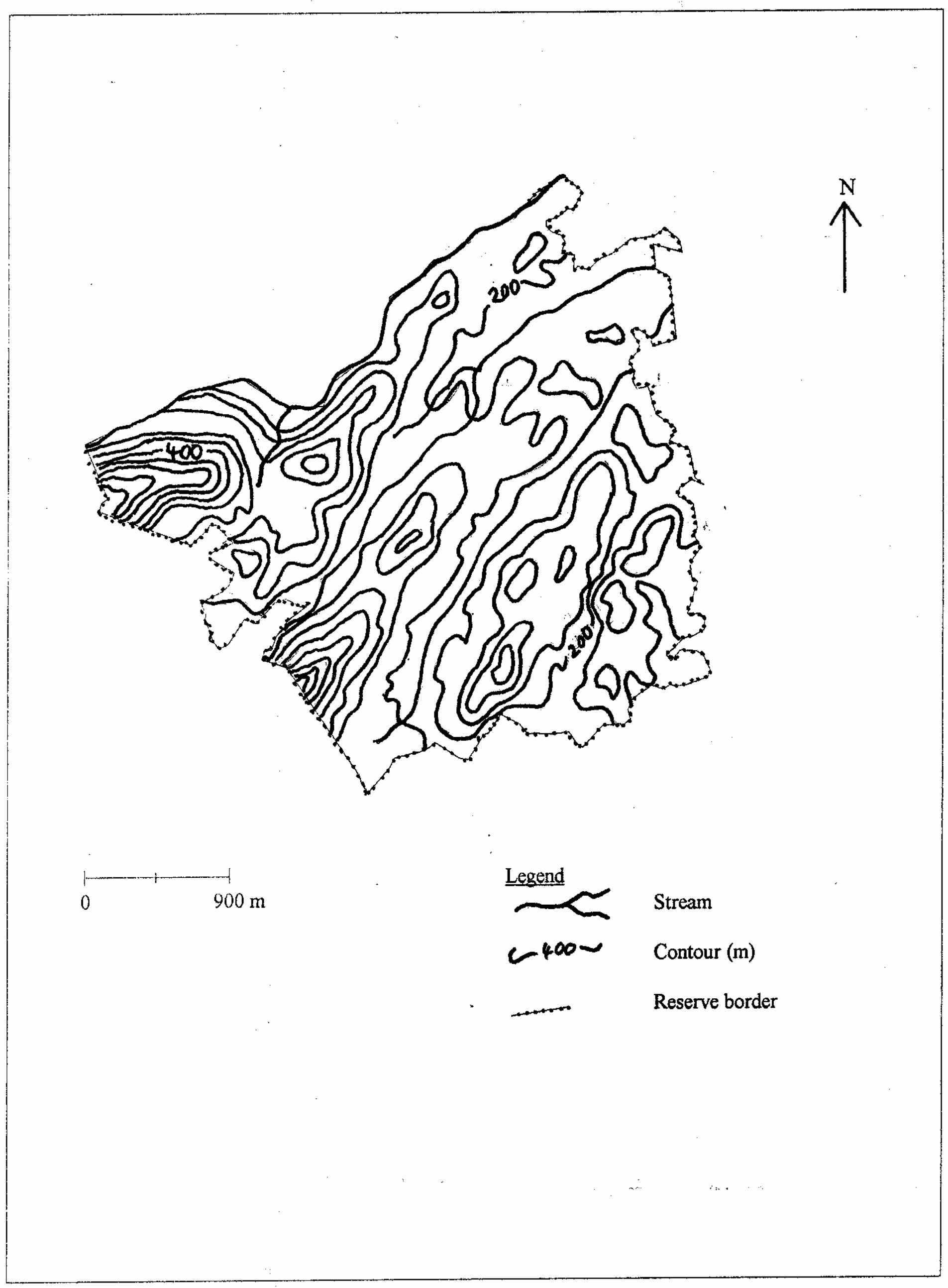


Figure 2. Topographical map of Semdoe Forest Reserve.

3.2 KWAMGUMI FOREST RESERVE

3.2.1 Site Description

Name:	Kwamgumi Forest Reserve Muheza District, Tanga Region, Tanzania.
Area:	1128.8 ha; 11.3 km^2; 4 sq. miles
Status:	Central Government Forest Reserve Gazetted 1905, Gazettement notice GN 195
Maps:	Ordnance Survey topographic maps 1: 50 000 Series Y742 Sheet 110/3 'Hemagoma' of 1988 and Sheet 110/4 'Gombero' of 1989 Forest Division map: Jb 204
Year of baseline survey	1996

3.2.2 Location

Grid reference:	38^{o}44'E 4^{o}57'S
Elevation	150 - 915 m a.s.l.

Kwamgumi Forest Reserve is situated in the central area of the East Usambara mountains (Figure 3). This reserve forms part of a forest continuum with the adjoining Segoma and Bamba Ridge Forest Reserves. Segoma FR is continuous along the entire southern boundary of Kwamgumi and Bamba Ridge FR is continuous along the entire eastern boundary. The area north of the reserve is a cocoa estate including some privately owned forest. Part of the estate is in the process of gazettement. This northern area has been included in the current study and adds an estimated minimum area of 1053ha to the official size of the Forest Reserve, giving a minimum total area surveyed of 2761ha.

3.2.3 Land use

The latest survey of the area was carried out by Hyytiäinen (1995) and updated by Johansson & Sandy (1996). The results for Kwamgumi Forest Reserve are summarised in Table 5 below. The majority of Kwamgumi Forest Reserve can be classified as lowland forest.

Table 5. Land use distribution in Kwamgumi Forest Reserve (Johansson & Sandy 1996).

Kwamgumi Forest Reserve	Area (ha)	Percent (%)
Dense lowland forest	1,071.6	94.9
Dense submontane forest	16.9	1.5
Peasant cultivation	3.1	0.3
Barren land	37.2	3.3
Total for the reserve:	**1128.8**	**100.0**

3.2.4 Topography

The reserve encompasses the catchment basin for tributaries of the Muzi river. The Muzi is a subsidiary of the Sigi river, which is the main catchment river of the East Usambara mountains. The reserve consists of a ridge running in an arc around a number of small valleys. The ridge rises to three peaks. To the west the Kwachawe Range runs north-south linked by a lower ridge to Segoma Peak in the centre of the reserve. On the eastern border lies Muhinduro Peak of Bamba Ridge Forest Reserve. The Muzi River marks some of the western border of the reserve (Figure 4).

3.2.5 History and Status

The reserve was gazetted during the German colonial period. During the 1950s the primary access road to Tanga ran through the reserve along the Muzi. This road is no longer in use and is impassable. During the late 1980s the Sikh Saw Mills extensively logged the forest and logging tracks are still evident. These tracks reach up to 500m a.s.l.. A number of other researchers have visited the reserve including Vestergaard (1994) and a Cambridge University Expedition

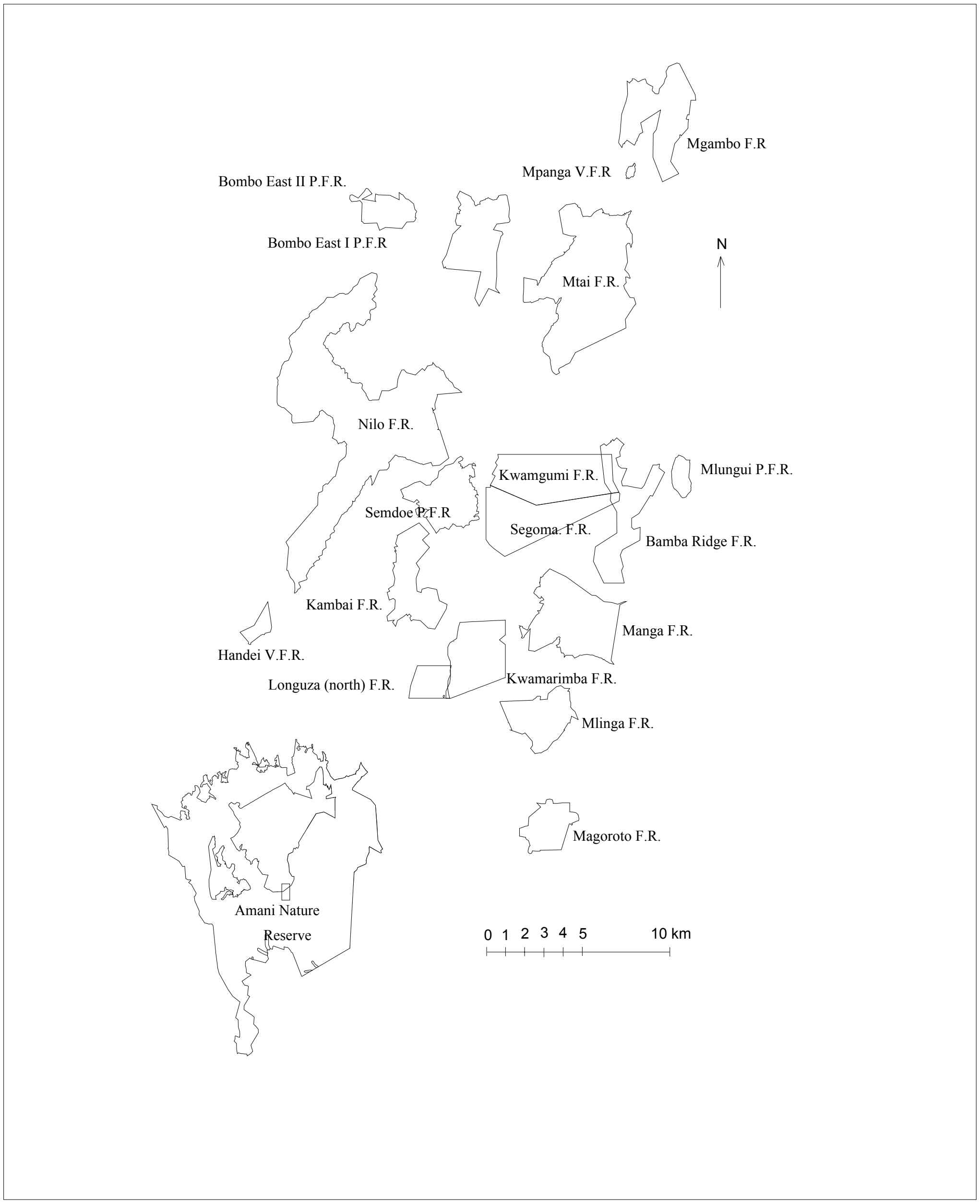


Figure 3. The location of Kwamgumi Forest Reserve in relation to other East Usambara forests.

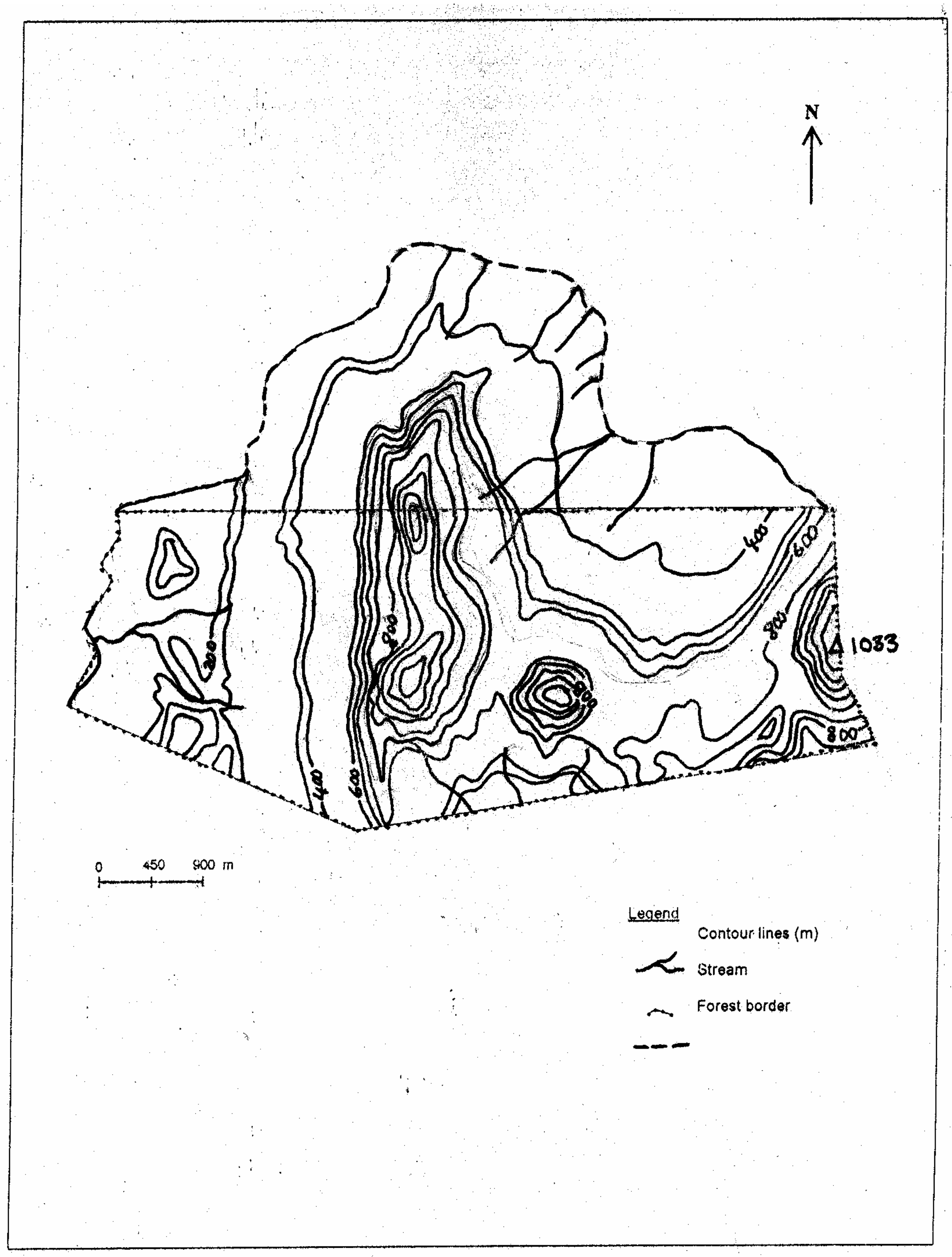


Figure 4. Topographical map of Kwamgumi Forest Reserve.

4.0 MONITORING OF FOREST VEGETATION

Staddon, S.C., Beharrell, N.K. & Killenga, R.

4.1 INTRODUCTION

Options for the monitoring of vegetation within the East Usambara mountains were investigated through a review and analysis of EUBS results and through fieldwork involving the semi-permanent sample plots established during EUBS. A review of available literature was also made. Work involved the consideration of sampling-intensity, sampling interval, data collection methodology and data analysis, and culminated in recommendations for the monitoring of forest vegetation in the East Usambara mountains.

4.2 METHODS

Fieldwork involved re-visiting forest reserves (FRs) within the East Usambaras and gathering data from a selection of vegetation plots (VPs). Data concerned the relocation of VPs, the marked trees and the detection of change of these trees. Literature based work concerned the results of EUBS work within VPs and are referred to in the results.

4.2.1 Selection of forest reserves and vegetation plots

Two FRs within the East Usambaras were selected in which data collection could be carried out. Forest reserve selection was based on the following criteria:

- date of original EUBS baseline survey
- current activities within the reserve, for example Joint Forest Management programmes
- logistical considerations involving access, base camp site, water availability
- size and habitat range of the reserve.

In the original EUBS surveys, semi-permanent VPs of 20 m x 50 m were established in the south-east corner of a 450 m x 900 m grid superimposed over the whole FR (FRs surveyed earlier had grids of 450 m x 450 m). Within each FR chosen for the current monitoring work, a stratified then systematic random sample of these VPs was selected.

The total sample set of VPs was initially stratified based on habitat classification; lowland forest (0-849 m a.s.l.), submontane forest (850-1249 m a.s.l.) and montane forest (>1250 m a.s.l.). In order to represent each stratum VPs were selected from each in proportion to the total number within that stratum. The number of VPs equivalent to sampling-intensities of 5%, 10%, 15%, 20% and 25% of the original survey was calculated. Incorporating each stratum, the appropriate number of VPs was then selected at random from the systematically arranged VPs established by EUBS.

When calculating the number of VPs equivalent to each sampling-intensity, numbers were rounded up so that only whole VPs were revisited for monitoring purposes. For each sampling-intensity VPs were selected independently i.e. VPs chosen for lower sampling-intensities were not nested sub sets of those chosen for the higher sampling-intensities i.e. the sum of 5% and 10% VPs did not make the 15% VPs. Any repetition of VPs between different sampling-intensities was thus coincidental. It was considered that these methods would allow a more thorough analysis of results. Within one FR time allowed for all VPs to be revisited, thus producing data equivalent to that from 100% of the sampling-intensity of the original survey.

The equations used for the above calculations are as follows:

Total no. of VPs to monitor at each sampling-intensity	=	Total no. of VPs / 100	x	sampling-intensity

No. of VPs to monitor from each stratification at each sampling-intensity	=	Total no. of VPs / No. of VPs from the stratification subset	x	Total no. of VPs to monitor at each sampling-intensity

4.2.2 Work within vegetation plots

Relocating and demarcating the vegetation plots

During the original EUBS surveys vegetation plots were located every 450 m along transect-lines of the grid system. Transects started at a known point and were orientated using a compass, cut causing minimum disturbance and marked with red plastic tags tied to trees every 2-5 m at eye-height. Vegetation plots were temporarily demarcated using two 20 m and two 50 m ropes orientated north-south and east-west respectively. Within each VP the diameter at breast height (dbh; 1.3 m) of all trees $\geq$10 cm dbh were measured and the tree identified. The point of measurement (POM; where dbh was measured), plot number and an individual, sequential number was marked on each tree using red gloss paint. Tree number 1 was located nearest to the south-east corner of the VP.

During monitoring work, vegetation plots were relocated using a compass and map and where old tags were still evident on the vegetation or the ground, along the transect lines. The south-east corner of the VP was relocated through a combination of the presence of tags (three were originally used to mark the corner), the position of previously marked trees and the knowledge of local Field Assistants. The VP was temporarily re-established by using a compass to orientate two 20 m and two 50 m ropes along each boundary. (Transect lines were re-tagged with sisal and when sure of the position, re-tagged with red tags. ‘Central’ access lines were re-tagged with yellow tags).

Tree measurements

Within each VP all trees marked in the EUBS survey were recorded as found or not found and if found, as alive or dead. The legibility of the original paint marking the individual tree number, POM and plot number was recorded as legible, ‘workoutable’ or illegible. The term workoutable encompassed those trees that had markings that could be partly read but not fully understood. These tree numbers were *worked out* after all other trees within the VP had been identified and with the aid of vegetation plot sketches drawn during EUBS.

All tree marks were re-painted using red gloss paint. ‘Ingrowth’ (comprising trees $\geq$10 cm dbh that have grown into this size class since the EUBS survey) were identified, dbh measured and tree number, POM and plot number painted. Each ingrowth tree was given an individual number that was sequential and followed on from the last tree number allocated in the EUBS survey. Tentative identification of ingrowth was made in the field and specimens were collected where necessary for formal identification.

In order to assess the inter-recorder accuracy of dbh measurements, one VP was selected in which all trees were repeatedly measured, with as many replications as was possible. The VP was selected based on the number of relocated trees within it and the ease of access. This work would provide a measure of the accuracy (or more strictly, the variation) between recorders.

4.2.3 Global Positioning System (GPS) records at vegetation plots

Global Positioning System (GPS) units were used to record the location of the vegetation plots and positions of transect lines. Locations were recorded where possible i.e. when there were sufficient canopy gaps for fixing 3 or more satellites. Garmin 12 hand-held GPS units were used on map datum ARC 1960, which is considered to be the most accurate when used in conjunction with the topographical maps available.

