PLANT SPECIES COMPOSITION AND RESTORATION POTENTIAL THROUGH SOIL SEED BANK IN ZARANINGE AND MBWEBWE COASTAL FORESTS, BAGAMOYO DISTRICT, TANZANIA

BY

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ABSTRACT

The aim of the study was to assess plant species composition and its relation with soil seed bank as a basis for forest restoration through natural regeneration in Zaraninge and Mbwebwe coastal forests, Bagamoyo District Tanzania. Eighteen sample plots of size 0.07 ha were established systematically along transect in each of the two forests. Soil samples were collected within each plot at 0-10cm, 10-20cm and 20-30cm depths. The analysis was based on Importance Value Index computed from the average of relative basal area, density and frequency. Soil samples were analyzed for seed density of different plant species at the different depths. 62 and 50 plant species were identified in Zaraninge and Mbwebwe forests respectively. Out of 62 vascular plants identified in Zaraninge three species were rare plants, 35 common species and seven endemic to coastal forests. Mbwebwe forest had three rare plants, 26 common species and five endemic to coastal forests. The Shannon-Winner and Simpson Diversity Indices were 2.843, 0.093 and 2.5, 0.12 for Zaraninge and Mbwebwe forests respectively showing that the forests have high species diversity. The seed bank density for vascular plants was 2,782seeds m^{-2} and 1,170seeds m^{-2} and for rare plants was 103 and 68seeds m^{-2} for Zaraninge and Mbwebwe forests respectively. 71 seedlings emerged from all samples of the two forests, most of them being herbs and grasses. One rare plant species germinated from both forests. Majority (55%) of the seedlings emerged from 0-10cm soil layer. Based on the number of germinated seeds there was no close relationship between species composition of standing vegetation and composition of the seed bank. It is concluded that forest restoration through soil seed bank may greatly depend on seed bank at the surface soil horizons. The study suggests longer germination trial in order to capture full soil seed bank potentials.

DECLARATION

I, NANCY ELIAD PIMA, do hereby declare to the Senate of Sokoine University of Agriculture (SUA) that this dissertation is my own original work and that has neither been submitted nor being concurrently submitted for a higher degree award in any other University.

……………………………………… 08/7/2009

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The above declaration is confirmed

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Prof. S.S. Madoffe Date

(Supervisor)

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DEDICATION

This work is dedicated to my husband Joshua Maguzu, parents Eliad Pima and Jane Semng'indo, sisters, brothers and my beloved daughter Gaudensia Joshua.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Coastal forests are chain of thicket and forest patches scatted along the coastal margins of Eastern Tanzania embedded within savanna woodlands, wetlands, grasslands and in farmlands (Burgess *et al.*, 2000). The coastal forests of mainland Tanzania cover an area of about 700 km^2 which are protected as national or local authority forest reserves and forests in the general land (Burgess *et al.*, 2000). Tanzania's coastal forests support globally important and unique ecological communities, but are scientifically poorly known and are severely threatened from logging and agriculture (Sheil and Burgess, 1990). Despite their limited size, Tanzania coastal forests are increasingly recognized as a major center of species diversity and endemism.

Ecological restoration is used as a process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (Mansourian *et al.*, 2005). It is an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability (SER, 2002). Forest restoration may be achieved through natural regeneration from coppicing, soil seed bank or artificial planting. Restoration though natural seed bank may be relatively cheap and reliable compared to other methods (Mansourian *et al.*, 2005). Zaraninge and Mbwebwe coastal forests in Tanzania are under degradation threats from human impacts and may require ecological restoration especially for rare plant species in the future. Quantifying the abundance of rare plant species and understanding how the abundance is related to the soil seed bank is an important step in species restoration and management in-situ.

Standing vegetation in mature forests has reproductive structures that remain in the soil for a period of time or germinates immediately after seed dispersal. Seed bank is a central topic for plant communities restoration (Blanckenhagen and Poschlod, 2005). According to Roberts (1981) the term soil seed bank has been used to designate the viable seed reservoir present in the soil. Conversely, for Bakker (1989) this reservoir corresponds to the seeds not germinated but potentially capable of replacing the annual adult plants, which have disappeared through natural death or not, and perennial plants that are susceptible to plant diseases, disturbance and animal consumption, including man. All viable seeds present in the soil or mixed to soil debris constitute the soil seed bank (Simpson *et al.*, 1989). Seed bank may play an important role in the conservation of genetic diversity and natural restoration of ecosystems as well as specific plant species (Bernhardt and Ulbel, 1995).

Seed dynamics play an important role in structuring and maintaining plant communities. Seeds sustain populations during temporarily unfavorable conditions, allow establishment in new areas, and can introduce novel genotypes to populations. Seed banks, in particular, are important in maintaining species and genetic diversity in communities and in allowing species to persist through disturbance or adverse conditions (Thompson, 1992; Rees, 1996). The presence of seed banks in the soil allows a plant species to maximize their chances of survival and creating benefits for that population (Hyatt, 1999). Seeds stored in the seed bank can withstand harsh conditions over many years allowing the plant species to be propagated many years after initial seed dispersal. This study provides baseline information needed for restoration of plant species through seed bank.

1.2 Problem Statement and Justification

Assessment of forest condition is an important precursor to the planning and implementation of restoration programmes. Forest loss and fragmentation are combining to threaten species of ecological and socio-economic significance in many parts of Tanzania calling for restoration planning to mitigate the losses. Many restoration programmes fail because pressures that caused deforestation are not addressed, and the restored forest suffer the same fate as the original forests (Mansourian *et al.,* 2005). However, it requires a clear understanding of the relationship between plant species composition and the presence of propagules on site that are representative of the vegetation that existed. Soil seed banks are important sources of restoration propagules.

Heavy human disturbance especially extensive timber logging, agricultural clearance, fire burning have been documented to occur in Zaraninge and Mbwebwe coastal forest (Mwasumbi *et al.,* 1994). Such disturbances have different impacts on different plant species including loss of some endemic, threatened and other species such as *Milicia excelsa*, *Afzelia quanzensis* and *Pterocarpus angolensis* which may sometimes need restoration. Given the difficulties in undertaking species restoration in degraded lands through artificial means, natural regeneration through existing soil propagules (seed bank) may be a feasible option. However, the success of such option depends greatly on whether the seed bank is a reflection of the existing vegetation.

The relationship between plant composition and soil seed banks is however not well documented in Tanzanian forests given the variety and variability of forest ecosystems. Furthermore the knowledge on the abundance of rare and threatened species in Zaraninge and Mbwebwe forests and the potential for their restoration through soil seed bank remains relatively scanty. This study was conducted to assess plants species composition and their relation to the soil seed bank as basis of forest restoration through natural regeneration in Zaraninge and Mbwebwe forests. This assessment provides baseline information for restoration of rare and other plant species through soil seed bank in Zaraninge and Mbwebwe coastal forests.

1.3 Research Objectives

1.3.1 General objective

The main objective of the study was to assess plant species composition and its relation to the soil seed bank as basis of forest restoration through natural regeneration in Zaraninge and Mbwebwe coastal forests.

1.3.2 Specific objective

The specific objectives were to;

1) Assess plant species composition, richness, dominance and identify rare plant species in Zaraninge and Mbwebwe forests.
2) Determine the soil seed bank density and its relation to species composition of the standing vegetation in Zaraninge and Mbwebwe forests.

1.4 Hypothesis

Ho: There is no significant variation between seed bank and standing vegetation in Zaraninge and Mbwebwe forests.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Species Composition in Forest Ecosystems

Vegetation composition refers to the relative amounts of a particular species as a percentage of the total number of species in a community (Clarke and Stubblefield, 1994; Munishi, 2001). Species composition reflects a combination of environmental and historical events at a site; hence, changes in species composition can provide a sensitive measure of ecologically relevant changes in the environment (Philippi *et al.,* 1998). In some forest types, the number of tree species may increase with age, but in others, the old-growth stage may be relatively simple, with low species diversity. Species composition may change with time due to variations in moisture levels associated with seasonal rainfall fluctuations (Munishi, 2001). Unpredictable disturbance, environmental contrast within and among tree fall gaps that favor trees with different regeneration requirements may also influence species composition. Further, random conditions affecting reproductive or mortality rates can also maintain species diversity through competition for resources (Clarke and Stubblefield, 1994).