The VP locations during the majority of EUBS had not been recorded using a GPS. The location of the VPs was instead given as an approximate grid-reference based on fieldwork, maps and compasses. The GPS data can thus be incorporated with the baseline and monitoring data and are a useful tool for future monitoring.

4.3 RESULTS

Semdoe and Kwamgumi FRs were chosen for fieldwork activities in line with the criteria set down in section 4.2. Each FR was originally surveyed at a different time, had no complicating current activities, presented logistical ease and encompassed a different area and range of habitats. A full description of each reserve is presented in section 3.1 and 3.2 and a brief comparison given here (Table 6).

Table 6. Summary comparison of forest reserves chosen for monitoring fieldwork, based on data collected during EUBS.

	Semdoe Forest Reserve	Kwamgumi Forest Reserve
Year of EUBS	1997	1996
Size	950 ha (9.5km^2)	1708 ha (17.1km^2)
Elevation	160-520m a.s.l.	150-915m a.s.l.
Habitat type	lowland forest	lowland & submontane forest
Number of VPs established	19	49
Total number of species recorded in VPs	81	192
Number of endemic and near-endemic tree species	25	54
Number of forest-dependent tree species	19	68

4.3.1 Vegetation plot selection and status

Vegetation plot selection

Following the procedure and equations outlined in section 4.2.1, VPs were initially stratified according to habitat and then randomly selected for each sampling-intensity. Within Kwamgumi FR two of the original 49 VPs were recorded as submontane forest. Neither of these VPs was represented at any sampling-intensity, as the proportion was too low to result in the selection of a whole plot. There was no stratification within Semdoe FR as all VPs were recorded as lowland forest.

From initial fieldwork it became evident that a number of plots could not be re-located, many due to damage by fire. In order that enough data be collected for statistical analyses alternative VPs were selected, although information regarding these unlocated VPs was in itself of use. The VPs selected for each reserve are given in Table 7.

Table 7. Vegetation plots (VP) established by EUBS selected for monitoring fieldwork in Semdoe and Kwamgumi Forest Reserves.

SEMDOE FOREST RESERVE

Sampling intensity	No. of VPs to select	VPs selected				
5%	1	4				
10%	2	12	15			
15%	3	2	12	18		
20%	4	1	3	7	10	
25%	5	2	9	11	12	14
Cumulative no. of VPs selected				*12*		
Total no. of VPs originally established				*19*		
VPs not relocated		-	(VP 6 could not be monitored due to access problems)			

KWAMGUMI FOREST RESERVE

Sampling intensity	No. of VPs to select	VPs selected											
5%	3	12	35	36									
10%	5	12	29	32	34	39							
15%	7	1	7	31	35	41	46	49					
20%	10	7	8	18	20	29	31	32	36	42	43		
25%	12	8	13	15	17	18	21	32	33	34	35	43	46
Cumulative no. of VPs selected				*24*									
Total no. of VPs originally established				*49*									
VPs not relocated		9	25	37	38	44	48	(Total = 6)					

All 19 VPs established within Semdoe FR were relocated (100 %), although VP 6 could not be used in monitoring work due to access problems. Data were thus collected from 95 % of plots in Semdoe FR. Six out of a total of 30 VPs within Kwamgumi FR could not be relocated. This represents 20% of those searched for. Three of these VPs were not relocated due to access problems and two due to fire damage that rendered tree marking illegible.

Vegetation status

Within each VP, the status of all trees marked in the original EUBS surveys were recorded (Table 8 and Appendix 4 & 5).

Table 8. The status of trees within vegetation plots (VPs) during monitoring activities in Semdoe and Kwamgumi Forest Reserves.

	No. of trees marked in original survey	Number (and %) of trees Found alive	Found dead	Found in total	Not Found
SEMDOE FR					
Total	600	471	61	532	68
Mean per VP	33.33	26.17 (**88.16** %)	3.39 (11.84%)	29.56 (**78.34** %)	3.78 (21.66 %)
standard deviation	17.45	18.02	3.81	19.17	5.39
(n = 19 originally and 18 during monitoring)					
KWAMGUMI FR					
Total	1151	952	62	1014	137
Mean per VP	47.96	39.67 (**91.09** %)	2.58 (8.91 %)	42.25 (**87.35** %)	5.71 (12.65 %)
standard deviation	11.02	14.33	2.73	13.84	7.74
(n = 49 originally and 24 during monitoring)					

Note: Figures given for 'Found in total' combine those for 'Found alive' & 'Found dead'. Percentages for 'Found alive' & 'Found dead' thus equal 100, as do those for 'Found in total' & 'Not found'.

The majority of trees within VPs in both Semdoe and Kwamgumi FRs were relocated, with the average (percentage) higher in Kwamgumi (87 %) than in Semdoe (78 %). The majority of relocated trees were alive in both reserves, but again the average (percentage) was higher in Kwamgumi (91 %) than in Semdoe (88 %). Alive and ingrowth trees re-located within Semdoe FR during monitoring presented 95 % of the original number of trees recorded within the VPs from EUBS and 91 % respectively from Kwamgumi.

In practice, the majority of trees were relocated if they were still marked i.e. the paint was still legible. Paint legibility was assessed for each of the three markings on the tree; the individual tree number, POM and plot number (Table 9 and Appendix 6 & 7).

Table 9. Paint legibility of marked trees in vegetation plots (VPs) in Semdoe and Kwamgumi Forest Reserves at the time of monitoring activities.

	No. of trees found alive	Legibility of paint marking: Individual tree number Y	W	N	Point Of Measurement Y	W	N	Plot number Y	W	N
SEMDOE FR										
Total number	488	427	51	10	461	22	5	449	29	10
Total as a %	-	**87.5** %	10.5 %	2.0 %	**94.5** %	4.5 %	1.0 %	**92.0** %	5.9 %	2.0 %
Mean per VP	27.11	25.12	3.00	0.59	27.12	1.29	0.29	26.41	1.71	0.59
st. deviation (n = 18)	18.24	14.95	3.62	0.94	16.01	1.76	0.47	15.85	2.11	0.80
KWAMGUMI FR										
Total number	951	732	194	26	810	121	25	763	158	31
Total as a %	-	**77.0** %	20.4 %	2.7 %	**85.2** %	12.7 %	2.6 %	**80.2** %	16.6 %	3.3 %
Mean per VP	39.63	30.50	8.08	1.08	33.75	5.04	1.04	31.79	6.58	1.29
st. deviation (n = 24)	14.25	13.00	7.95	1.72	13.45	5.68	1.55	13.26	7.00	1.78

Key: Y – Yes, marking was legible W – marking is 'Workoutable' N – No, marking was not legible

The majority of tree markings established during EUBS on live trees found during monitoring work were thus legible. In Semdoe FR, 98 % of individual tree numbers, 99% of POMs and 98% of plot numbers were at least workoutable (sum of 'yes' and 'workoutable'). In Kwamgumi FR these figures were 97 % of individual tree numbers, 98 % of POMs and 97 % of plot numbers.

There was considerable variation about the mean legibility per VP, with standard deviations greater than means in some cases. Within Semdoe FR, VPs 7, 9, 10 and 11 revealed particularly high numbers of 'workoutable' or illegible marks. All of these VPs showed signs of both recent and past fire. Within Kwamgumi FR, VPs 12, 20, 21, 29, 36 and 42 revealed similarly high numbers, although most showed no signs of fire.

4.3.2 Tree growth assessment

During monitoring activities, the dbh of all trees originally marked within VPs were recorded at the original POM. The change in dbh between the original survey and monitoring measurements was calculated. The mean change in dbh over time per VP and associated standard deviation, standard error and 95% confidence limits were calculated (Table 10 and Appendix 4 & 5).

Table 10. Summary statistics for the change in diameter at breast height (dbh; 1.3m) of trees marked in vegetation plots (VPs) in Semdoe and Kwamgumi Forest Reserves.

SEMDOE FOREST RESERVE

VP	no. of trees re-measured	Range of change in dbh (cm) in original survey	mean change in dbh	standard deviation of mean	standard error	confidence limit (95%)
1	4	-6.00 – 3.72	0.7	4.6	2.28	4.47
2	0	-	-	-	-	-
3	9	-1.51 – 5.09	1.5	2.1	0.69	1.36
4	18	-11.13 – 6.33	-0.5	4.6	1.09	2.13
5	3	-1.77 – 5.21	1.1	3.7	2.11	4.14
7	53	-9.03 – 32.21	2.9	5.7	0.78	1.52
8	35	-13.81 – 20.65	0.0	5.3	0.90	1.76
9	55	-9.08 – 5.45	0.4	2.5	0.34	0.66
10	28	-9.92 – 3.82	0.0	2.4	0.46	0.90
11	26	-1.50 – 11.10	2.0	2.3	0.44	0.87
12	32	-8.33 – 4.93	0.4	2.5	0.44	0.87
13	56	-17.68 – 15.77	0.5	3.5	0.47	0.91
14	24	-14.20 – 6.62	-0.2	3.9	0.80	1.56
15	26	-4.37 – 38.67	3.3	9.7	1.90	3.73
16	23	-8.65 – 8.99	1.3	3.4	0.72	1.40
17	33	-19.38 – 9.21	-0.2	4.5	0.79	1.55
18	1	3.71	3.7	-	-	-
19	26	-3.62 – 12.87	2.1	3.3	0.65	1.26
Total	**452**	**Means**	**1.1**	**4.0**	**0.93**	**1.82**

Table 10. Continued.

KWAMGUMI FOREST RESERVE

VP	no. of trees re-measured	Range of change in dbh (cm) in original survey	Mean Change in dbh	standard deviation of mean	standard error	confidence limit (95%)
1	27	-10.55 – 4.56	0.0	3.4	0.66	1.29
7	20	-11.00 – 8.56	0.9	4.3	0.96	1.88
8	30	-17.38 – 11.28	1.7	4.3	0.79	1.55
11	43	-9.63 – 8.79	1.0	2.8	0.42	0.82
12	66	-0.8 – 9.60	1.1	1.4	0.17	0.33
13	29	-10.31 – 8.86	0.5	2.9	0.54	1.05
15	46	-10.64 – 12.78	1.5	3.4	0.51	0.99
17	52	-5.68 – 5.15	0.6	2.0	0.27	0.54
18	22	-4.27 – 7.76	3.4	6.0	1.28	2.51
20	33	-13.63 – 6.19	1.9	3.4	0.58	1.15
21	48	-10.63 – 32.25	2.0	8.6	1.23	2.42
29	65	-9.90 – 4.83	0.4	1.9	0.24	0.47
31	36	-0.40 – 17.63	2.3	3.4	0.57	1.11
32	34	-2.74 – 30.64	2.3	6.8	1.17	2.29
33	53	-11.74 – 10.14	-0.3	3.3	0.45	0.89
34	44	-12.93 – 12.01	0.3	3.4	0.51	1.01
35	48	-6.07 – 22.01	1.4	3.7	0.54	1.05
36	44	-12.20 – 19.01	0.6	4.3	0.65	1.28
40	40	-8.09 – 14.75	2.9	5.0	0.79	1.54
41	36	-11.77 – 6.52	-0.2	3.4	0.57	1.12
42	31	-17.13 – 10.83	-2.7	7.4	1.32	2.59
43	32	-16.82 – 11.28	0.9	4.4	0.78	1.53
46	49	-2.31 – 4.78	1.3	1.5	0.22	0.42
49	1	2.11	2.1	-	-	-
Total	**929**	**Mean**	**1.1**	**4.0**	**0.33**	**0.65**

The average increase in dbh of trees in both Semdoe and Kwamgumi FRs was thus 1.1 ± 4.0 cm. There was much variation both within and between VPs. The standard error and 95 % confidence limits associated with the change in dbh of the average tree in both FRs were different. These were far larger in Semdoe (0.93 and 1.82 respectively) than Kwamgumi (0.33 and 0.65 respectively). This was to be expected as the sample set in Semdoe (n = 16) was only approximately two-thirds that of Kwamgumi (n = 23).

It would appear that in certain VPs in both Semdoe and Kwamgumi FRs, the dbh of the average tree had decreased between the date of the EUBS and monitoring work. As trees cannot 'shrink' (except for daily fluctuations related to water stress or debarking), these results reflect inaccuracies in measuring, either at the time of the original survey or during monitoring activities.

Control plot: assessment of stem dbh measurements

In an attempt to quantify this inaccuracy, the dbh of 46 stems from 43 trees originally marked in VP 11 in Kwamgumi FR (control plot) were re-measured by 38 recorders (working independently). Some trees were multi-stemmed, in which case each stem was treated as a separate individual for the purposes of this study. For each stem the mean change in dbh and associated standard deviation, standard error and 95 % confidence limits, based on these 38 replications, were calculated. Appendix 8 lists the means of the stem measurements from EUBS and monitoring from the control plot (VP 11 KW).

The mean change in dbh within the control plot was 0.77 ± 1.42 (n = 46). The associated standard error was 0.23. The standard error constitutes the error during EUBS and during monitoring work, thus the total error over time is 0.46 (0.23 multiplied by two). 0.46 cm is thus effectively the 'recorder error'.

Practically this means that a stem must increase in size by ≥ 0.46 cm in order to be able to record a true change in dbh. In other words, any figure below this may simply reflect recorder error and *not* a true increase in dbh.

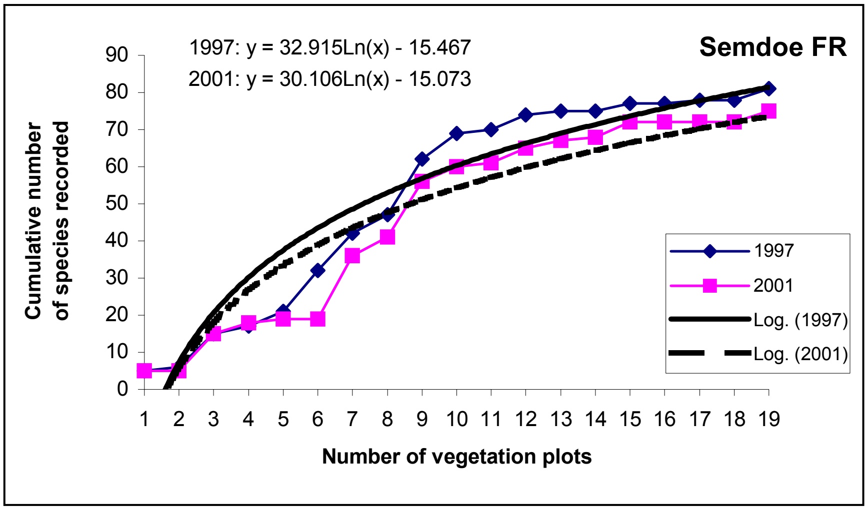
The average increase in dbh between EUBS and monitoring work in Semdoe and Kwamgumi FRs was 1.1 ± 4.0 cm. By subtracting the effective recorder error of 0.46 cm from this average increase, a true change in dbh of at least 0.64 cm in the average tree in Semdoe and Kwamgumi VPs is concluded.

4.3.3 Comparison of Baseline (EUBS) and Monitoring

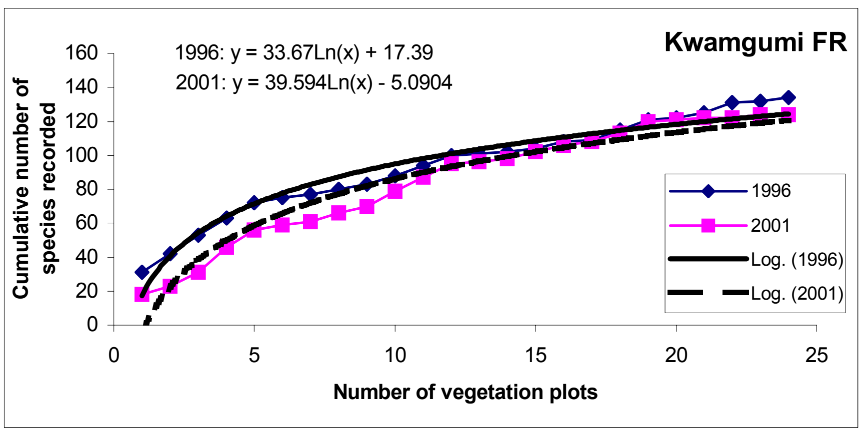
Work concerning the monitoring of species richness was based on both fieldwork carried out in Semdoe and Kwamgumi FRs and deskwork involving results from all previous EUBS. The EUBS report for each FR contains a checklist of plant species recorded within VPs and a species accumulation curve based on these. In monitoring VPs in Semdoe and Kwamgumi FRs, the present study was concerned with ascertaining whether species richness had changed since the baseline work, whether the accumulation of species differed and whether the presence and absence of species previously recorded within the FR had altered. Comparisons between species richness within both FRs during baseline and monitoring work were based on all those VPs re-visited during the monitoring activities. This equates to 18 of the 19 VPs in Semdoe FR and 24 of the 49 in Kwamgumi FR.

Species accumulation

Species accumulation curves were produced for each FR, presenting accumulation during both baseline and monitoring work (Figure 5).



(a)



(b)

Figure 5. Species accumulation curves of trees recorded within vegetation plots at the time of baseline and monitoring work (a) within Semdoe Forest Reserve (EUBS: 1997) and (b) within Kwamgumi Forest Reserve (EUBS: 1996).

From visual assessment and consideration of equations, the species accumulation curves appear to be fairly constant over time, i.e. that they had not changed greatly between the baseline and the monitoring activities. This was especially true of Semdoe FR for which the equations were very similar over time. It should be noted that the number of VPs visited to gather the data for these curves was different between each FR. For Kwamgumi FR the number was only half of the original VPs surveyed whilst in Semdoe FR it was 95 %.

Species Richness: Baseline VS Monitoring

The species accumulation curve revealed information on species richness but not the individual species involved. The number of species recorded during baseline and monitoring work was thus assessed (Table 12) and individual species considered. Ingrowth identifications (Appendix 3) were used for this purpose.

Table 12. Summary of species richness recorded during EUBS and monitoring work within Semdoe and Kwamgumi Forest Reserves.

	Semdoe Forest Reserve	Kwamgumi Forest Reserve
EUBS		
Total number of species recorded	79	134
Number only recorded during EUBS	10	14
MONITORING		
Total number of species recorded	75	124
Number only recorded during monitoring	6	4
EUBS & MONITORING		
Number of species recorded during both	69	120
Total number of species recorded	85	138

Within Semdoe FR, 10 species were thus 'lost' between EUBS and monitoring work, whilst 6 were 'gained'. Within Kwamgumi FR the number lost was 14 and gained 4 (Table 12).

Table 13. Species recorded during only either EUBS or monitoring work in Semdoe and Kwamgumi Forest Reserve.

SEMDOE FOREST RESERVE

Family	Species	Ecol. type	Habitat	Endemic status	VP located in	Description
SPECIES RECORDED ONLY DURING EUBS:						
Araliaceae	*Cussonia zimmermannii*	f	L	N	19	1 large tree, found dead during monitoring
Euphorbiaceae	*Mildbraedi fraxinifolius*	?	?	?	14	5 individuals, not found during monitoring
Leguminosae – Mimosoideae	*Acacia mellifera*	O	S	W	10	1 large individual, not found during monitoring
Leguminosae – Mimosoideae	*Newtonia paucijuga*	F	L	N	10	1 large individual, not found during monitoring
Leguminosae – Papilionoideae	*Erythrina caffra*	O	S	W	1	1 small individual, not found during monitoring
SPECIES RECORDED ONLY DURING MONITORING:						
Leguminosae – Papilionoideae	*Pterocarpus mildbraedii*	F	L	N	13	1 medium individual, not found during monitoring
Leguminosae – Papilionoideae	*Pterocarpus tinctorius*	F	S & L	W	10	1 medium individual, not found during monitoring
Sapindaceae	*Allophylus* sp.	-	-	-	9	1 small individual, not found during monitoring
Sapotaceae	*Manilkara sulcata*	f	L	W	4	1 medium individual, found dead during monitoring
Sterculiaceae	*Cola greenwayi*	F	S	W	12	1 small individual, found dead during monitoring
Apocynaceae	*Pleiocarpa pycnatha*	F	L & S	W	7	Ingrowth, 1 individual
Melianthaceae	*Bersama abyssinica*	f	S	N	4	Ingrowth, 1 individual

Table 13. Continued

Family	Species	Ecol. type	Habitat	Endemic status	VP located in	Description
Sapotaceae	*Manilkara sansibarensis*	f	L	W	4	Ingrowth, 1 individual
Sterculiaceae	*Dombeya schupange*	O	L	N	19	Ingrowth, 1 individual
Ulmaceae	*Celtis zenkleri*	f	L & S	W	3	Ingrowth, 3 individuals
Ulmaceae	*Trema orientalis*	f	L & S	W	1,5,11,14	Ingrowth, 29 individuals
KWAMGUMI FOREST RESERVE						
SPECIES RECORDED ONLY DURING EUBS: Kwamgumi						
Annonaceae	*Mkilua fragrans*	F	S	N	1	1 medium individual, not found during monitoring
Bignoniaceae	*Markhamia* sp.	-	-	-	43	-
Bombaceae	*Ceiba pentandra*	f	S	W	42	1 large individual, found dead during monitoring
Combretaceae	*Combretum* sp.	-	-	-	43	-
Combretaceae	*Pteleopsis myrtifolia*	f	L	W	49	1 large tree, not found during monitoring
Euphorbiaceae	*Drypetes* sp.	-	-	-	1	-
Euphorbiaceae	*Suregada zanzibarense*	f	L	W	49	1 medium individual, not found during monitoring
Leguminosae – Caesalpiniaceae	*Cynometra webberi*	f	L	N	8	1 large individual, found dead during monitoring
Moraceae	*Milicia excelsa*	f	L & S	W	1,42	1 small & 1 medium individual, not found during monitoring
Rubiaceae	*Rothmania* sp.	-	-	-	43	-
Rubiaceae	*Rytigynia schumannii*	F	M	N	1	1 medium individual, not found during monitoring
Sapotaceae	*Englerophytum* sp.	-	-	-	43	-
Sterculiaceae	*Cola* sp.	-	-	-	43	-
Ulmaceae	*Terminalia* sp.	-	-	-	43	-
SPECIES RECORDED ONLY DURING MONITORING: Kwamgumi						
Ochnaceae	*Brackenridgea zanguebarica*	F	S	W	12	Ingrowth, 2 individuals
Oleaceae	*Chioanthus* sp.	-	-	-	34	Ingrowth, 1 individual
Leguminosae – Papilionoideae	*Erythrina abyssinica*	O	L & S	W	20	Ingrowth, 1 individual
Rubiaceae	*Rytigynia pallens*	?	?	?	21	Ingrowth

KEY TO ABBREVIATIONS FOR TABLE 13.

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.

? Insufficient data

Semdoe FR 'lost' and 'gained' species

Within Semdoe FR it can be seen that the majority of species 'lost' were represented by only one individual. Although the species richness had therefore decreased, the abundance of individuals was little effected. This lost individual was in most cases not found during monitoring activities, indicating that it had died or fallen and was not located on the ground, or that it had been cut and removed (this would be indicated in the assessment of human disturbance within the VP), or that it was in fact still there and a more thorough search would reveal it (unlikely).

Some individuals were found dead, the cause of which, if not natural, could be ascertained from considering any human disturbances within the VP, i.e. fire. The trees lost in Semdoe FR were recorded in VPs that had all been disturbed by fire, although all but 2 of the 18 VPs in total showed signs of fire damage. There was no evidence of recent cutting in any of the VPs containing these lost species, although there were signs of cutting at the time of EUBS.

The species 'gained' during monitoring work all represent species present within the VPs as ingrowth. The VPs in which these species were recorded tended not to be those where species were lost, but all showed signs of fire damage both during EUBS and monitoring work. As the majority of VPs in the FR had suffered fire damage, no pattern in the distribution of these species could easily be ascertained.

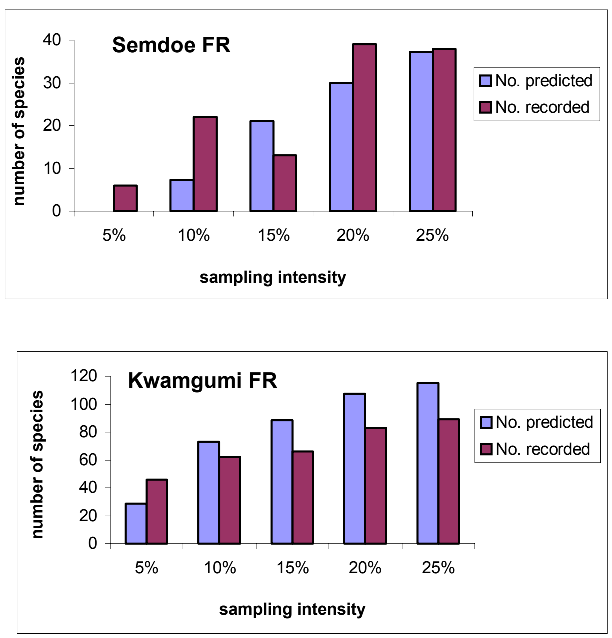
Of the lost species, most were forest non-dependent, with approximately equal numbers of widespread and endemic or near-endemic species. *Pterocarpus mildbraedii*, *P. tinctorius* and *Cola greenwayi* are species often cut for use as building poles whilst *Newtonia paucijuga* is used for fuelwood (Ruffo 1989). Of the species gained, one is forest dependent and one a non-forest species. Both were widespread species. *Bersama abyssinica*, a gained species, is used for timber (Ruffo 1989).

Kwamgumi FR 'lost' and 'gained' species

Within Kwamgumi FR, as in Semdoe FR, the majority of lost species were represented by only one individual. Although there was no overlap in VPs in which lost and gained species were recorded, again all VPs showed evidence of both fire and cutting or logging. Four of the 10 species lost were recorded in VP 1, in which recent fire damage was noted. VP 49 (in which one of the species lost had been recorded) had suffered extensive recent fire damage, resulting in a loss of 76 % of trees originally recorded. No clear patterns in the distribution of these lost and gained species was found. Of the species lost, half were forest dependent and only 3 out of 10 were endemic or near-endemic. *Milicia excelsa*, is an important timber species (Ruffo 1989). Of the species gained, most were forest non-dependent and as for species lost, approximately a third were endemic or near-endemic.

4.3.4 Predictive and recorded numbers of species

The species accumulation curves for Semdoe and Kwamgumi FRs (based on those VPs re-visited during monitoring work) were shown to be approximately equal between EUBS and monitoring work, thus fairly constant over time. An assumption was thus made that the number of species was stable over time. The equation of the logarithmic best-fit line associated with the accumulation curve was used to predict the percentage of original species recorded that may be expected to be found if the FR were to be re-surveyed (or monitored) at a range of sampling-intensities. These predicted numbers could then be compared to those actually recorded at each sampling-intensity (Figure 6 and Appendix 9). This would enable an assessment to be made of the use of random sampling of VPs to indicate the state of affairs at each sampling-intensity.



(a)

(b)

Figure 6. A comparison of the number of species expected to be recorded at various sampling-intensities based on 'predictive curves' calculated using EUBS data, with those numbers actually recorded in VPs at each sampling-intensity (a) within Semdoe Forest Reserve and (b) within Kwamgumi Forest Reserve.

Species accumulation: Semdoe

Within Semdoe FR the number of species both predicted and recorded, as expected, increased with sampling-intensity. The increase in the number recorded was however fairly irregular. The number predicted and recorded at each sampling-intensity was not statistically significantly different (Mann-Whitney U test, p=0.530) and at a sampling-intensity of 25% the numbers were identical.

Species accumulation: Kwamgumi

Within Kwamgumi FR the number of species both predicted and recorded, as for Semdoe FR, also increased with sampling-intensity. The number of species recorded did however increase at a much steadier rate than within Kwamgumi. The number predicted and recorded at each sampling-intensity, was again, not statistically significantly different (Mann-Whitney U test, p=0.347). The difference between the two numbers was fairly constant between sampling-intensities of 10% or above. The number recorded was lower than the number predicted and as this has been shown to be the case (Table 6), the results from these sampling-intensities reflect the situation well.

Species accumulation curves: 1995 - 2000

Based on the assumption that other FRs within the East Usambaras will act in a similar way to Semdoe and Kwamgumi FRs, the species accumulation curves for all were analysed. The equation of the logarithmic best-fit line associated to each curve was used, as for Semdoe and Kwamgumi FRs, to predict the percentage of original species recorded that may be expected if the FR was re-surveyed at differing sampling-intensities. This would then provide information for future monitoring within all East Usambara FRs. As a number of FRs were surveyed using a 450 m x 450 m grid, the accumulation curves for these FRs were re-worked in order to use only those VPs that would have been established if a 450 m x 900 m grid had been employed. This would make all FRs comparable in terms of the number of species predicted to be recorded at each sampling-intensity (Figure 7, Table 14 and Appendix 9).

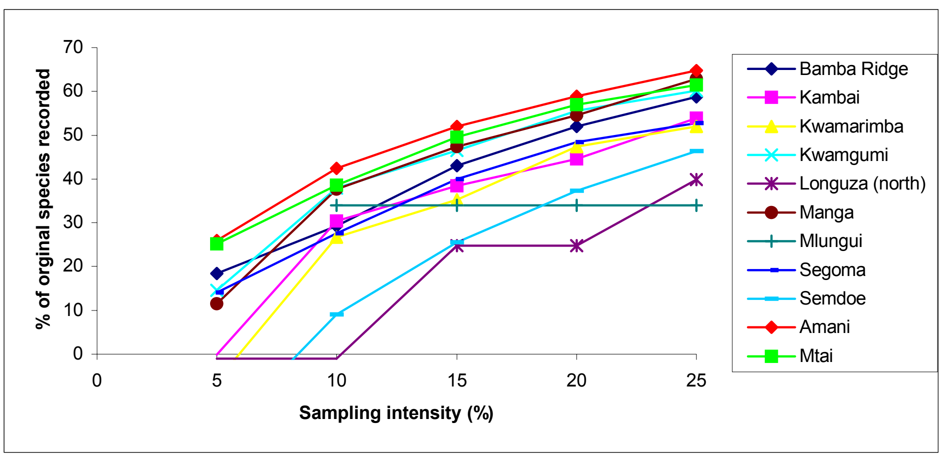
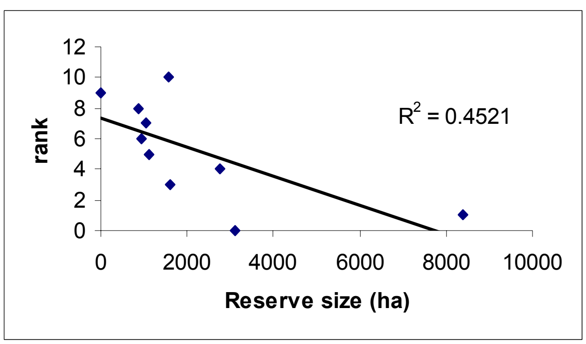


Figure 7. A prediction of the percentage of original species expected to be recorded during re-survey at a variety of sampling-intensities for all Forest Reserves thus far surveyed by EUBS.

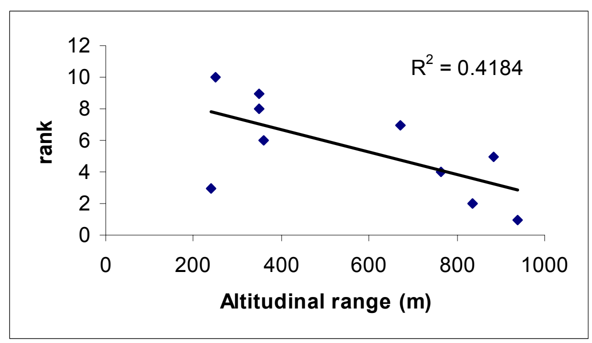
Table 14. Summary of Forest Reserves, species richness and the percentage of original species richness expected to be recorded during re-survey at various sampling-intensities.

Forest Reserve	No. of original VPs	No. of species originally recorded	Size (ha)	Altitudinal range (m)	% of original species expected at each sampling-intensity				
					5%	10%	15%	20%	25%
Amani	182	246	8380	190-1130	26	42	52	59	65
Bamba Ridge	24	129	1132	150-1033	18	29	43	52	59
Kambai	26	132	1046	200-870	0	30	38	45	54
Kwamarimba	28	137	887	95-445	-6	27	35	47	52
Kwamgumi	49	192	2761	150-915	15	38	46	56	60
Longuza (N)	10	82	1580	95-345	-1	-1	25	25	40
Manga	46	115	1616	120-360	11	38	47	55	63
Mlungui	5	45	200	200-450	-	34	34	34	34
Mtai	73	177	3107	180-1016	25	39	50	57	61
Segoma	53	148	1934	160-520	14	28	40	48	53
Semdoe	19	81	950	95-445	-19	9	26	37	46

There are clearly similarities in the rate of increase of the 'species predicted' curve between FRs, although the origin differs. The percentage of original species expected at a 15 % sampling-intensity in Longuza (north) FR is for example only half that of the same for Amani or Mtai FRs. It would appear to be possible to rank the FRs based on these results, with a continuum between those FRs in which you would expect to record a high percentage of the original species at a given sampling-intensity, to those for which you would expect only a low number. This was carried out and the subsequent ranking compared to the physical features of size and altitudinal range of the FRs, along with species richness (Figure 8).



(a)



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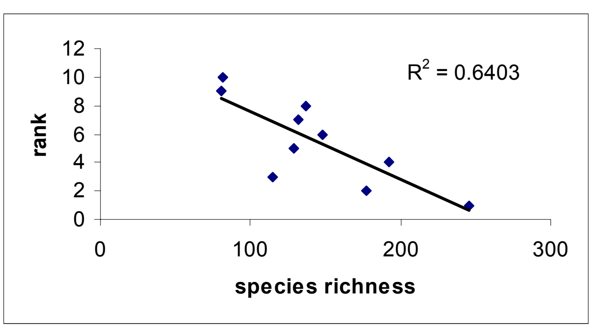


Ranking of Forest Reserves

Amani	1
Mtai	2
Manga	3
Kwamgumi	4
Bamba Ridge	5
Segoma	6
Kambai	7
Kwamarimba	8
Semdoe	9
Longuza (north)	10

(c)

Figure 8. Rank of Forest Reserves based on number of species predicted to be recorded at a given sampling-intensity against (a) size, (b) altitudinal range and (c) species richness of the reserve.

The relationship between FR ranking and FR size, altitudinal range and species richness are all negative, i.e. the FR of greatest size, altitudinal range and highest species richness ranks first. The coefficients of determination associated with each line of best fit in Figure 8 indicate that the species richness of a FR explains a greater proportion of the variability in FR ranking than do its size or altitudinal range. Species richness in itself has a relationship to FR size ($r^2 = 0.6984$) and altitudinal range ($r^2 = 0.591$) and thus all three factors are likely to exert a complex combined effect on FR ranking.

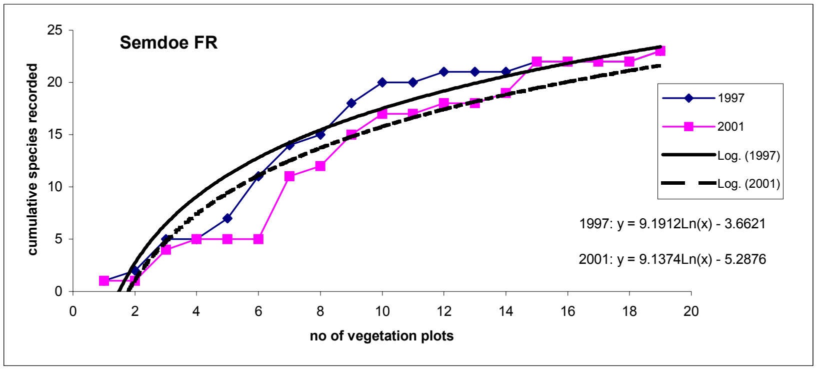
4.3.5 Plant endemism

Three criteria were used in all EUBS to analyse the uniqueness of biodiversity within each FR and to assess vulnerability to disturbance; ecological requirement, level of endemism and typical habitat association. Within each EUBS report the number of species and individuals within each category of the above criteria are given. For example, the numbers of forest dependent (F), non-forest dependent (f) and non-forest (O) species. In the current monitoring work the level of endemism amongst trees within VPs was considered, as one example of work that could be done involving these three criteria.

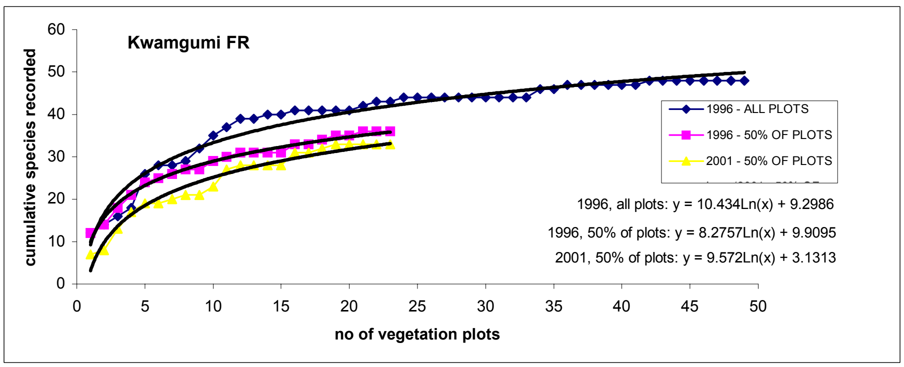
In line with work on species richness, monitoring work was concerned with ascertaining answers to the following questions:

Has the total number of endemic and near-endemic species changed since the EUBS baseline?
Does the accumulation of endemic and near-endemic species differ since the EUBS baseline?
Has the presence or absence of endemic and near-endemic species altered since the EUBS baseline?
What effects do the sampling intensities have on the recording of endemic and near-endemic species?

The accumulation of endemic and near-endemic species was first considered by comparing that during EUBS with that during monitoring work. For Semdoe FR this was carried out for all VPs revisited (c.100% of those during EUBS). For Kwamgumi FR only 24 of the original 49 VPs could be analysed, although the accumulation within these VPs was also compared to that for all 49 VPs during EUBS (Figure 9).



(a)

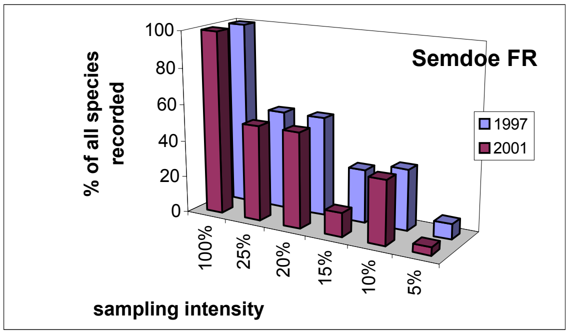


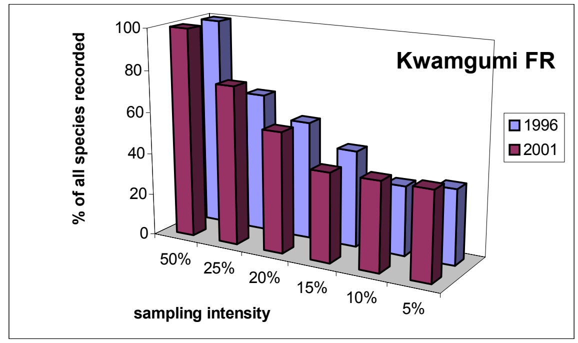
(b)

Figure 9. The accumulation of endemic and near-endemic species recorded in vegetation plots during EUBS and monitoring work (2001) within (a) Semdoe Forest Reserve (EUBS: 1997) and (b) Kwamgumi Forest Reserve (EUBS: 1996).