Classification and assessment of vegetation pattern and species association is important tool for land management, restoration and conservation. The knowledge of plant community dynamics and species association as influenced by environmental factors will be important as these abandoned (degraded) lands become available for forest restoration (Munishi, 2001). The species composition of a forest ecosystem helps partly to define the forest community on a floristic basis. Several communities may have similar physiognomy yet differ in the identity of dominants or other species. The abundance, importance, or dominance of each species can be expressed numerically so that different communities can be compared on the basis of species similarities and differences (Dalling *et al.*, 1998). Species composition is also used to determine forest condition and trend, which are valuable tools to judge the impact of previous management and guide future decisions.

The ancient lineage forest of Zaraninge containing endemic and many rare species has a high conservation value. A strict protection is even more important since coastal forest vegetation is extremely vulnerable to disturbances (Clarke and Stubblefield, 1994). Mwasumbi *et al.* (1994) have shown that heavy human disturbances (especially extensive timber logging, agricultural clearance) of coastal forests reduce their biodiversity values as plant-diversity and the habitats of rare plant species are lost.

2.2 Soil Seed Banks

Seed bank can be defined as an aggregation of diaspores in and on the soil surfaces which are potentially capable of germinating and thereby replacing adult plants which die due to diseases, senescence, disturbance or consumption by animals (Falinska, 1999). Most diaspores are infact fruits but are generally referred to as seeds. Seed banks have only recently begun to be incorporated in demographic models of plant populations. This is probably because seed bank data (e.g. seed survival and germination rates) are often more difficult to collect (Leckie *et al.*, 2000) than data of adult plants. In addition, seed banks are highly variable in composition, lifetime, and functional significance. The seed longevity in the soil varies among species, depending on the characteristics of the seeds, burial depth, and climatic conditions. Also longevity of seeds can range from nearly zero (germination directly when reaching the soil or even before) to several hundreds of years (Falinska, 1999).

2.3 Importance of Seed Bank

The term soil seed bank has been used to designate the viable seed reservoir present in soil (Leckie *et al.*, 2000). This reservoir corresponds to the seeds not germinated but, potentially capable of replacing the annual adult plants, which have disappeared by natural death and perennial plants that are susceptible to plant diseases, disturbance and animal consumption, including man. All viable seeds present in the soil or mixed to soil debris constitute the soil seed bank. Little is known about the influence of forest management on the interaction between the seed bank and the aboveground vegetation (Leckie *et al.*, 2000).

Soil seed banks play an important role in the conservation of genetic diversity and natural restoration of wetland vegetation (drying of ponds, water erosion) as well as to recover endangered plant species. It also plays an important role in many other ecosystems. For example, rapid revegetation of burned or ploughed sites is in a big part due to soil seed bank. But also forest ecosystems especially in gaps contain a number of specialized plant species forming persistent soil seed banks. Soil seed banks are also important in restoration of human influenced or destroyed ecosystems. Their absence slows revegetation down (Bernhardt and Ulbel, 1995).

Leckie *et al.* (2000) found that in temperate deciduous forests, seeds of woody species are prevalent in low-sunlight areas with thicker leaf litter and more nutrient-rich soil. They also found that a significant portion of the seed bank contained shade-tolerant species, contrary to other studies that observed mostly seeds of shade-intolerant species. Other abiotic factors can also have a noticeable effect on the makeup of seed banks (Hyatt and Casper, 2000). Some of these factors affecting seed germination are temperature changes and rainfall amounts (Hyatt, 1999).

2.4 Seed Bank Classification and Dynamics

Thompson (1992) recognized three classes of seed banks. Transient seed banks include seeds which persist in the soil for less than one year, often much less. The second category is short-term persistence seed banks that include species with seeds that persists in the soil for at least one year, but less than five years and their significance are to maintain plant populations after poor seed setting in the dry season or after cutting too early. Finally, is a long-term persistent seed bank with seeds which persist in the soil for at least five years thereby contributing to regeneration or restoration of destroyed or degraded plant communities.

Seed dynamics play an important role in structuring and maintaining plant communities. Seeds sustain populations during temporarily unfavorable conditions, allow establishment in new areas, and can introduce novel genotypes to populations. Seed banks, in particular, are important in maintaining species and genetic diversity in communities and in allowing species to persist through disturbance or adverse conditions (Thompson, 1992; Rees, 1996). The dynamics of the seed bank provide an understanding of the important limiting factors or processes that occur within that community. The dynamics of a seed bank involve a series of events in relation to time (Simpson *et al.*, 1989) and the input is determined by the seed "rain". This way of dispersion includes passive forms, mechanical ejection of seeds, fire, wind, water and animals. The result from physiological answer of plants to environmental factors that induce germination, seed burial or redispersion of the seeds and predation of the seeds by other animals (Christoffoleti and Caetano, 1998).