The accumulation of endemic and near-endemic species within Semdoe FR was very similar during monitoring work to that during EUBS. The logarithmic lines of best fit associated with each species accumulation curve have a very similar rate of increase and origin, and the actual curves level off at the same number of species. The tree composition with regards to endemic and near-endemic species is thus stable over time. The same can be said of Kwamgumi FR although the origin of the curve was slightly lower during EUBS. The curve showing species accumulation based on all VPs during EUBS makes an interesting comparison with the curves based on accumulation within only c.50% of VPs. The rate of increase and origin are higher when considering all VPs compared to only half both during EUBS and monitoring work.

In order to investigate the effect of sampling-intensity on the recording of endemic and near-endemic species further, the numbers of species recorded at each sampling-intensity were analysed. The number of endemic and near-endemic species recorded at each sampling-intensity were compared to the total number recorded in all VPs re-visited during monitoring work, therefore c.100% of VPs in Semdoe FR and c.50% in Kwamgumi FR (Figure 10).





(a) (b)

Figure 10. The percentage (of total for that year) of endemic and near-endemic species recorded at various sampling-intensities both during EUBS and monitoring (2001) within (a) Semdoe Forest Reserve (EUBS: 1997, Total: c.100% of VPs) and (b) Kwamgumi Forest Reserve (EUBS: 1996, Total: c.50% of VPs).

Within Semdoe FR an increase in the percentage of endemic and near-endemic species recorded with sampling-intensity was, unsurprisingly, evident. The percentage recorded at a given sampling-intensity did however differ between years (between EUBS and monitoring work). The difference was less when considering sampling-intensities of 20% or above. The comparison of curves presenting the accumulation of endemic and near-endemic species have been shown to be very similar and thus any discrepancy between the numbers, or percentages, recorded between years may well reflect the (ultimately) random selection of VPs from which data was gathered. At lower sampling-intensities the number of VPs chosen was obviously smaller and may encompass a greater degree of variation than would data from a larger number of VPs.

Within Kwamgumi FR an increase in the percentage of endemic and near-endemic species recorded with sampling-intensity was also evident. The percentage recorded at a given sampling-intensity between years was fairly similar for all sampling-intensities, although possibly less so for sampling-intensities 10% or under.

In order to gain a further insight into the importance of any changes in the numbers or accumulation of endemic or near-endemic species, the individual species concerned were considered (Table 15 & 16 and Appendix 10 & 11).

Table 15. Summary of endemic and near-endemic species recorded during EUBS and monitoring work within Semdoe and Kwamgumi Forest Reserves.

	Semdoe Forest Reserve	Kwamgumi Forest Reserve
EUBS		
Total number of species recorded	23	36
Number only recorded during EUBS	2	4
MONITORING		
Total number of species recorded	23	33
Number only recorded during monitoring	2	1
EUBS & MONITORING		
Number recorded during both	21	32
Total number of species recorded	25	37

Table 16. Endemic and near-endemic species recorded during only either EUBS or monitoring work in Semdoe and Kwamgumi Forest Reserves.

SEMDOE FOREST RESERVE			
Family	**Species**	**VP**	**Description**
SPECIES RECORDED ONLY DURING EUBS			
Araliaceae	*Cussonia zimmermanii*	19	1 medium individual, found dead during monitoring
Leguminosae - Papilionoideae	*Pterocarpus mildbraedii*	13	1 small individual, not found during monitoring
SPECIES RECORDED ONLY DURING MONITORING			
Melianthaceae	*Bersama abyssinica*	4	Ingrowth
Sterculiaceae	*Dombeya schupange*	19	Ingrowth

KWAMGUMI FOREST RESERVE			
Family	**Species**	**VP**	**Description**
SPECIES RECORDED ONLY DURING EUBS			
Annonaceae	*Mkiua fragrans*	1	1 small individual, not found during monitoring
Burseraceae	*Commiphora eminii zimermannii*	42	1 large individual, found dead during monitoring
Leguminosae - Caesalpiniaceae	*Cynometra webberi*	8	1 large individual, found dead during monitoring
Rubiaceae	*Tricalysia anomala*	8	1 medium individual, not found during monitoring
SPECIES RECORDED ONLY DURING MONITORING			
Leguminosae - Caesalpiniaceae	*Cynometra longipedicellata*	34	Ingrowth

Within Semdoe FR, two species were thus ‘lost’ between EUBS and monitoring whilst two were ‘gained’. Both loses were represented by only 1 small or medium individual and thus were not significant in terms of loss of abundance or basal area. One species, *Pterocarpus mildbraedi*, is however a forest-dependent species whilst also being used locally for building poles (Ruffo 1989). The two species gained were recorded as ingrowth and therefore not significant in terms of basal area, although one is an important timber tree; *Bersama abyssinica*. There did not appear to be any pattern in the distribution of lost or gained species; most were located in VPs near to FR borders in which fire and cutting were evident during both EUBS and monitoring work. From figures given in the EUBS report, none of these VPs would appear to be in areas of the FR that are important in terms of numbers of species or individuals of endemic or near-endemic species.

Within Kwamgumi FR, four species were 'lost' and one species 'gained', making the total number of endemic and near-endemic species lower during monitoring than EUBS. The species losses were represented by only 1 individual in each case and most were in VPs that showed no signs of recent or past disturbance, thus suggesting natural death. Two of the species lost were forest-dependent species; *Mkilua fragrans* and *Tricalysia anomala*. One species, *Cynometra webberi*, is an important local source of building poles and fuelwood (Ruffo 1989). The species gained was as ingrowth, although this species was recorded during EUBS but only in those VPs not revisited during monitoring work and thus ignored in the present comparisons. This species is also an important local source of building poles and fuelwood. There did not appear to be any pattern in the distribution of lost or gained species, which were located both in areas near to FR borders and in the centre of the FR. There was no pattern of recent or past disturbance between these VPs and as in Semdoe FR, none are in areas considered to be particularly important in terms of numbers of species or individuals of endemic or near-endemic species.

As in the analysis of species richness, no work was carried out with regard to the change in dbh or basal area of endemic and near-endemic species. This was due to the issues surrounding the degree of accuracy of the measurements involved and the ability to be able to report change over such a short time period.

4.3.6 Global Positioning Systems (GPS)

The location of almost all VPs relocated within both Semdoe and Kwamgumi FRs were fixed using a GPS with co-ordinates recorded in Appendix 1.

4.4 DISCUSSION

Various aspects of the methods and results as presented in sections 4.2 and 4.3 are initially discussed; the conclusions from which are used to justify the monitoring procedures recommended in section 6.0. This is followed by a review of Semdoe and Kwamgumi FRs based on the results of monitoring provided here.

4.4.1 Vegetation plot selection and sampling intensity

The stratified then random systematic selection of VPs for sampling is deemed to be a good method. Although no submontane or montane stratum were apparent in either Semdoe or Kwamgumi FRs, for those FRs with a greater altitudinal range this method would allow the incorporation of major habitats within the FR. Stratified random sampling is one of the most commonly used and most efficient methods of sampling unit selection (Sutter 1991) and is thus recommended here.

Various sampling-intensities were considered in this study, the effects of these were analysed in a number of ways. These included consideration of species richness predicted and recorded at each sampling-intensity and the percentage of total endemic and near-endemic species recorded at each sampling-intensity. If time had allowed, a comparison of tree status, species accumulation, 'lost' and 'gained' species and accumulation of endemic and near-endemic species would also have been conducted. Based on a combination of various aspects of the monitoring work it would appear that a sampling-intensity of 15% or above provides the truest representation of the state of larger trees within the FRs. Figure 6 (a) reveals the number of predicted and recorded species within Semdoe FR to be highly variable at sampling-intensities of 15% or less of that of the baseline. Figure 6 (b) shows the same data for Kwamgumi FR and at 5% sampling-intensity the number predicted and recorded does not fit into the pattern that is otherwise present in all sampling-intensities. Figure 10 (a) reveals that the percentage of endemic and near-endemic species recorded during the baseline and monitoring work in Semdoe FR is only similar (which is the true situation) at sampling-intensities above 15%. Figure 10 (b) shows the same for Kwamgumi FR, although the pattern is not so obvious and the figures are similar at sampling-intensities above 10%.

4.4.2 Vegetation plot relocation and status

The majority of VPs within both Semdoe and Kwamgumi FR were relocated. Whilst all 19 VPs were relocated within Semdoe FR, six of the 30 searched for in Kwamgumi FR were not relocated. This figure is in part an artefact of the number required for sampling purposes i.e. 24 VPs were required and thus VPs were searched for until this number was found.

A major difficulty in the field was the precise relocation of the south-east corner of VPs. The majority of tags marking the position were no longer evident and thus relocating was reliant on the position of previously marked trees and knowledge of Field Assistants who worked during the EUBS survey. This situation is not ideal (especially in VPs with few trees) as the recording of ingrowth may be greatly effected.

The majority of previously marked trees within VPs were both found and found alive. The number found, in part, reflects the legibility of paint marking trees and whether accurate sketch maps of the VP existed. The legibility of paint was found to be high for all three markings (individual tree number, POM and VP number) although the figures given in section 4.3.2 are only those for live trees. In some cases trees, or even whole VPs, could not be relocated due to the fact that paint markings had been completely lost, thus were effectively illegible. Two of the six VPs not relocated in Kwamgumi FR were due to such reasons. The figures given for illegible markings is thus likely to be an underestimation as the legibility within these unlocated VPs is not included.

As the EUBS surveys were carried out in Semdoe and Kwamgumi FRs in consecutive years, no real temporal information can be gleaned with regard to the long-term legibility of paint markings. Semdoe FR was however surveyed in 1997 and the percentage of legible markings was slightly higher than that for Kwamgumi FR which was surveyed in the previous year. An assessment of the decrease in legibility with time since painting would no doubt prove interesting and fruitful in terms of identifying the optimum interval for repainting markings. In absence of such a study, the 4 or 5 years that have passed since initial painting of marks is considered an adequate interval for repainting.

The quality and quantity of sketch maps of VPs was fairly low and thus they were not often of great help in relocating previously marked trees.

4.4.3 Tree growth

The change in dbh of all live trees was calculated and averaged for each VP and for each FR. The degree of accuracy to which dbh measurements can be given was calculated and is substantially less than the mean change in dbh detected within each FR. These results would suggest that an interval of 4 or 5 years is thus sufficient over which to confidently recorded growth.

4.4.4 Baseline VS Monitoring

Comparing the accumulation of species during monitoring work with that during EUBS work proved to be an informative analysis. As species accumulation curves are produced in all EUBS reports it seems logical to use them in this way and derive maximum use. Comparing numbers of species ‘lost’ and ‘gained’ between EUBS and monitoring work was also informative and would be especially relevant were high numbers of either forest dependent or endemic and near-endemic species to be involved. The gain of species is however to be expected and at least over the first few monitoring periods is likely to be high. This reflects the long time over which species accumulation curves take to reach an asymptote, especially in tropical biotas (Gauld 1997). Unfortunately no work could be carried out to investigate the growth of particular species in terms of dbh or basal area. This may have provided interesting information with regard to species of particular interest; possibly those identified as invasive or pioneer or of local use.

Based on the species accumulation curves of EUBS, the number of species expected to be recorded at each sampling-intensity was calculated and is presented in Table 13 (section 4.3.4.2). The figures for Semdoe and Kwamgumi FRs were compared to those actually recorded (Figure 6, section 4.3.4.2). According to the species accumulation curve and total number of species recorded in Semdoe FR during both EUBS and monitoring, the numbers predicted and recorded should have been very similar. The numbers were indeed shown to be not statistically significantly different. Visual inspection of Figure 6 shows the numbers are most similar at a sampling-intensity of 25%. According to the species accumulation curve and total number of species recorded in Kwamgumi FR again during EUBS and monitoring, the number recorded should have been slightly lower than the number predicted. Visually, this was shown to be the case except at a sampling-intensity of 5%, although there was no statistically significant difference in the numbers predicted and recorded overall. The predicted numbers of species for FRs not worked in during monitoring are thus likely to be of most use when comparisons with the number recorded are based on larger sampling-intensities. FRs were ranked in terms of the number of species predicted at a given sampling-intensity and this ranking compared to various aspects of the FRs; size, altitudinal range and species richness. It was suspected that a pattern may emerge and although it did in that ranking was most fully explained by species richness, species richness is in itself related to FR size (and to a lesser degree altitudinal range). The combined effect of these factors means that no direct link between the value of any one and the number of species predicted for a FR can be found. It was thought at one stage that a relationship may emerge that would allow the prediction of species numbers within a FR of a known size (for example) that had not been surveyed by EUBS. This is however not possible.

4.4.5 Plant endemism

Plant endemism within both FRs during EUBS and monitoring work was analysed as an example of what could be done for any chosen group of species. The accumulation of endemic and near-endemic species was compared between EUBS and monitoring work and for Kwamgumi FR between 50% sampling-intensity (both during EUBS and monitoring) and 100% sampling-intensity. The accumulation based on 50% sampling-intensity in Kwamgumi FR was shown to be lower than that based on 100% both during EUBS and monitoring. This was to be expected as the number of species recorded increases with area (at least until a certain point). This obviously also has relevance in the recommendation of a sampling-intensity for future monitoring work.

4.4.6 Conclusions per forest reserve

Semdoe Forest Reserve
Based on the findings of the present study it would appear that the forests of Semdoe FR are currently (2001) in a similar state to that during the EUBS survey in 1997. The total number of trees and shrubs recorded in VPs was only 5% lower during monitoring work than EUBS work. The accumulation of species between these two times is also very similar. The number of endemic and near-endemic species was also only 5% lower during monitoring. All VPs were relocated within the reserve, although there was evidence of recent fire in many.

The data presented here represent that from just two working periods and does not include that concerned with tree growth, thus limited emphasis should be placed on the findings. There would however not appear to be great cause for concern with regard to the state of Semdoe FR, either in terms of overall species richness or endemic species richness. The extent of fire should however be the target of some future work and assessment.

Kwamgumi Forest Reserve
Based on the findings of the present study it would appear that the forests of Kwamgumi FR are currently (2001) in a fairly similar state to that during the EUBS survey in 1996. The total number of trees and shrubs recorded in VPs was 9% lower during monitoring work than EUBS work. The accumulation of species between these two times was also fairly similar. The number of endemic and near-endemic species was 7% lower during monitoring work. A number of vegetation plots could not however be relocated due to fire damage. As with Semdoe FR, limited emphasis should be placed on these findings. However, although the figures for species richness and endemic species richness have decreased compared to those in EUBS more so than in Semdoe FR, there does not appear to great cause for concern for the state of the forests in Kwamgumi either. Again, the threat of fire is evident with the FR and should be the target of some future work and assessment.

5.0 FAUNA RECORDS

Staddon, S.C., Beharrell, N.K. & Switzer, D.

5.1 INTRODUCTION

In addition to work concerned with the monitoring of vegetation, opportunistic work was undertaken concerning the fauna species within both forest reserves re-visited. These activities can not be deemed monitoring activities since specific study/ search hours were not standardised but were carried out as and when feasible.

5.2 METHODS

The following selected fauna groups were sampled using a variety of methods. For detailed research aims, objectives and methods see *Methodology Report* (SEE 1998).

5.2.1 Bats

Bats were sampled using varying combinations and configurations of mist-nets (2 x 6m, 1 x 9m). Nets were placed across predicted 'flight corridors' such as rivers and paths, with the top of the net at a maximum height of 3m. Nets were opened at dusk and checked every 15 minutes until they were closed at dawn if not before. Data was recorded on standardised data sheets regarding the identification, sex, breeding status, weight and biometrics of each bat captured. Detailed habitat notes were taken for each mist-netting location and the number of net-metre hours calculated.

5.2.2 Reptiles and amphibians

Reptiles and amphibians were collected opportunistically within each FR. Diurnal and nocturnal collections were made, focusing on the collection of chameleons and frogs by torchlight at night. After rain, typical amphibian habitats were the focus of collection.

5.2.3 Casual observations

Casual observations of large mammals including primates were recorded at each forest reserve, opportunistically.

5.2.4 Identification

In order to verify the identification of species recorded a number of measures were taken. Wherever possible, two specimens (one male, one female) of each species recorded were taken and sent to a variety of experts for taxonomic verification (Appendix 2). Specimens were also taken of anything that could not be confidently identified in the field or cross-referenced to a specimen already taken. Detailed habitat notes of capture locations accompanied all specimens in order to aid identification.

5.3 RESULTS

Formal identifications have been received for all reptiles and amphibian specimens collected, whilst identifications for bats remain at field level.

5.3.1 Semdoe Forest Reserve

A total of 930 net-metre hours were accumulated during mist-netting for bats. The species of bat, reptile and amphibian recorded in Semdoe FR during monitoring work are given in Table 17 and a comparison with those recorded during EUBS in Table 18.

Table 17. Species of bat, reptile and amphibian recorded in Semdoe Forest Reserve carried in addition to vegetation monitoring work. Ecological type, endemic status, IUCN status and CITES status were compiled from the National Biodiversity Database (UDSM 1997) (for all taxon) and Kingdon (1974) for bats, Broadley & Howell (unpubl.), Howell (1993) and Branch (1994) for reptiles and Howell (1993) and Poynton & Broadley (1991) for amphibians.

Species	Common name	Ecological type	Endemic status	Threat status
BATS				
PTEROPODIDAE				
Epomophorus anurus *	Epauletted fruit bat	f	W	
Epomophorus wahlbergi *	Wahlberg's fruit bat	f	W	
Lissonycteris angolensis *	Angolan fruit bat	F	W	
Rousettus aegyptiacus *	Egyptian fruit bat	f	W	
NYCTERIDAE				
Nycteris thebacica *	Slit-faced bat	f	W	
RHINOLOPHIDAE				
Rhinolophus simulator *	Horseshoe bat	F	W	
VESPERTILIONIDAE				
Glauconycteris argentata *	Butterfly bat	f	W	
Glauconycteris variegata *	Butterfly bat	f	W	
Myotis bocagei *	Hairy bat	f	W	
Scotoeus hirundo *	Evening bat	f	W	
Scotophilus leucogaster *	House bat	?	W	
Scotophilus sp. *	House bat	-	-	
MOLOSSIDAE				
Tadarida (Mops) sp. *	Mops free-tailed bat	-	-	
REPTILES				
CHAMAELEONIDAE				
Chamaeleo dilepis *	Flap-necked chameleon	f	W	CITES II
COLUBRIDAE				
Dipsadaboa flavida broadleyi *	Marbled tree snake	f	W	

Table 17 continued

AMPHIBIANS				
ARTHROLETIDAE				
Arthroleptis stenodactylus	Shovel-footed squeaker	f	W	
BUFONIDAE				
Bufo maculatus *	Toad	O	W	
Mertensophryne micranotis	Micro-toad	F	N	
Nectophrynoides tornieri *	Dwarf toad	F	N	CITES I
RHACOPHORIDAE				
Chiromantis xerampelina *	Grey foam-nest frog	f	W	
RANIDAE				
Phrynobatrachus acridoides	East African puddle frog	f	W	
Ptychadena anchietae *	Plain grass frog	f	W	
Rana angolensis *	Dusky-throated frog	f	W	

* Not recorded during EUBS (1997)

KEY TO ABBREVIATIONS FOR TABLE 17

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.

Threat Status: includes IUCN 2000 [1], NBD 1997 [2] and CITES 2000 [3]

EN – Endangered CITES II – Appendix II

VU - Vulnerable

Table 18. Number of bat, reptile and amphibian species groups recorded in Semdoe Forest Reserve during EUBS and monitoring work.

	Bats	Reptiles	Amphibians
Number of species recorded during EUBS	0	13	11
Number of species recorded during monitoring work	13	2	8
Number of species not previously recorded before monitoring work	*13*	*2*	*5*

In Semdoe FR a total of 20 species were thus added to the species lists compiled during EUBS. The majority of new records were bats. Due to heavy rains no bats were recorded in Semdoe FR during EUBS. No bat species recorded during monitoring work were of restricted ranges although two were forest-dependent. Despite records of 13 reptile species during EUBS, neither of the species recorded during monitoring had previously been recorded. Neither were of restricted range or forest-dependent although one was listed in CITES Appendix II. Over half of the amphibian species recorded during monitoring had not previously been recorded. One of these species; *Nectophrynoides tornieri*, was a near-endemic and forest-dependent species, two species were listed by NBD (UDSM 1997).

Casual mammal observations

During the monitoring activities mammal observations were recorded. The following species were recorded during EUBS and monitoring: Angola pied colobus (*Colobus angolensis palliatus*), Blue monkey (*Cercopithecus mitis*);[visual],Eastern tree hyrax (*Dendrohyrax validus*); [oral].

One species had not been recorded from EUBS, the African buffalo (*Syncerus caffer*). Two individuals of the African buffalo were observations. Records of the individuals included direct visual observations, tracks, sleeping areas and dung. The individuals appeared to be both female and were not aggressive. Local knowledge suggested that a calf was present with the two females however, no direct evidence of the presence of a calf was recorded.

5.3.2 Kwamgumi Forest Reserve

A total of 651 net-metre hours were accumulated during mist-netting for bats. The species of bat, reptile and amphibian recorded in Kwamgumi FR during monitoring work is given in Table 19 and a comparison with those recorded during EUBS in Table 20.

Table 19. Species of bat, reptile and amphibian recorded in Kwamgumi Forest Reserve during monitoring work. (Ecological type, endemic status, IUCN status and CITES status were compiled from the National Biodiversity Database (UDSM 1997) (for all taxon) and Kingdon (1974) for bats, Broadley & Howell (unpubl.), Howell (1993) and Branch (1994) for reptiles and Howell (1993) and Poynton & Broadley (1991) for amphibians).

Species	Common name	Ecological type	Endemic status	Threat status
BATS				
PTEROPODIDAE				
Lissonycteris angolensis	Angolan fruit bat	F	W	
NYCTERIDAE				
Nycteris grandis	Slit-faced bat	F	W	
RHINOLOPHIDAE				
Rhinolophus hildebranti *	Horseshoe bat	f	W	
Rhinolophus landeri *	Horseshoe bat	f	W	
Rhinolophus simulator *	Horseshoe bat	F	W	
HIPPOSIDERIDAE				
Hipposideros caffer *	Leaf-nosed bat	f	W	
Hipposideros ruber	Leaf-nosed bat	f	W	
Triaenops persicus	Persian leaf-nosed bat	f	W	
VESPERTILIONIDAE				
Myotis bocagei	Hairy bat	f	W	
REPTILES				
CHAMAELEONIDAE				
Rhampholeon brevicaudatus	Bearded pygmy chameleon	F	N	
COLUBRIDAE				
Philothamnus macrops *	Usambara Green snake	F	N	
ELAPIDAE				
Elapsoidea nigra	Usambara Garter-Snake	F	N	

Table 19 continued

AMPHIBIANS				
ARTHROLEPTIDAE				
Arthroleptis stenodactylus	Shovel-footed squeaker	f	W	
Arthroleptis cf. xenodactyloides	Squeaker	f	W	
BUFONIDAE				
Bufo maculatus *	Toad	O	W	
Nectophrynoides tornieri	Dwarf toad	F	N	CITES I
HYPEROLIDAE				
Hyperolius argus *	Argus reed frog	O	N	
Hyperolius mariae *	Reed frog	f	N	
Hyperolius cf. nasutus *	Long reed frog	O	W	
Hyperolius viridiflavis *	Reed frog	O	W	
RANIDAE				
Arthroleptides martiensseni *		F	N	
Hylarana galamensis *	River frog	O	W	
Phyrnobatrachus acridoides	East African puddle frog	f	W	
Ptychadena anchietae	Plain grass frog	f	W	

* Not recorded during EUBS (1996)

KEY TO ABBREVIATIONS FOR TABLE 19

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.

Threat Status: includes IUCN 2000 [1], NBD 1997 [2] and CITES 2000 [3]

EN – Endangered CITES II – Appendix II

VU – Vulnerable DD – Data deficient

Table 20. Number of species of selected groups recorded in Kwamgumi Forest Reserve during EUBS and monitoring work.

	Bats	Reptiles	Amphibians
Number of species recorded during EUBS	17	28	24
Number of species recorded during monitoring work	9	3	12
Number of species not previously recorded before monitoring work	*4*	*1*	*7*

In Kwamgumi FR a total of 12 species were thus added to the species lists compiled during EUBS. The majority of new records were amphibians. Almost half of the bat species recorded during monitoring were not previously recorded. None of these species were of restricted range although one was forest-dependent. The one reptile species not previously recorded was both of restricted range and forest-dependent, the Usambara green snake (*Philothamnus macrops*). All reptiles recorded were listed by NBD (UDSM 1997). Over half of the amphibian species recorded during monitoring had not previously been recorded. Three of these species were of restricted range and one was forest-dependent. These species were also listed by NBD (UDSM 1997).

Casual mammal observations
During the monitoring activities mammal observations were recorded. The following species were recorded during EUBS and monitoring: Angola pied colobus (*Colobus angolensis palliatus*), Blue monkey (*Cercopithecus mitis*);[visual],Eastern tree hyrax (*Dendrohyrax validus*); [oral] and Bush pig (*Potamochoerus larvatus*); [tracks and signs].

5.4 DISCUSSION

5.4.1 Semdoe Forest Reserve

Several species can be added to the baseline species list compiled by EUBS for Semdoe Forest Reserve, including both restricted range and forest-dependent species.

Species richness

A revised summary of fauna families and species, as presented in Table 29 of the EUBS technical report for Semdoe FR (Frontier Tanzania 2001a) is given (Table 21).

Table 21. Summary of fauna families and species in Semdoe Forest Reserve, updated with records from monitoring work. (If different, numbers recorded during EUBS are given in brackets). Note: no bird or butterfly work was carried out during the monitoring activities.

Taxon	Number of families	Number of species
Mammals	18 (13)	30 (17)
Birds	11	14
Reptiles	8 (6)	15 (13)
Amphibians	7 (6)	16 (11)
Butterflies	7	68

The number of both families and species has thus increased through the sampling carried out during monitoring work. This is especially evident in the mammals due to the high number of bat species recorded during monitoring activities.

Ecological type

A revised summary of ecological type of fauna groups, as presented in Table 31 of the EUBS technical report for Semdoe (Frontier Tanzania. 2001a) is given (Table 22).

Table 22. Summary of ecological type of mammal, bird, reptile, amphibian and butterfly species in Semdoe Forest Reserve, updated with records from monitoring work. (If different, numbers recorded during EUBS are given in parenthesis).

Ecological type	Number of species	% of total species Recorded
(F) Forest-dependent	41 (37)	28 (29)
(f) Forest dwelling but not forest dependent	91 (76)	61
(O) Non-forest species	10 (9)	7
Unknown	7 (4)	5 (3)
Total	149 (126)	100

The percentage of forest-dependent species has thus reduced, although very slightly, whilst the percentage unknown has risen slightly. The overall picture of ecological requirements of species within the reserve has thus not greatly changed between the time of EUBS and monitoring work.

Endemic status

A revised summary of endemic status of fauna groups, as presented in Table 32 of the EUBS technical report for Semdoe Frontier Tanzania 2001a) is given (Table 23).

Table 23. Summary of endemic status of mammal, bird, reptile and amphibian species in Semdoe Forest Reserve, updated with records from monitoring work. (If different, numbers recorded during EUBS are given in parenthesis).

Endemic status	Number of species	% of total species recorded
(E) Endemic to the Usambara mountains	0	0
(N) Near-endemic: restricted range	16 (14)	11
(W) Widespread distribution	131 (112)	88 (89)
Unknown	2 (0)	1 (0)
Total	149 (126)	100

The percentage of endemic and near-endemic species has thus not changed between the time of EUBS and monitoring work.

Casual mammal observations
The two monkey species and one hyrax species were recorded again during monitoring with one new large mammal record, the African buffalo. Other species were not searched for or recorded. The most interesting record was of the African buffalo. This species has not been sighted or recorded within the East Usambara mountains for a long time. Elephant were recorded in the 1950s as abundant in lowland areas particularly the Sigi-Muzi valley (Dowsett *et al* 1954). One may make an estimate that buffalo may have remained in the forests until the 1950s. However, local knowledge suggests that the African buffalo has not been recorded in the East Usambara mountains since the 1930s.

5.4.2 Kwamgumi Forest Reserve

Several species can be added to the original species list compiled by EUBS for Kwamgumi Forest Reserve, including both restricted range and forest-dependent species.

Species richness
A revised summary of faunal families and species, as presented in Table 31 of the EUBS technical report for Kwamgumi FR (Frontier Tanzania. 1999b) is given (Table 24).

Table 24. Summary of faunal families and species in Kwamgumi Forest Reserve, updated with recorded from monitoring work. (If different, numbers recorded during EUBS are given in brackets). Note: no bird or butterfly work was carried out during the monitoring activities.

Taxon	Number of families	Number of species
Mammals	12 (11)	51 (47)
Birds	31	68
Reptiles	12	29 (28)
Amphibians	7	36 (29)
Butterflies	5	31

The number of both families and species has thus increased through the sampling carried out during monitoring work.

Ecological type
A revised summary of ecological type of faunal groups, as presented in Table 33 of the EUBS technical report for Kwamgumi (Frontier Tanzania 1999b) is given (Table 25).

Table 25. Summary of ecological type of mammal, bird, reptile, amphibian and butterfly species in Kwamgumi Forest Reserve, updated with recorded from monitoring work. (If different, numbers recorded during EUBS are given in parenthesis).

Ecological type	Number of species	% of total species Recorded
(F) Forest-dependent	79 (71)	35
(f) Forest dwelling but not forest dependent	99 (88)	44 (43)
(O) Non-forest species	21 (16)	9 (8)
Unknown	28	12 (14)
Total	227 (203)	100

The percentage of forest-dependent species has thus remained the same. The overall picture of ecological requirements of species within the reserve has thus not greatly changed between the time of EUBS and monitoring work.

Endemic status
A revised summary of endemic status of faunal groups, as presented in Table 34 of the EUBS technical report for Kwamgumi (Frontier Tanzania 1999b) is given (Table 26).

Table 26. Summary of endemic status of mammal, bird, reptile and amphibian species in Kwamgumi Forest Reserve, updated with brackets).

Endemic status	Number of species	% of total species recorded
(E) Endemic to the Usambara mountains	3	1
(N) Near-endemic: restricted range	32 (26)	14 (13)
(W) Widespread distribution	165 (147)	73 (72)
Unknown	27	12 (13)
Total	227 (203)	100

The percentage of endemic species has thus not changed between the time of EUBS and monitoring work whilst that of near-endemic species has slightly reduced.

Casual mammal observations
Four species were recorded during monitoring that were present during baseline (EUBS), other species were no searched for or recorded.

6.0 RECOMMENDATIONS FOR FOREST MONITORING

Staddon, S.C. & Beharrell, N.K.

The following recommendations represent options for the monitoring of botanical diversity within the East Usamabara forest reserves. Those given for the monitoring of trees and shrubs ≥10cm dbh, were primarily based on the work carried out by EUBS and the current study, particularly with regard to methods and analysis. The recommendations may be justified by considering the discussion given in section 4.4 of this report. Recommendations are also given for the monitoring of regeneration and brief ideas for the monitoring of *Maesopsis eminii* and defunct logging roads and the use of GIS and remote sensing in monitoring. These are based more widely on available literature and have not been tested in the field, as those for trees and shrubs ≥10cm dbh have.

6.1 MONITORING OF TREES AND SHRUBS ≥10CM DBH

6.1.1 Objectives

Clearly defined objectives form the basis of any monitoring programme, the clarity determining the focus and quality of the subsequent monitoring design and analysis (Sutter 1996).

- To assess the survival, growth, species composition and abundance of trees and shrubs ≥10cm dbh.
- To use the semi-permanent 50m x 20m vegetation plots established by EUBS as the sampling unit.
- To select vegetation plots for sampling in a stratified (by habitat) then systematic random manner from all those established by EUBS.
- To sample at an intensity of 15% -25% of the original baseline survey by EUBS, depending on forest reserve (FR) and resources available for monitoring.
- To instigate the appropriate action, either managerial or investigative, when certain predetermined conditions are met.
- To initially review the monitoring programme every 5 years and thereafter every 10 years.

6.1.2 Methods

Methods should clearly set out how the objectives of the programme are to be achieved; simplicity in the data collection methodology will lead to ease in analysis and interpretation of results (Usher 1991).

- **Initially select vegetation plots** (VPs) established by EUBS in a stratified (by habitat; lowland forest (<850m a.s.l.), submontane forest (850-1249m a.s.l.) and montane forest (>1250m a.s.l.) then systematic random manner (see section 4.2.1 in this report). Thereafter monitor only these VPs.
- **Sample at 15% - 25% intensity** of the EUBS survey, depending on the resources available and size of FR (larger FRs will require proportionally less VPs to be surveyed in order to record a given percentage of those species originally recorded; see Table 14, section 4.3.4.2 in this report).
  (In Semdoe and Kwamgumi FRs the current study can form the first monitoring period and thus for these FRs, use VPs re-established during this work).
- **Relocate VPs** on the ground using defined access routes, GPS co-ordinates and stake marking the south-east corner. (During the initial monitoring period VPs will be relocated using maps, grid references, tagged transects and local knowledge. If this proves difficult, the 'search pattern' given by

Alder and Synnott (1992) may be used. The location of each VP will subsequently be fixed using GPS and a durable wooden stake sunk into the ground to more permanently mark the location of the south-east corner of the VP).
(*Alternative option*: if resources allow, use four wooden stakes to initially mark all corners of the VP).

- **Temporarily re-establish VP** using two 20m and two 50m ropes, orientated using a compass from the south-east corner, cutting only saplings (if necessary) on the outside edge in order to place ropes.
  (*Alternative option*: if resources allow, clear and keep boundaries defined on an annual basis).
- **Record the status of all trees** previously marked within the VP, noting whether the individual is found alive, found dead or not found.
  (*Additional option*: identify the cause of death of those individuals found dead, using the single-letter mortality codes given by Synnott (1979)).
- **Measure the diameter** of all previously marked trees found alive at the original point of measurement (POM), rounding down to the nearest whole mm. All stems of a multi-stemmed individual should be recorded separately and the cumulative total calculated. Any difficulties in measurement caused by buttresses or excrescences at the POM should be noted.
- If buttresses reach the original POM a new one should be established 1.5m above the original and subsequent measurements of dbh referred to as the *alternative diameter*. The dbh at both the original and new POM should be recorded for one year, thereafter recording only the alternative diameter (see Alder and Synnott (1992) for a full explanation of this procedure).
- **Repaint the three markings** on each live individual; the unique tree number, the POM and VP number. The POM should be painted as a continuous band, using crayon initially to mark the exact position of the measuring tape, with which the top of the painted band should coincide.
  (EUBS surveys marked only a small horizontal band at the POM but it is considered that a continuous band would increase the precision of dbh measurement through insuring that the tape is held at exactly the same level each time).
  (*Alternative option*: if resources allow, use corrosion-resistant alloy nails to fix pre-numbered tags to trees at a set height above the POM as an additional or alternative means to identify individual tree).
- **Distinguish ingrowth and identify the species** using a botanist and herbarium facilities, although initially by vernacular name. Collect botanical specimens when required following methods given in Kokwaro (1997).
  (*Additional option*: use botanical specimens for the training of local forestry officers in plant identification).
- **Give each ingrowth individual a unique number** that is sequential from the last number given previously and ensure it is recorded as ingrowth.
- **Establish a POM 1.3m above the ground**, measured from the uphill side of a tree on a slope, the inside of the lean of a leaning tree, directly above excrescences that occur at the POM and 1.3m above the convergence of buttresses. Measure the diameter at the POM, rounding down to the nearest whole mm. All stems should be recorded separately and the cumulative total calculated. Any difficulties in measurement caused by buttresses or excrescences at the POM should be noted.
- **Mark the unique tree number**, POM and VP number on each ingrowth using red gloss exterior-grade paint.
- Initially produce a map of the VP, using one 20m and one 50m tape measure in order to record the co-ordinates of each tree within the VP, working from the south-east corner. A plotter may then be used to produce a map of the VP showing the position of trees and their dbh represented by different sized circles. During subsequent monitoring ingrowth should be added to this map.
  (*Alternative option*: if resources (namely time) do not allow, visually dividing the VP into 10m x 10m subplots within which the approximate positions of trees are marked on a sketch map along with the unique tree number).
- **Carry out the above procedures every 5 years** in order to provide information on the presence and absence of species and every 10 years in order to provide information on growth.

- **Keep access routes to the corner of each VP open** by clearing on an annual basis, along transect lines (this also allows for qualitative data to be collected regarding human disturbance within the FR inparticular).

6.1.3 Analysis

Analysis aims to identify trends, cycles and 'noise' existing within monitoring data. It should be simple, easily interpretable and provide definitive results (Usher 1991).

Tree status

- Compare the number of trees found alive, found dead and not found within all VPs in terms of total number and/or mean number per VP.
- Compare these figures to those from previous monitoring and baseline data.
- Compare these figures to the number (total and/or mean per VP) of ingrowth trees recorded within VPs.
- Ascertain whether any trends or cycles are evident in the number of live, dead and unfound trees recorded over time.
- Calculate the statistical significance of any difference in numbers using simple non-parametric tests e.g. chi-square test, Mann-Whitney *U*-test or Kruskal-Wallis test.
  (Non-parametric tests are required as the permanency of VPs renders data between years non-independent, thus violating one of the assumptions of parametric tests).

Growth of stems

- Calculate the change in diameter (at the POM) of all live trees since the last monitoring and since the EUBS (baseline) survey.
- Calculate the average change in diameter within VPs and the whole FR (giving associated 95% confidence limits), reporting only that which exceeds the calculated precision of measurement; 0.77 $\pm$ 0.45cm (see section 4.3.3 in this report).
- Convert diameter to basal area and compare these figures to those from previous monitoring and from EUBS (baseline).
- Produce size-class frequency histograms (based on basal area) and compare to those from previous monitoring and from EUBS (baseline).
- Ascertain whether any trends or cycles are evident in the pattern of growth of trees and shrubs over time.
- As for the analysis of vegetation status, calculate the statistical significance of any difference in numbers using simple non-parametric tests.

Species composition and abundance

- Compare the total number of species recorded and the number recorded only in the year in question to the total number recorded previously and the number only recorded within specific years (see Table 13 section 4.3.4.1 in this report).
- Consider the individual species newly recorded and those no longer recorded in terms of ecological type, endemic status, local use and the number and size of individuals involved.
- Contrast the accumulation of species with that during previous monitoring, using the origin and rate of increase as a basis for comparison (see section 4.3.4.1 in this report).
- Calculate the number of species expected to be recorded at a given sampling-intensity using the equation of the best-fit logarithmic line associated with the species accumulation curve of the original EUBS (baseline) survey (see Table 14, in this report).

- Compare this figure to that actually recorded and statistically test the significance of any departure form homogeneity between the two (see section 4.3.4.2 in this report).
- Consider the change in basal area of species selected to be of importance with regard to ecological type and/or endemic status and/or local use. Compare for example the change in basal area or basal area size-class distribution with that of previous monitoring.
- Use the above techniques to specifically analyse the state of forest-dependent, endemic and near-endemic species and possibly timber species, repeating procedures including only these particular species (see section 4.3.5 in this report).
- Ascertain whether any trends or cycles are evident in the species richness and rate of species accumulation of all species and selected species (forest-dependent, endemic and near-endemic species and possibly timber species) and basal area of selected species over time.
- As for the analysis of vegetation status, calculate the statistical significance of any difference in numbers using simple non-parametric tests.

The results obtained for the above analyses should be compared across the forest reserves of the East Usambaras in order to ascertain whether any trends in distribution are evident.

6.1.4 Interpretation

Effective interpretation of results allows their true significance to be ascertained, causal factors to be identified and appropriate action to be taken when deemed necessary.