In addition, the number of seeds, which are incorporated into the soil and those which are lost and their persistence is determined by various factors. These include seed size, shape, seed 'rain' pattern, availability of seed dispersers, longevity and factors controlling germination such as light and levels of carbon dioxide. Birds and animals are important seeds dispersers as they disperse seeds into new areas when consumed as food material and passed out of their body unharmed (Traboud, 1994). Plant height could influence seed dispersal. Plants, which are short and with small crown can disperse seeds closer to the mother plant and tall plants with bigger crown can disperse seeds far away.

2.5 Rare Plant Species

A rare species is an organism which is very uncommon or scarce. This designation may be applied to either a plant or animal taxon, and may be distinct from the term "endangered" or "threatened species" (MacNally and Brown, 2001). A species may be endangered or vulnerable, but not considered rare if, for example, it has a large dispersed population but its numbers are declining rapidly or predicted to do so. Rare species are generally considered threatened simply because the inability of small population sizes to recover from stochastic events and the potential for a rapid decline in population (MacNally, and Brown, 2001). Many species are rare because they require habitat conditions that are no longer prevalent. But just as many, if not more, are rare because they occur only in highly restricted habitats that are of a more recent origin and may never become common. These plants have specific needs met by a unique combination of habitat factors not often duplicated (Cochrane, 2008). It is estimated that, 10 million species of the Earths are disappearing each year (Healy, 2002). Between one and two thirds of all plants and animal species are predicted to become extinct, mainly in the tropics, during the second half of the next century largely due to human impacts. This is inevitable if the current trend continue. The current extinction rate is now approaching 1000 times the back ground rate, i.e. what would occur in a natural environment without human impact and may climb to 10000 times the back ground during the next century if the present trends continue (Killenga, 2007). In Zaraninge forest, forested land has traditionally been cleared for cultivation and older people remember that forest used to be larger in extent. Ginger plants associated with past settlements have been found on the lower plateau slopes and within open wetlands on the plateau top although there is no obvious sign of any recent clearance in these localities. This has lead to decrease in rare plant species.

2.6 Restoration of Forest Ecosystems

Restoration refers to re-establish the presumed structure, productivity and species diversity of the forest originally present at a site. The ecological processes and functions of the restored forest will closely match those of the original forest

(Gilmour *et al.,* 2000). Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER, 2004). Ecological restoration is an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability. Frequently, the ecosystem that requires restoration has been degraded, damaged, transformed or entirely destroyed as the direct or indirect result of human activities. In some cases, these impacts to ecosystems have been caused or aggravated by natural agencies such as wildfire, floods, storms, or volcanic eruption, to the point at which the ecosystem cannot recover its predisturbance state or its historic developmental trajectory (SER, 2004).

Evaluation of forest restoration should consider why forest loss or degradation has occurred. Many restoration programmes have failed because the pressure that caused deforestation has not been addressed and restored forest suffer the same fate as the original forests (Mansourian *et al.,* 2005). Ecological restoration may also be difficult for other reasons. In some severely degraded sites the number of species to be restored may be too high or the magnitude of the changes such as exposure, topsoil erosion or increases in salinity may be so great that restoration is too difficult to achieve even if the technical means were available. The costs of attempting full restoration of the original system might simply be too high. In some situations social constraints may also apply. Some traditional land owners or managers may be unwilling to agree restoration of degraded sites they are not currently using because it is not a goal they share or because they believe restoration might somehow lessen their rights to its future use. In such cases outside intervention to achieve restoration is unlikely to be successful (Gilmour *et al.*, 2000). Understanding the nature of the pressures and working with local community to plan restoration in ways that are mutually beneficial increases the chances of restoration succeeding (Mansourian *et al.*, 2005). Heavy human disturbances especially extensive timber logging, agricultural clearance, fire burning reduce biodiversity values as loss of plant-diversity and the habitats of rare plant species (Mwasumbi *et al.*, 1994).