- Interpret any trends identified within the wider context of any cyclical patterns revealed.
- Consider factors that may be controlling influences on any trends or cycles identified e.g. Has an increase in fire been concurrent with an increase in the number of dead trees recorded? Has a series of dry years coincided with low growth rates? Has a reduction in the number of certain species corresponded to an increase in local demand for building poles?
- Interpret results in order to instigate the appropriate action when deemed necessary i.e. set standards against which current conditions are contrasted and which if met result in either managerial or investigative actions.

The following are situations that if arrived at should be interpreted as indicating the need for action. These figures were reached after discussion with regard to East Usambara forest monitoring and are recommended at this point in time from this current study. (The figures are not irrevocable, if through the course of time they are shown to be inappropriate they should be changed. This should be especially true after the initial 'surveillance' period):

1. If the number of trees found dead or not found is more than 25% of the number of trees found alive plus the number of ingrowth (averaged throughout the monitoring programme).
2. If the increase in dbh or basal area (of all or of selected forest-dependent, endemic and near-endemic species and possibly timber species) over a 10 year period falls below 75% of the average recorded throughout the monitoring programme.
3. If the overall size class distribution (of all or of selected species) is shown to be statistically significantly different from any of those recorded throughout the monitoring programme.
4. If the total number of species recorded falls below 80% of the average throughout the monitoring programme.
5. If the number of forest-dependent or endemic and near-endemic species falls below 85% of the average throughout the monitoring programme.

6. If the distribution of species (overall or of selected species) no longer recorded within the FR reveals a pattern that is consistent with that of any form of human disturbance e.g. fire or pole-cutting.
7. If a decrease in the rate of species accumulation is combined with a difference in the number of predicted and recorded species of more than 75%.

6.1.5 Action – managerial and investigative

The action required in response to a change detected by a monitoring programme will greatly depend upon a number of factors ultimately related to the type of change. Action may take the form of specific management of the resources being monitored and/or investigative work.

- When the interpretation of results reveals a meaningful change in the status of trees and shrubs, appropriate action must be taken promptly and efficiently.
- Management actions may include an increase in the patrolling of FR borders, an increase in the effort to tackle fires spread form *shambas*, increased awareness raising through environmental education or the concentration of resources within a community based Joint Forest Management activities. The choice of appropriate management in specific situations is however beyond the remit of the current project and is a matter to be discussed and decided upon within EUCAMP.
- Investigative actions may take the form of small-scale, short-term projects intended to identify the cause of a species situation. They are case-dependent and thus cannot be pre-proposed. Work to monitor human disturbance run concurrently to that monitoring trees and shrubs $\geq$10cm dbh may be of great use in these situations.

6.1.6 Review of monitoring programme

All monitoring needs a cut-off or at least a review built into it (Goldsmith 1991). Monitoring is usually a long-term activity and opportunity needs to be made to review all aspects of a programme as further information is received.

- The monitoring programme should be reviewed every 5 years for the first three monitoring periods (15 years) in order to assess objectives, methods, analyses and interpretation of results. Work carried out during this initial 15 year period may then also be seen as surveillance work, providing information that will give a truer picture of the 'baseline' condition of the FR, upon which future changes through time may be more meaningfully contrasted.
- After this time, the monitoring programme should be reviewed every 10 years in order to assess the allocation of resources to the project and the results and outputs derived from it.

6.1.7 Data recording, storage and management

Efficient and secure data management is required if a monitoring programme is to run effectively and be of major benefit, especially over the long-term.

- Data should be collected in the field on appropriately designed, pre-printed recording forms that should be filled in with pencil and filed efficiently and safely for future retrieval.

- Data should be entered onto a computer database that includes all relevant information and from which this information is readily extractable. In this case Access 2000, incorporated or compatible with the current EUCAMP database.
- Ideally the database would be compatible with other software such as GIS packages.
- In order to maintain the accuracy and integrity of the database, data should be entered by trained personnel only and randomly checked by another member of staff at least once during each inputting period (i.e. that following each monitoring fieldwork period).
- The database should be kept up to date at all times.
- The database must be backed up on CD or Zip disk at the end of each inputting period and multiple hard copies retained.

6.1.8 Monitoring programme personnel

The validity of results and interpretations and the subsequent outputs of a monitoring programme will directly reflect the decisions and choices made by the personnel running it.

- EUCAMP staff should take full responsibility for the running of the monitoring programme, with the Management Committee, Biodiversity Officers, Forestry Officers and technical and administrative support working at the appropriate level.
- All staff should be fully trained and fully conversant with all objectives and procedures regarding the monitoring programme.
- Continuity in staff is to be highly recommended.
- Hold regular evaluation meetings
- Gain third party funding to increase levels of expertise with particular reference to Global Information System (GIS) use.

6.2 MONITORING OF REGENERATION

The recommendations given here are based on the same principles of monitoring as for trees and shrubs ≥10cm dbh and thus only the recommendations themselves are given (i.e. the principles given in italics in each sub-section of 6.1 are not repeated).

6.2.1 Objectives

- To assess the survival, species composition and abundance of regeneration (trees and shrubs <10cm dbh).
- To use semi-permanent 6m x 6m subplots located within vegetation plots (VPs; used for monitoring trees and shrubs ≥10cm dbh) as the sampling unit.
- To sample at the intensity of that of VPs.
- To sample every 5 years
- To instigate the appropriate action, either managerial or investigative, when certain predetermined conditions are met.
- To initially review the monitoring programme every 5 years and thereafter every 10 years.

6.2.2 Methods

It is envisaged that the fieldwork will be conducted at the same time as that for the monitoring of trees and shrubs ≥10cm dbh and thus relocation of sampling site is dealt with in section 6.1.2.

- **Initially establish, and thereafter re-establish, a 6m x 6m subplot** in the south-east corner of the VPs established by EUBS and selected for monitoring of trees and shrubs ≥10cm dbh. Four 6m ropes, orientated using a compass from the south-east corner, should be used to do this. Cutting in order to place ropes should be kept to an absolute minimum and certainly not within the plot itself.
- **Record the status of all seedlings** (<1cm dbh) **and saplings** (1-9.9cm dbh), noting whether the individual is found alive, dead or not found.
- **Measure the diameter** of all saplings and seedlings and the height of, rounding down to the nearest whole mm. Diameter measurements should be made using callipers and height measurements using a 1m rule, recording the highest point of the tree without straightening it. All stems of a multi-stemmed individual should be measured separately but the cumulative total calculated.
  (*Alternative option*: if resources allow, use a telescopic height pole to measure the height of seedlings).
- Paint the POM marking for each live individual; this should be done with spots of paint marking the position of the callipers used to measure the diameter. (During the initial monitoring, the POM will need to be painted for all individuals; procedures should follow those given in section 6.1.2).
- **Distinguish ingrowth** into the seedling and sapling categories and identify species in the field using a botanist or through botanical specimens for identification in a herbarium only if no damage is caused to the individual in the collection. The vernacular name of individuals should also be recorded
- **Give each ingrowth a unique number** that is sequential form the last number given previously, noting that the individual is recorded as ingrowth (although this is a misnomer for seedlings).
- **Establish and mark the POM using paint** (following the procedure given above) and mark the individual tree number using an alloy tag tied to the seedling or sapling using copper wire tied loosely and resting on the ground. (During initial monitoring this will need to be done for all individuals).

- **Produce a sketch map of the subplot**, visually dividing it into 2m x 2m sub-subplots within which the approximate position of seedlings and saplings are marked along with the unique tree number. During subsequent monitoring ingrowth should be added to this sketch map.
- **Carry out the above procedures every 5 years**.

6.2.3 Analysis

Vegetation status

- Compare the number of seedlings and saplings found alive, found dead and not found within all sub-plots in terms of total number and/or mean per sub-plot.
- Compare these figures to those from previous monitoring.
- Compare these figures to the number (total and/or mean per sub-plot) of ingrowth seedlings and saplings recorded within the sub-plots.
- Calculate the statistical significance of any difference in numbers using simple non-parametric tests e.g. chi-square test, Mann-Whitney *U*-test or Kruskal-Wallis test.
  (Non-parametric tests are required as the permanency of VPs renders data between years non-independent, thus violating one of the assumptions of parametric tests).

Growth of vegetation

- Produce size-class frequency histograms (based on height for seedlings and diameter for saplings) and compare to those from previous monitoring.
- Ascertain whether any trends or cycles are evident in the pattern of growth of trees and shrubs over time.
- As for the analysis of vegetation status, calculate the statistical significance of any difference in numbers using simple non-parametric tests.

Species composition

- Compare the total number of species recorded and the number recorded only in the year in question to the total number recorded previously and the number only recorded within specific years (see Table 13 section 4.3.4.1 in this report).
- Consider the individual species newly recorded and those no longer recorded in terms of ecological type, endemic status, local use and the number and size of individuals involved.
- Ascertain whether any trends or cycles are evident in the species richness and rate of species accumulation of all species and selected species (forest-dependent, endemic and near-endemic species and possibly timber species) and basal area of selected species over time.
- As for the analysis of vegetation status, calculate the statistical significance of any difference in numbers using simple non-parametric tests.

6.2.4 Interpretation

- Interpret any trends identified within the wider context of any cyclical patterns revealed.
- Consider factors that may be controlling influences on any trends or cycles identified e.g. Has an increase in fire been concurrent with a change in the abundance of seedling regeneration recorded? Has a reduction in the number of certain species corresponded to an increase in local demand for trap making or traditional building materials?

- Interpret results in order to instigate the appropriate action when deemed necessary i.e. set standards against which current conditions are contrasted and which if met result in either managerial or investigative actions.

'Healthy' levels of regeneration are dependent upon many factors including vegetation type and thus may vary across a given FR. No conditions are thus given here, at which it should be interpreted that action is needed. It is instead suggested that an in depth literature review is made in order to identify 'typical' survival rates of seedlings and saplings in different habitat types and under different degrees of competition (effected by seedling and/or sapling density). The numbers of regeneration recorded during monitoring can subsequently be compared to these figures and if meaningful differences (not definable until figures are known) are detected then the appropriate action can be implemented.

6.2.5 Action – managerial and investigative

As given for the monitoring of trees and shrubs ≥10cm dbh (see section 6.1.5).

6.2.6 Review of monitoring programme

As given for the monitoring of trees and shrubs ≥10cm dbh (see section 6.1.6).

6.2.7 Data storage and management

As given for the monitoring of trees and shrubs ≥10cm dbh (see section 6.1.7).

6.2.8 Monitoring programme personnel

As given for the monitoring of trees and shrubs ≥10cm dbh (see section 6.1.8).

6.3 MONITORING OF *MAESOPSIS EMINII*

Maesopsis eminii Engl. (Rhamnaceae) is a fast growing, gregarious pioneer trees species, native to central Africa, including western Tanzania (Viisteensaari *et al*. 2000). Large-scale spread of the alien species in the East Usambaras started with the establishment of plantations in the 1970's; a practice that ceased in 1981 (Viisteensaari *et al*. 2000). Within natural forests the spread of *M. eminii* would appear to be closely related to human disturbance (Geddes 1998, Viisteensaari *et al*. 2000). Conflicting reports surround the threat posed by *M. eminii* to the natural vegetation of closed tropical forests however and a variety of management strategies have been recommended based on these (Binggeli 1989, Binggeli & Hamilton 1993, Hall 1995, Geddes 1998).

Activities to monitor the spread and threat of *M. eminii* within East Usamabara FRs may thus concentrate efforts in disturbed areas, for example in logged areas, along defunct logging roads and in gaps created by pit-sawing. Monitoring could be based on areas of highest disturbance identified in EUBS and supplemented with information from concurrently run programmes of disturbance monitoring within the FR. Monitoring should aim to assess the presence of *M. eminii* within both regeneration and lower canopy layers and compare this to the regeneration and presence of native forest species. This would allow the true threat of *M. eminii* to the natural vegetation to be ascertained.

6.4 MONITORING OF DEFUNCT LOGGING ROADS

Logging activities have occurred within the East Usambaras since colonial Germans started logging to clear land for plantations in the Amani area in 1886 (Frontier Tanzania 2001). Commercial logging activities continued at various intensities throughout the East Usambaras until the 1980's, ultimately being dominated by Sikh Saw Mills Ltd. Although now defunct, logging roads remain in many FRs and many represent access routes that are still in use. The abundance of forest regeneration along roads is (at least partly) related to the frequency of such use.

Monitoring of defunct logging roads in the East Usambaras may aim to assess their use as access routes and to assess the degree of regeneration along them. Results stemming from the former aim may find application in monitoring work aimed at assessing the extent of human disturbance within the FRs. Those from the latter would provide interesting information regarding the species composition and abundance of regeneration and could possibly tied in with monitoring work aimed at assessing the spread and threat of the alien tree species *Maesopsis eminii*.

6.5 THE USE OF GIS IN MONITORING

Geographical Information Systems (GIS) are a powerful tool in the realm of monitoring and will undoubtedly become more so in the future. GIS may be used to map any data that is collected during EUBS or potential future monitoring work, revealing patterns or trends in distributions both spatially and temporally. A variety of categories of information, including ecological and social, may be overlain on maps in order to ascertain possible causal factors involved in changes detected through monitoring work.

Any monitoring programme within the East Usambaras should aim to provide opportunities for the use of GIS. From the many available, the GIS package most suitable for the monitoring programme's aims and predicted outputs should be identified. The compatibility of all monitoring programme databases with the chosen GIS package should be ensured. GIS may subsequently be used to highlight areas of particular importance with regard to various factors e.g. levels of endemism or forest-dependency, reveal temporal changes in these factors or compare the extent of certain factors with that of human disturbance. Initially applied to FRs within the East Usambaras, the potential for GIS to provide comparisons between this mountain area and others within the Eastern Arc should not be over-looked.

6.6 THE USE OF REMOTE SENSING IN MONITORING

Remote sensing encompasses a range of space and airborne techniques and again, constitutes a powerful tool for monitoring that is bound to increase in importance with both time and the development of new technologies. Satellite images have in fact been available for over 25 years, although data is now collected more frequently and scenes can be downloaded from the Internet (Muchoney & Unnasch 2001). Remote sensing may be used to reveal trends in land cover, extent and rates of deforestation, the status of habitats, the presence of threats and various ecological processes. Ecological or environmental data may be combined with social, economic, political, legal and institutional data in order to identify trends and patterns that may exist between any combinations of these. Modelling packages may also be used to predict future change based on information provided by remote sensing.

Any monitoring programme within the East Usambaras should seriously consider the use of remote sensing. It could be used to assess the true extent of forests and different habitat types, their change over time and their distribution compared to that of perceived threats. EUBS data can provide the ‘ground truthing’ for aerial and/or satellite observations and aerial surveys may be used to provide information that is intermediate in scale to that provided by fieldwork and satellite observations. The latter can be used in comparisons of individual FRs or the entire East Usambaras with other Eastern Arc mountains, other East African forests, sub-Saharan forests and even forests on a global scale.

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APPENDIX 1: GPS CO-ORDINATES FOR VEGETATION PLOTS

Semdoe Forest Reserve

	Longitude (E)			Latitude (S)			
Plot Number	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds	
1	38	41	32	4	57	57.3	Actual Reading
2	38	41	31.1	4	57	43.5	Actual Reading
3	38	41	30.5	4	57	27.9	Actual Reading
4	38	41	30.8	4	57	12.8	Actual Reading
5	38	42	1.8	4	58	14.3	Actual Reading
6	38	42	1.5	4	57	56.5	Theoretical
7	38	42	1.5	4	57	51.8	Actual Reading
8	38	41	0.1	4	57	26.9	Actual Reading
9	38	42	1.2	4	5	13.7	Actual Reading
10	38	42	1.2	4	7	59.1	Theoretical
11	38	41	59.9	4	56	41.4	Actual Reading
12	38	42	31.3	4	56	56.8	Actual Reading
13	38	42	31.6	4	57	41.1	Actual Reading
14	38	42	30.5	4	57	27.1	Actual Reading
15	38	42	28.6	4	57	12	Actual Reading
16	38	42	30.5	4	56	57.7	Actual Reading
17	38	42	30.5	4	56	43	Theoretical
18	38	42	30.8	4	58	11.4	Theoretical
19	38	41	1.7	4	57	13.2	Theoretical

Kwamgumi Forest Reserve

	Longitude (E)			Latitude (S)			
Plot Number	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds	
1	38	43	48.3	4	56	41.8	Actual Reading
2	38	43	51.9	4	56	42.9	Actual Reading
3	38	43	6.8	4	56	42.2	Actual Reading
4	38	44	29.6	4	56	49.5	Actual Reading
5	38	44	44.2	4	56	39.5	Theoretical
6	38	44	58.8	4	56	39.5	Theoretical
7	38	45	14.7	4	56	46.2	Actual Reading
8	38	45	29.3	4	56	46.3	Theoretical
9	38	45	14.4	4	56	39.5	Theoretical
10	38	45	43.9	4	56	36.3	Theoretical
11	38	43	51.8	4	56	5.8	Actual Reading
12	38	44	6.8	4	56	2.9	Theoretical
13	38	45	58.5	4	56	36.3	Theoretical
14	38	43	23.7	4	57	1.1	Actual
15	38	43	38.3	4	57	1.1	Theoretical
16	38	43	51.3	4	57	1.1	Theoretical
17	38	44	6.3	4	57	1.1	Theoretical
18	38	44	18.5	4	57	11.3	Actual Reading
19	38	44	17.5	4	55	46	Actual Reading

Appendix 1. Continued

20	38	44	28.9	4	56	8.7	Actual Reading
21	38	44	53.5	4	57	15.3	Theoretical
22	38	44	43.6	4	56	8.7	Theoretical
23	38	44	58.2	4	56	8.7	Theoretical
24	38	45	8.1	4	57	15.3	Theoretical
25	38	45	22.7	4	57	15.3	Theoretical
26	38	45	47.3	4	57	15.3	Theoretical
27	38	46	52	4	57	15.3	Theoretical
28	38	44	6.6	4	57	15.3	Theoretical
29	38	45	38.9	4	57	15.3	Actual Reading
30	38	45	12.8	4	56	8.7	Theoretical
31	38	45	46	4	56	10.7	Actual Reading
32	38	46	50.6	4	56	10.7	Theoretical
33	38	44	5.3	4	56	10.7	Theoretical
34	38	44	21.1	4	55	34.3	Actual
35	38	44	28.7	4	55	43.6	Actual Reading
36	38	45	49.8	4	55	44.4	Actual Reading
37	38	45	4.4	4	55	44.4	Theoretical
38	38	45	19	4	55	44.4	Theoretical
39	38	45	33.7	4	55	44.4	Theoretical
40	38	46	3.3	4	55	45.2	Actual Reading
41	38	46	17.8	4	55	45.2	Theoretical
42	38	44	47.3	4	55	15.9	Actual Reading
43	38	45	1.9	4	55	15.9	Theoretical
44	38	45	14.2	4	55	15.5	Actual
45	38	45	31.1	4	55	15.9	Theoretical
46	38	44	55.7	4	54	45.9	Actual Reading
47	38	45	10.3	4	54	45.9	Theoretical
48	38	45	24.9	4	54	45.9	Theoretical
49	38	44	44.2	4	54	49.1	Actual Reading

Actual reading: recorded from GPS
Therorectical Redaing: calculated from the nearest actual reading of a vegetation plot

GPS: Garmin 12 Hand held units, using Map datum ARC 1960.

APPENDIX 2: TAXONOMIC VERIFICATION

BOTANY

Mr. Albert Ntemi	EUCAMP	PO Box 5869, Tanga
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APPENDIX 3: INGROWTH IDENTIFICATIONS

Field identifications were recorded of in growth species and representative specimens were verified by botanists from TAFORI and EUCAMP.

Semdoe Forest Reserve

Family	Genus	species	Vegetation plot number	Tree number
Papilionoideae	*Milletia*	*usaramensis*	1	9
Ulmaceae	*Trema*	*orientalis*	1	8
Papilionoideae	*Milletia*	*usaramensis*	3	19
Ulmaceae	*Celtis*	*zenkeri*	3	21
Ebenaceae	*Diospyros*	*natalensis*	4	34
Melianthaceae	*Bersama*	*abyssinica subsp. abyssina var. holtzii*	4	39
Sapotaceae	*Manikara*	*sansibarensis*	4	37
Apocynaceae	*Pleiocarpa*	*pycnatha*	7	62
Mimosoidae	*Albizia*	*sp.*	7	64
Moraceae	*Ficus*	*vallis*	7	61
Bignoniaceae	*Fernandoa*	*magnifica*	8	64
Ebenaceae	*Diospyros*	*natalensis*	8	62
Rubiaceae	*Rothmannia*	*manganjae*	9	64
Papilionoideae	*Milletia*	*sacleuxii*	10	62

Appendix 3. Continued: Kwamgumi Forest Reserve

Family	Genus	species	Vegetation plot number	Tree number
Anacardiaceae	*Sorindeia*	*madagascarensis*	1	62
Euphorbiaceae	*Drypetes*	*natalensis*	1	63
Moraceae	*Mesogyne*	*insignis*	1	68
Papilionoideae	*Angylocalyx*	*braunii*	1	61
Apocynaceae	*Tabernaemontana*	*pachysiphon*	8	37
Bombaceae	*Bombax*	*rhodognaphalon*	8	41
Sterculiaceae	*Cola*	*usambarensis*	8	40
Rubiaceae	*Sericanthe*	*odoratissima*	11	45
Ebenaceae	*Diospyros*	*natalensis*	12	70
Euphorbiaceae	*Drypetes*	*sp.*	12	77
Ochnaceae	*Brackenridgea*	*zanguebarica*	12	75
Sapindaceae	*Blighia*	*unijugata*	12	82
Sterculiaceae	*Cola*	*clavata*	12	72
Sterculiaceae	*Cola*	*clavata*	12	74
Sterculiaceae	*Cola*	*greenwayi*	12	87
Papilionoideae	*Angylocalyx*	*braunii*	14	45
Caesalpiniodeae	*Erythrophleum*	*suaveolens*	15	28
Rutaceae	*Vepris*	*noblis*	15	53
Sapotaceae	*Englerophytum*	*natalense*	15	51
Apocynaceae	*Tabernaemontana*	*sp.*	18	44
Papilionoideae	*Erythrina*	*abyssinica*	20	50
Rubiaceae	*Oxyanthus*	*speciosus*	20	56
Sapotaceae	*Englerophytum*	*natalense*	20	54
Ulmaceae	*Trema*	*orientalis*	20	53
Moraceae	*Ficus*	*sur*	31	42
Papilionoideae	*Angylocalyx*	*braunii*	31	43
Sapindaceae	*Chytranthus*	*obliquinervis*	31	44
Bignoniaceae	*Fernandoa*	*magnifica*	34	58
Caesalpiniodeae	*Cynometra*	*longipedcellata*	34	56
Ebenaceae	*Diospyros*	*natalensis*	34	55
Oleaceae	*Chionanthus*	*sp.*	34	57
Sapotaceae	*Englerophytum*	*natalense*	35	56
Sterculiaceae	*Cola*	*clavata*	36	50
Violaceae	*Rinorea*	*ferruginea*	36	49
Euphorbiaceae	*Ricinodendron*	*heudelotii*	40	56
Moraceae	*Antiaris*	*toxicaria*	40	53
Apocynaceae	*Tabernaemontana*	*ventricosa*	41	46
Ebenaceae	*Diospyros*	*natalensis*	41	40
Ebenaceae	*Diospyros*	*natalensis*	41	45
Combretaceae	*Combretum*	*schumanii*	43	41
Ulmaceae	*Celtis*	*africana*	43	39
Ulmaceae	*Celtis*	*africana*	43	38
Caesalpiniodeae	*Scorodephloeus*	*fischeri*	46	57
Euphorbiaceae	*Drypetes*	*usambarica*	46	56
Papilionoideae	*Angylocalyx*	*braunii*	46	55

APPENDIX 4: DATA GATHERED IN VEGETATION PLOTS IN SEMDOE FOREST RESERVE

				EUBS SURVEY			MONITORING WORK														
				Year	Disturbance	No. trees	Year	Disturbance	Number of trees				Percentage of trees (of original number surveyed)				CHANGE IN DBH				
Plot ID	**Transect no.**	**Altitude**	**slope**						**found Total**	**found Alive**	**found Dead**	**Not found**	**found Total**	**found Alive**	**found Dead**	**Not found**	**mean**	**st dev**	**n**	**st error**	**95% confidence limit**
1	4	240	14	1997	cutting,fire	7	2001	fire, traps	5	5	0	2	71.43	100.00	0.00	28.57	0.68	4.56	4	2.280	4.469
2	4	210	13	1997	cultivation	1	2001	cultivation	0	0	0	1	0.00			100.00					
3	4	230	14	1997	cutting,fire	16	2001	fire	12	9	3	4	75.00	75.00	25.00	25.00	1.46	2.08	9	0.693	1.359
4	4	270	22	1997	cutting,fire	33	2001	fire	32	28	4	1	96.97	87.50	12.50	3.03	-0.49	4.62	18	1.089	2.134
5	3	178	28	1997	fire	21	2001	fire	4	3	1	17	19.05	75.00	25.00	80.95	1.09	3.66	3	2.113	4.142
6	3	PLOT NOT MONITORED (due to bees)																			
7	3	145	6	1997	cutting,fire	60	2001	fire	55	53	2	5	91.67	96.36	3.64	8.33	2.87	5.65	53	0.776	1.521
8	3	140	15	1997	fire	41	2001	fire	40	38	2	1	97.56	95.00	5.00	2.44	0.00	5.32	35	0.899	1.763
9	3	155	20	1997	cutting	63	2001	fire	60	58	2	3	95.24	96.67	3.33	4.76	0.40	2.51	55	0.338	0.663
10	3	180	19	1997	cutting	34	2001	fire	33	28	5	1	97.06	84.85	15.15	2.94	-0.01	2.44	28	0.461	0.904
11	3	200	10	1997	cutting,logging ,fire	31	2001	fire, path	28	26	2	3	90.32	92.86	7.14	9.68	1.97	2.26	26	0.443	0.869
12	2	140	21	1997	cutting	40	2001	fire	40	33	7	0	100.00	82.50	17.50	0.00	0.43	2.51	32	0.444	0.870
13	2	155	23	1997	cutting,fire	60	2001	fire	58	57	1	2	96.67	98.28	1.72	3.33	0.53	3.49	56	0.466	0.914
14	1	140	17	1997	cutting,fire	28	2001	fire	27	25	2	1	96.43	92.59	7.41	3.57	-0.17	3.91	24	0.798	1.564
15	2	140	6	1997	cutting,fire	39	2001	fire	31	26	5	8	79.49	83.87	16.13	20.51	3.30	9.70	26	1.902	3.729
16	2	140	18	1997	fire	24	2001	cutting	24	23	1	0	100.00	95.83	4.17	0.00	1.30	3.43	23	0.715	1.402
17	2	135	12	1997	cutting,fire	48	2001	road	47	32	15	1	97.92	68.09	31.91	2.08	-0.19	4.53	33	0.789	1.546
18	2	165	7	1997	fire	19	2001	pitsaw,fire	1	1	0	18	5.26	100.00	0.00	94.74	3.71		1		
19	5	350	25	1997	trap	35	2001	fire	35	26	9	0	100.00	74.29	25.71	0.00	2.14	3.29	26	0.645	1.265
					Total	**600**		**Total**	**532**	**471**	**61**	**68**									
					Mean	**33.33**		**Mean**	**29.56**	**26.17**	**3.39**	**3.78**	**78.34**	**88.16**	**11.84**	**21.66**	**1.12**	**4.00**		**0.93**	**1.82**
					St Dev	**17.45**		**St Dev**	**19.17**	**18.02**	**3.81**	**5.39**	**33.59**	**10.23**	**10.23**	**33.59**	**1.29**	**1.87**			

APPENDIX 5: DATA GATHERED IN VEGETATION PLOTS IN KWAMGUMI FOREST RESERVE

				EUBS SURVEY			MONITORING WORK														
				Year	Disturbance	No. trees	Year	Disturbance	Number of trees				Percentage of trees (of original number surveyed)				CHANGE IN DBH				
Plot ID	**Transect no.**	**Altitude**	**slope**						**found Total**	**found Alive**	**found Dead**	**Not found**	**found Total**	**found Alive**	**found Dead**	**Not found**	**mean**	**st dev**	**n**	**st error**	**95% confidence limit**
1	2	160	15	1996	logging	**57**	2001	fire damage	30	29	1	27	52.63	96.67	3.33	47.37	-0.03	3.41	27	0.66	1.29
7*	2	600	30	1996	clearing	**23**	2001	-	20	20	0	3	86.96	100.00	0.00	13.04	0.85	4.30	20	0.96	1.88
8	2	650	35	1996	-	**35**	2001	-	32	30	2	3	91.43	93.75	6.25	8.57	1.68	4.33	30	0.79	1.55
9	2	PLOT NOT FOUND																			
11*	1	150	2	1996	-	**44**	2001	fire damage	44	43	1	0	100.00	97.73	2.27	0.00	0.98	2.75	43	0.42	0.82
12	1	220	22	1996	cutting	**69**	2001	-	69	66	3	0	100.00	95.65	4.35	0.00	1.09	1.38	66	0.17	0.33
13	2	500	1	1996	cutting	**40**	2001	-	34	30	4	6	85.00	88.24	11.76	15.00	0.45	2.89	29	0.54	1.05
15	3	210	33	1996	-	**50**	2001	-	48	46	2	2	96.00	95.83	4.17	4.00	1.47	3.44	46	0.51	0.99
17*	3	200	21	1996	cutting	**53**	2001	-	53	52	1	0	100.00	98.11	1.89	0.00	0.55	1.97	52	0.27	0.54
18	3	525	25	1996	-	**42**	2001	fire damage	32	25	7	10	76.19	78.13	21.88	23.81	3.35	6.01	22	1.28	2.51
20	1	550	35	1996	logging	**48**	2001	-	35	35	0	13	72.92	100.00	0.00	27.08	1.94	3.36	33	0.58	1.15
21	3	560	39	1996	logging	**65**	2001	fire damage, logging	58	48	10	7	89.23	82.76	17.24	10.77	1.99	8.55	48	1.23	2.42
25	3	PLOT NOT FOUND																			
29	3	760	35	1996	-	**67**	2001	-	67	67	0	0	100.00	100.00	0.00	0.00	0.43	1.93	65	0.24	0.47
31	1	355	25	1996	cutting	**41**	2001	traps, path	39	36	3	2	95.12	92.31	7.69	4.88	2.32	3.39	36	0.57	1.11
32	1	400	10	1996	-	**43**	2001	fire damage	38	38	0	5	88.37	100.00	0.00	11.63	2.32	6.81	34	1.17	2.29
33	1	480	25	1996	-	**61**	2001	path	59	56	3	2	96.72	94.92	5.08	3.28	-0.30	3.29	53	0.45	0.89
34	0	350	33	1996	cultivation	**49**	2001	-	49	46	3	0	100.00	93.88	6.12	0.00	0.34	3.41	44	0.51	1.01
35	0	420	14	1996	cutting	**55**	2001	-	51	48	3	4	92.73	94.12	5.88	7.27	1.42	3.71	48	0.54	1.05
36	0	450	24	1996	logging	**47**	2001	-	44	44	0	3	93.62	100.00	0.00	6.38	0.56	4.34	44	0.65	1.28
38	0	PLOT NOT FOUND																			
40*	0	200	2	1996	-	**52**	2001	cutting	41	40	1	11	78.85	97.56	2.44	21.15	2.89	4.98	40	0.79	1.54
41	0	350	10	1996	-	**39**	2001	fire damage	39	36	3	0	100.00	92.31	7.69	0.00	-0.17	3.42	36	0.57	1.12
42	-1	350	35	1996	cutting	**42**	2001	-	40	34	6	2	95.24	85.00	15.00	4.76	-2.70	7.36	31	1.32	2.59
43	-1	300	12	1996	-	**37**	2001	-	33	33	0	4	89.19	100.00	0.00	10.81	0.88	4.42	32	0.78	1.53
44	-1	PLOT NOT FOUND																			
46	-2	280	15	1996	-	**54**	2001	fire damage	50	49	1	4	92.59	98.00	2.00	7.41	1.25	1.51	49	0.22	0.42
48	-2	PLOT NOT FOUND																			
49	-2	200	5	1996	-	**38**	2001	fire damage	9	1	8	29	23.68	11.11	88.89	76.32	2.11	-	1		
					Total	**1151**		**Total**	**1014**	**952**	**62**	**137**									
					Mean	**47.96**		**Mean**	**42.25**	**39.67**	**2.58**	**5.71**	**87.35**	**91.09**	**8.91**	**12.65**	**1.07**	**3.95**			
					St Dev	**11.02**		**St Dev**	**13.84**	**14.33**	**2.73**	**7.74**	**17.49**	**18.00**	**18.00**	**17.49**	**1.25**	**1.81**		**0.34**	**0.66**

APPENDIX 6: LEGIBILITY OF PAINT MARKING TREES IN VEGETATION PLOTS IN SEMDOE FOREST RESERVE

Vegetation Plot	*No. of trees found alive*	Legibility of paint for: DBH line			Plot number			Individual tree number		
		Y	W	N	Y	W	N	Y	W	N
1	*5*	5	0	0	5	0	0	2	3	0
2	*0*									
3	*9*	8	1	0	9	0	0	7	2	0
4	*28*	28	0	0	28	0	0	27	1	0
5	*3*	2	1	0	1	1	1	2	1	0
7	*53*	46	6	1	47	5	1	44	7	2
8	*38*	37	1	0	37	1	0	35	3	0
9	*58*	53	4	1	50	7	1	43	14	1
10	*28*	25	3	0	22	4	2	22	4	2
11	*26*	26	0	0	23	2	1	23	0	3
12	*33*	32	1	0	31	2	0	28	5	0
13	*57*	53	3	1	53	4	0	51	6	0
14	*39*	36	2	1	35	2	2	34	4	1
15	*26*	25	0	1	24	0	2	25	0	1
16	*26*	26	0	0	25	1	0	25	1	0
17	*32*	32	0	0	32	0	0	32	0	0
18	*1*	1	0	0	1	0	0	1	0	0
19	*26*	26	0	0	26	0	0	26	0	0
Total no.	*488*	*461*	*22*	*5*	*449*	*29*	*10*	*427*	*51*	*10*
Mean	*27.11*	*27.12*	*1.29*	*0.29*	*26.41*	*1.71*	*0.59*	*25.12*	*3.00*	*0.59*
st dev	*18.24*	*16.01*	*1.76*	*0.47*	*15.85*	*2.11*	*0.80*	*14.95*	*3.62*	*0.94*

n = 18

Abbreviations: Y - Yes, marking is legible, W - Marking is 'workoutable', N - No, marking is not legible

APPENDIX 7: LEGIBILITY OF PAINT MARKING TREES IN VEGETATION PLOTS IN KWAMGUMI FOREST RESERVE

Vegetation Plot	*No. of trees found alive*	Legibility of paint for: DBH line			Plot number			Individual tree number		
		Y	W	N	Y	W	N	Y	W	N
1	*29*	27	2	0	25	3	1	22	5	2
7	*20*	11	8	1	13	6	1	9	10	1
8	*30*	30	0	0	29	1	0	28	2	0
11	*43*	43	0	0	43	0	0	43	0	0
12	*66*	58	8	0	51	13	2	44	19	3
13	*30*	30	0	0	26	1	3	29	1	0
15	*46*	45	1	0	45	1	0	41	5	0
17	*52*	45	7	0	43	9	0	43	9	0
18	*25*	17	5	3	15	7	3	12	9	4
20	*35*	25	15	0	17	14	4	15	20	0
21	*48*	36	9	3	23	23	2	25	21	2
29	*66*	49	15	2	47	16	4	41	23	3
31	*36*	28	6	2	29	7	0	31	5	0
32	*38*	32	4	2	31	6	1	28	9	1
33	*56*	49	7	0	49	7	0	49	7	0
34	*46*	45	1	0	44	2	0	43	3	0
35	*48*	46	2	0	46	2	0	46	2	0
36	*44*	19	22	3	18	25	1	17	27	0
40	*40*	39	0	1	39	0	1	38	1	1
41	*36*	32	2	2	32	3	1	30	5	1
42	*34*	27	1	6	25	2	7	25	2	7
43	*33*	31	2	0	30	3	0	30	3	0
46	*49*	45	4	0	42	7	0	42	6	1
49	*1*	1	0	0	1	0	0	1	0	0
Total no.	*951*	*810*	*121*	*25*	*763*	*158*	*31*	*732*	*194*	*26*
Mean	*39.63*	*33.75*	*5.04*	*1.04*	*31.79*	*6.58*	*1.29*	*30.50*	*8.08*	*1.08*
st dev	*14.25*	*13.45*	*5.68*	*1.55*	*13.26*	*7.00*	*1.78*	*13.00*	*7.95*	*1.72*

n = 18

Abbreviations: Y - Yes, marking is legible, W - Marking is 'workoutable', N - No, marking is not legible

APPENDIX 8: Summary of results from work to assess the accuracy of dbh measurement: Control Plot: VP 11 Kwamgumi FR

Tree number	mean diameter (EUBS)	mean diameter (monitoring work)	mean change in dbh	standard deviation	standard error	95% confidence limit
1a	7.5	8.91	1.41	0.19	0.03	0.06
1b	3	3.25	0.08	0.81	0.13	0.26
2	44	45.11	1.11	1.03	0.17	0.33
3	22.5	26.52	4.02	0.26	0.04	0.08
4a	11	11.27	0.27	1.89	0.31	0.60
5	28	28.08	0.08	0.26	0.04	0.08
6	13	13.76	0.76	0.15	0.02	0.05
7	13	10.77	-2.23	0.15	0.02	0.05
8	11	14.84	3.84	0.31	0.05	0.10
9	93.5	89.93	-3.57	11.29	1.83	3.59
10	13	13.22	0.22	0.21	0.03	0.07
11	28.5	30.20	1.70	3.50	0.57	1.11
12	56	59.13	3.13	6.49	1.05	2.06
13	13	13.50	0.50	0.16	0.03	0.05
14	34.5	35.91	1.41	1.52	0.25	0.48
15	13	15.98	2.98	0.34	0.05	0.11
16	13.5	13.61	0.11	0.15	0.02	0.05
17	44.5	43.69	-0.81	4.70	0.76	1.49
18	24	25.31	1.31	1.78	0.29	0.57
20	11	11.86	0.23	2.70	0.44	0.86
21	16	16.75	0.75	0.22	0.04	0.07
22	20.5	19.85	-0.65	0.37	0.06	0.12
23	13	13.64	0.64	0.19	0.03	0.06
24	13	13.29	0.29	0.56	0.09	0.18
25	13	12.88	-0.12	0.25	0.04	0.08
26	21	22.03	1.03	0.35	0.06	0.11
27	23.5	25.01	1.51	0.26	0.04	0.08
28	21.5	22.12	0.62	0.22	0.04	0.07
29	52.5	53.92	1.42	4.74	0.77	1.51
30	90	91.39	1.39	7.53	1.22	2.39
31a	15	15.54	0.54	1.70	0.28	0.54
31b	10.5	11.33	0.23	3.10	0.50	0.98
31c	3.5	3.28	-2.12	1.65	0.27	0.52
32	28	28.72	0.72	0.35	0.06	0.11
33	11	14.71	3.71	0.59	0.10	0.19
34	40	47.08	7.08	0.83	0.13	0.26
35	32	33.33	1.33	0.52	0.09	0.17
36	14.5	12.79	-1.71	0.20	0.03	0.06
37	14	14.46	0.46	0.54	0.09	0.17
38	12.5	11.78	-0.72	0.64	0.10	0.20
39	31.5	31.13	-0.37	0.39	0.06	0.12
40	28	29.64	1.64	0.55	0.09	0.17
41	14	15.36	1.36	0.60	0.10	0.19
42	19	19.00	0.00	0.57	0.09	0.18
43	11	11.03	0.03	0.19	0.03	0.06
44	14	13.88	-0.12	0.20	0.03	0.06
Means (n = 46)	23.48	24.32	0.77	1.42	0.23	0.45

APPENDIX 9: Data from species accumulation curves presented in EUBS with regard to predicting numbers of species expected to be recorded at different sampling intensities

Forest Reserve	Equation of log line associated with accumulation curve	No. of plots equal to the sampling intensities					No. of species expected at the sampling intensities					No. of species expected as % of total recorded during EUBS				
		5%	10%	15%	20%	25%	5%	10%	15%	20%	25%	5%	10%	15%	20%	25%
Amani	y = 58.506 Ln (x) - 64.823	9	18	27	36	46	64	104	128	145	159	26	42	52	59	65
Bamba Ridge	y = 34.669 Ln (x) + 0.3423	1	2	4	5	6	24	38	55	67	76	18	29	43	52	59
Kambai	y = 36.65 Ln (x) - 0.0869	1	3	4	5	7	0	40	51	59	71	0	30	38	45	54
Kwamarimba	y = 40.94 Ln (x) - 8.4423	1	3	4	6	7	-8	37	48	65	71	-6	27	35	47	52
Kwamgumi	y = 48.945 Ln (x) - 6.0168	2	5	7	10	12	28	73	89	107	116	15	38	46	56	60
Longuza (N)	y = 30.449 Ln (x) - 0.8085	1	1	2	2	3	-1	-1	20	20	33	-1	-1	25	25	40
Manga	y = 32.935 Ln (x) - 9.627	2	5	7	9	12	13	43	54	63	72	11	38	47	55	63
Mlungui	y = 17.227 Ln (x) + 15.305	0	1	1	1	1	-	15	15	15	15		34	34	34	34
Mtai	y = 42.74 Ln (x) - 14.801	4	7	11	15	18	44	68	88	101	109	25	39	50	57	61
Segoma	y = 39.02 Ln (x) - 22.002	3	5	8	11	13	21	41	59	72	78	14	28	40	48	53
Semdoe	y = 32.915 Ln (x) - 15.467	1	2	3	4	5	-15	7	21	30	38	-19	9	26	37	46

APPENDIX 10: Endemic and near-endemic species recorded during monitoring work in Semdoe Forest Reserve

Family	Genus	species	Endemic status	Plot in which recorded during EUBS	Plot in which recorded during monitoring
Anacardiaceae	*Lannea*	*welwitschii*	N	7,6	7
Anacardiaceae	*Sorindeia*	*madagascariensis*	W (N)	2,7,9,10,17,18	7,9,10,17
Annonaceae	*Lettowianthus*	*stellatus*	N	10,18	10
Annonaceae	*Mondora*	*grandidieri*	N	3,4	3,4
Araliaceae	*Cussonia*	*zimmermanii*	N	19	
Bignoniaceae	*Fernandoa*	*magnifca*	N	8,9,18	8,9,14
Bombacaceae	*Bombax*	*rhodognaphalon*	N	3,10,14	3,14
Combretaceae	*Combretum*	*schumannii*	N	5,6,15	15
Ebenaceae	*Diospyros*	*kabuyeana*	N	7,12	7,12
Euphorbiaceae	*Drypetes*	*usambarica*	N	6,11,15	15
Euphorbiaceae	*Mildbraedia*	*carpinifolia*	N	6,14	14
Leguminosae - Caesalpiniaceae	*Dialium*	*holtzii*	N	5,6,7,8,9,13,14,15	7,8,9,13,14,15
Leguminosae - Caesalpiniaceae	*Julbernardia*	*magnistipulata*	N	15	15
Leguminosae - Caesalpiniaceae	*Scorodophloeus*	*fischeri*	N	1,10,15,18	1,10,15
Leguminosae - Papilionoideae	*Angylocalyx*	*braunii*	N	9	9
Leguminosae - Papilionoideae	*Millettia*	*sacleuxii*	N	10,11	10,11
Leguminosae - Papilionoideae	*Millettia*	*oblata*	N	12	12
Leguminosae - Papilionoideae	*Pterocarpus*	*mildebraedii*	N	6,13	
Melianthaceae	*Bersama*	*abyssinica*	N		4
Rubiaceae	*Tricalysia*	*anomala*	N	9	9
Sterculiaceae	*Dombeya*	*schupange*	N		19
Tiliaceae	*Grewia*	*holstii*	N	7,13,16,19	7,13,16,19
Tiliaceae	*Grewia*	*goetzeana*	N	6,7,12,13,14,16,18,19	7,12,13,14,16,19
Tiliaceae	*Nersogordonia*	*holstii*	N	9,10	9
Verbenaceae	*Vitex*	*amaniensis*	N	3	3

Endemic Status:
- E - Endemic: Occurring only in the Usambara mountains (EU -East Usambaras, WU – West Usambaras)
- N - Near endemic: Species with limited ranges usually only including coastal forest and/or the Eastern Arc mountains;
- W - Widespread distribution.

APPENDIX 11: Endemic and near-endemic species recorded during monitoring work in Kwamgumi Forest Reserve

Family	Genus	species	Endemic status	Plot in which recorded during EUBS	Plot in which recorded during monitoring
Anacardiaceae	*Lannea*	*welwitschii*	N	1,8,(48)	1,8
Annonaceae	*Lettowianthus*	*stellatus*	N	16,(44)	
Annonaceae	*Mkilua*	*fragrans*	N	1	
Annonaceae	*Monodora*	*grandidieri*	N	12	12
Annonaceae	*Polyceratocarpus*	*scheffleri*	N	6,17	17
Annonaceae	*Uvariodendron*	*gorgonis*	N	(10)	
Annonaceae	*Uvariodendron*	*pycnophyllum*	E (EU & WU)	11	11
Araliaceae	*Cussonia*	*zimmermani*	N	(22),40	40
Bignoniaceae	*Fernandoa*	*magnifica*	N	1, (2,3,10), 20,(26),40,46	20,34,40,46
Bombaceae	*Bombax*	*rhodognaphalon*	N	(3),7,(9,16),20,(47)	8,20
Burseraceae	*Commiphora*	*eminii zimermanni*	N	42	
Celastraceae	*Salacia*	*lehmbachii*	N	(9,23)	
Combretaceae	*Combretum*	*volkensii*	N	(45)	
Combretaceae	*Combretum*	*schumannii*	N	1,(4),11,(14),15, (17),33,35, (39),40,45,(47)	11,33,35,43
Ebenaceae	*Diospyros*	*kabuyeana*	N	1,(2,3,5),17,18,34,35, 41,(44),49	1,17,18,34,35,41
Euphorbiaceae	*Drypetes*	*usambarica*	N	1,(2,3,5),11,12,43,46	1,11,12,43,46
Guttiferae	*Allanblackia*	*stuhlmannii*	N	(5,28)	
Icacinaceae	*Alsodeiopsis*	*schumannii*	N	(5,10)	
Leguminosae - C	*Cynometra*	*longipedicellata*	E (EU)	(5)	34
Leguminosae - C	*Cynometra*	*webberi*	N	8,(9)	
Leguminosae - C	*Dialium*	*holtzii*	N	1,(2,3),11,12,15,(16), 17,35,46	1,11,12,15,17,35,46
Leguminosae - C	*Englerodendron*	*usambarense*	E (EU)	(5)	
Leguminosae - C	*Isoberlinia*	*scheffleri*	N	(6,9),20,(26)	20
Leguminosae - C	*Julbernardia*	*magnistipulata*	N	34	34
Leguminosae - C	*Scorodophloeus*	*fischeri*	N	1,(3,4),17,32,33,34, 36,(39),40 (44),46,(47,48)	1,17,32,33,34,36,40,46
Leguminosae - M	*Albizia*	*schimperiana*	N	(10,19),21,(22)	21
Leguminosae - M	*Newtonia*	*paucijuga*	N	1,12,15	1,12,15
Leguminosae - P	*Angylocalyx*	*braunii*	N	1,(3),18,41	1,18,31,41,46
Leguminosae - P	*Craibia*	*brevicaudata*	N	12,34	12,34
Leguminosae - P	*Milletia*	*usaramensis*	N	34,35,(39),42	34,35,42
Leguminosae - P	*Pterocarpus*	*mildbraedii*	N	(3,5),8,18,20,21	8,18,20,21
Myristicaceae	*Cephalosphaera*	*usambarensis*	N	(5,6),7,21	7,21
Rhizophoraceae	*Anisophyllea*	*obtusifolia*	N	(5)	
Rubiaceae	*Cremaspora*	*trifolia*	N	(24)	
Rubiaceae	*Oxyanthus*	*pyriformis*	N	(14),29	29
Rubiaceae	*Sericanthe*	*odoratissima*	N	11,20	11,20
Rubiaceae	*Tricalysia*	*anomala*	N	(2),8,(16,28)	
Sapindaceae	*Allophylus*	*melliodorus*	N	21	21
Sapindaceae	*Chytranthus*	*obliquinervis*	N	(9),15,20,(47)	15,20
Sapindaceae	*Placodiscus*	*amaniensis*	N	(5)	

Appendix 11 Continued

Simaroubaceae	*Odyndea*	*zimmermannii*	N	(5),13,21	21
Sterculiaceae	*Cola*	*scheffleri*	E	1,8,(9,10),13,20,21,(25, 26),29,31,36,(37,38)	8,13,20,21,29,31,36
Sterculiaceae	*Cola*	*usambarensis*	E (EU)	(4),12,(14),31,32,(38)	8,12,31
Sterculiaceae	*Dombeya*	*schumannii*	N	(4)	
Tiliaceae	*Nersogordonia*	*holtzii*	N	(2,3),8,(10),12,33	8,12,33
Verbenaceae	*Premna*	*chrysoclada*	N	1,20,21,(26),35,40	21,35,40
Verbenaceae	*Vitex*	*amaniensis*	N	(9),11,(22)	11
Violaceae	*Rinorea*	*angustifolia var. albersii*	E (EU & WU)	36	36

C – Caesalpiniaceae, M – Mimosoideae, P - Papilioniaceae

Endemic Status:

- E - Endemic: Occurring only in the Usambara mountains (EU -East Usambaras, WU – West Usambaras)
- N - Near endemic: Species with limited ranges usually only including coastal forest and/or the Eastern Arc mountains;
- W - Widespread distribution.

APPENDIX 12: Notes with regard to the grid and transect system established by EUBS as encountered during monitoring

Semdoe Forest Reserve

Plot orientation and transect grid system:
The orientation of the grid system within this FR is different to Kwamgumi. The transect lines run north - south, with the vegetation VPs positioned every 450 m and the central line run east - west, spacing the transect lines 900 m apart.

After 3 days of searching for vegetation VPs close to the base camp (038^{0}42’32.3 E 04^{0}56’05.6 S), VP 1 was relocated. It was assumed this was the starting point of the transecting grid, however the transect line was labelled number 3.

Notes regarding transect line re-location:
Transect 3: The origin of VP 1 (038^{0}41’32.0’’ E 04^{0}57’57.3’’ S) was found to be 50 m from the border beacon (038^{0}41’30.4’’ E 04^{0}57’57.9’’ S), i.e. the 50 m length of the VP ran from the beacon into the forest. At this position one can see down towards Kambai village and across to Kambai forest reserve. The borders of the two reserves meet at this point.

VP 1 was 50 m closer to the beacon than stated in the original 1997 notes, thus there must have been some initial confusion. However, using the sketch map of the vegetation VP and locating painted trees the VP was orientated and the transect line was cut northwards with evidence of only 1 red tag on the ground close to the origin point of the VP. The line cut to the road and then ran across into *shamba* (outside the FR boundary). The transect line was continued 450 m in order to locate VP 2. There was only one tree originally recorded within this VP with the majority of the 50 m x 20 m VP within *shamba* and thus outside the FR. This single tree was searched for with the aid of the VP sketch map, but was not found. The line was transected on and VPs 3 & 4 were accessed. The line to date has been red tagged from VP 3 to the north boundary, the Semdoe river (038^{0}42’23.9’’ E 04^{0}56’10.0’’ S).

Transect 2: This line was accessed from line 3. A central line was cut from VP 4 to VP 9 along the east - west bearing, for 900 m. The line was yellow tagged and transecting data was recorded.

VPs along transect 2 were then accessed from VP 9 with transect section re-cut to locate VPs to the north and south of VP 9. These lines have been red tagged. The transect lines did not follow exactly the original line, but are estimated to be within $\pm$10m in any direction. The lack of old tag evidence is not surprising as the forest is in a highly disturbed state, due to the 1997 fire. The shrub and ground layers are not easily walked and all sections of the forest have required extensive use of *panga* force in order to access VPs.

Transect 1: Was accessed from line 2. Central line 2 was cut from VP 9 to VP 15 and yellow tagged. From VP 15 the transect line was cut to the north to access VPs 16 & 17 and to the south to access VPs 14,13, 12 & 18.

The road cut across the transect line between VPs 16 and 15, at this point (038^{0}42’30.5’’ E 04^{0}56’57.7’’ S).

Transect 4: Was accessed from line 3. Central line 3 was cut from VP 4 to VP 19 and yellow tagged.
VP 20 was not located as the VP does not contain any trees.

Appendix 12. Continued.
Kwamgumi Forest Reserve

VP orientation and transect grid system:
Transect line orientation is east – west, Central lines run north - south
Transect lines were individually located and no central lines were cut.

Notes regarding transect line re-location:
Transect -2: VPs 49 and 46 were transected to and red tagged, yellow tagged to VP 47 where VP was located 15 - 20 m to the north. Yellow tagged to where VP 48 should be, but could not relocate VP, as area had been severely damaged by fire and no evidence of the VP was found.

Transect -1: VPs 42, 43 were located, lines were sisal tagged and transected to plot 44, but no evidence of VP was found, severe fire damage in area.

Transect line 0: VPs 34, 35 to 36 were red tagged. Sisal tagged to where VP37 could be i.e. 450 m but VP was not located. VP34 was transected and red tagged to the plantation where there is not a defined border. This point can be reached from the road from the house from Kwamtili Estate. Follow the road northwards from the junction of roads (near house) 30 m on right (east) follow path in plantation land and meet red tags.

VPs 40 and 41 were located from the east side of the reserve. This involved a car journey from the Kwamtili house (base camp) approximately 50 -60 minutes due to bad condition of road. Take the northerly road from the base camp heading to Churwa, right turning before Churwa, follow track through settlements and *shamba*, turns to footpath, but the area is drivable ($038^0$46'00.7'' E $04^0$55'35.1'' S). VPs were located to the south-west of where car was parked. It was a 15 min walk to the edge of forest. VP 40 was located quite easily from which VP 41 was transected to and red tagged. The tagging was out by c. 20 m to the north, the distance between end of transecting and VP was tagged yellow to the south.

Transect 1: This line crossed a path that can be taken from base camp. Path at base camp is an old road to the south, dwindles with distance i.e. becomes a footpath that is quite over-grown and crosses the transect line at ($038^0$43'55.1'' E $04^0$56'07.1'' S). From this point VPs 12 & 20 were located to the east (uphill). The line was sisal tagged only. VP 11 was located to the west (downhill) from the path and was red tagged from the path, only.

VPs 31, 32 & 33 were located from the east side of the reserve and where worked from a satellite camp. The satellite camp was located very close to VP 10, c. 50 m NW of the VP up the hill from the stream. The path up to the camp was located from the same car stop point as used for VPs 40 & 41 ($038^0$46'00.7'' E $04^0$55'35.1'' S). The line was transected from VP 31 to 32 and 33 with red tags. Where the line crosses the path between VPs 31 & 32 but with the VP 32 450 x 900 grid, the line goes down a steep slope to the stream. An easier way to descend is to go northwards and down the slope gradually cross the stream and head SE. VP 32 is east of the stream. There was a relatively large amount of evidence to follow from VP 32 to 33 i.e. old red tags on the ground and the vegetation. However this evidence was confusing as east of VP 32 the evidence stopped the line was continued and sisal tagged to the theoretical distance 450 m. The VP, 33 was not at this point but c. 20 m the south, and was easily reached along a path, that ran from the north border into the forest where there was evidence of cutting and small scale logging. This path petered out when it reached the VP. Evidence was located in the middle of the VP (most odd) and continued west towards VP 32. This evidence was followed and red tagged, then at the sisal tags and old evidence followed in the easterly direction were observed c. 20 m to the north. Thus this 20 m section to the north was red tagged to join the sisal line which was then red tagged to VP 32.

Transect 2: The west side of this transect line was accessed from the same paths as for T1. VP 1 was located following the path parallel to the Muzi river. The border of sorts is reasonably defined, in terms of there is obvious change between forest and plantation vegetation. VP 2 could be either accessed from VP 1 or from the path that cuts across T1, as it cuts across T2 further south. T2 was transected and red tagged from the border through VPs 1, 2, 3 & 4. The later three VPs were not within the random selection for monitoring and were thus not monitored. The

Appendix 12. Continued.

east side of T2 was accessed from the east and was worked from the satellite camp positioned close to VP 10. VP 9 could not be re-located and thus VP 7 was located and monitored instead. VP 8 was easily accessed and a 10-15 minute journey from the satellite camp. VP 10 was just east of the stream and was sisal tagged from VP 8. VP 13 was red tagged from VP 10.

Transect 3: This line was mainly accessed and worked from a second satellite camp, with the exception of VP 15 which was worked from base camp. The satellite camp was located south of the transect line and was closest to VP 18 ($038^0$43'41.4'' E $04^0$57'14.9'' S). Locating and accessing the VPs of this line was not an easy task. VPs 17 and 18 were located relatively easily, while access to VPs 29 and 21 was very steep, rocky and would be dangerous in wet weather. During the satellite camp VPs 17,18 and 29 were monitored. VP 21 was located but work could not be carried out until a later date because of time constraints. VP 25 was not located and the terrain was too difficult for the team with regard to time available and personnel. Thus VP 17 was monitored instead of VP 25. VP 21 was monitored whilst working with Semdoe, approximately a week after location. The transect lines were not red tagged effectively and tags were used as access only due to time constraints.

APPENDIX 13: Recording sheet used for trees previously marked in vegetation plots.

East Usambara Monitoring **Frontier Tanzania**

VEGETATION PLOTS (50 x 20m) - Original trees >10cm DBH

F.R. code | Day | Month | Year

Transect no. | Team

PLOT ID | Altitude (m) | Slope (deg.)

GPS: Way point

Latitude S

Longitude E

DISTURBANCE (Tick as appropriate)

Pitsawing		Campsite		Animal remains	
Fire damage		Mining (pits)		(excluding dung)	
Cultivation		Timber, planks, poles etc		Gunfire	
Settlement		Charcoal burning		Footpath	
ADDITIONAL INFORMATION		Traps, pitfalls etc.		Other	

TREES >10CM DBH

Status: A - Alive, D - Naturally dead, C - Cut

Paint still legible?: Y - Yes, N - No, W - Worked out eventually

Specimen number	DBH (cm)	Status	Paint still legible?		
			DBH line	Plot number	Tree number
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Appendix 13 Continued. (Back page)

Specimen Number	DBH (cm)	Status	Still legible?		
			DBH line	Plot number	Tree number
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45					
46					
47					
48					
49					
50					
51					
52					
53					
54					
55					
56					
Forest Reserve:	Plot number:		Date:		

APPENDIX 14: Recording sheets used to record GPS fixes.

East Usambara Monitoring
Frontier Tanzania
GPS Fixes

Type of site: ____________________
e.g. Vegetation plots, Transects.

F.R. code	Plot ID/ Transect no.	Description of site	Way point	Longitude	Latitude	Grid Reference
				E	S	
				E	S	
				E	S	
				E	S	
				E	S	
				E	S	
				E	S	

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

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