CHAPTER THREE

3.0 MATERIAL AND METHODS

3.1 Study Area Description

3.1.1 Location

The study was conducted in Zaraninge and Mbwebwe coastal forest located in Bagamoyo district, Coastal region which are approximately 50 km north of Bagamoyo town, 20 km south - west of Saadani National Park and 20 km north-west of Wami River (Burgess *et al.*, 2000). Zaraninge forest is one among the 39 recognized coastal forests in Tanzania (Sumbi, 1999; Burgess *et al.*, 2000). Zaraninge Coastal Forest was formally a forest reserve before being taken by Saadani National Park. The forest harbors unique diverse flora and fauna, with high endemism. The forest provides a variety of forest products and environmental functions to the surrounding communities (Sumbi, 1999).

Zaraninge occupies about 18 000 ha and lies between 6° 04' S - 6° 13' S and 38°35' E - 38°42' E with an altitudinal range of 100 m to 300 m above the sea level (Mwasumbi *et al.,* 1994; Burgess *et al*., 2000). There are six villages which are either located in the forest or surrounding it. These include Gongo, Matipwili, Saadani, Mkange, Mbwebwe and Tumbilini. The area is accessible by bus from Dar es Salaam to Miono, also by railway line to Matipwili and Mvave (Ansell and Dickinson, 1994). On the other hand, Mbwebwe forest was formally part of Zaraninge forest however currently it is a public forest after being detached from Zaraninge forest. The forest is about 61 ha and is adjacent to Zaraninge forest.

3.1.2 Climate

The climate is generally oceanic. The area experiences four months of dry season (June to September) and two wet seasons (February to May and October to December). Rainfall ranges between 820 mm and 1050 mm per year. The Tropical East African oceanic temperatures that are slightly modified by altitude influence Zaraninge Forest. February and March are the warmest months and August is the coldest. The average annual temperature is between 20.8°C and 26.5°C (Ansell and Dickinson, 1994).

3.1.3 Geology and Soils

The forest grows on a plateau of limestone and calcareous stone (possibly Jurassic age). Sandstone is exposed at the margins of the plateau. A large part of the forest is occupied by fairly homogeneous sandy soils with a thin dark humus layer (Ansell and Dickinson, 1994).

3.1.4 Hydrology

The forest lies within the catchment of the Wami River and there are no permanent running watercourses, although many seasonal water channels exist. Several permanent ponds are found in the wetland depression in the center and northwestern part of the forest. The water table in the depression appears to lie beneath an impermeable layer of clay, with pools forming on top of this. The seasonal nature of these wetlands result in markedly dropping of the water table and evaporating of the water trapped on the surface in certain periods. Two trapped permanent waterholes exist just outside the forest close to Gongo and Mbwebwe villages, providing water for local use (Ansell and Dickinson, 1994).

3.1.5 Flora

Homogeneous semi-deciduous forest occupies the plateau top comprising of forest edge and woodland species on the plateau sides. The forest has a fairly closed (80 % cover) 15 m high canopy with a distinct under storey layer at 10 m and a shrub layer at 3 m. Deadwood accounts for approximately 15 % of all the wood present. The plateau forest is rich in leguminous species. Dominant tree species include *Hymenaea verrucosa* (Caesalpinioideae), *Baphia kirkii* (Papillionaceae) and *Haplocoelum inoploeum* (Sapindaceae). Less common species include *Bombax schumannianum* (Bombaceae) and *Euphorbia* sp. *Dioscorea* sp. is abundant on the plateau edge.

In the sub canopy, trees *Cola microcarpa* (Sterculiaceae) is prevalent along with *Manilkala sp.* (Sapotaceae) and members of Euphorbiaceae. The shrub layer principally comprises seedlings of the canopy species along with legumes such as *Milletia impressa* and members of the Rubiaceae and Euphorbiaceae. *Milletia impressa, Asparagus setaceus* and grass *Panicum sp.* are prevalent in the herb layer.

Woodland and wooded grassland are present on the coastal plain surrounding the Kiono Plateau with tree species including *Terminalia boivinii, Diosyros consolatae, Albizia petersiana, Mallotus oppositifolius, Grewia microcarpa, Mystroxylon aethiopicum, Sterculia africana* and *Meyna tetraphylla*. An area of woodland on the eastern edge of the forest appears to be in the process of undergoing a succession to forest, and contains trees such as *Suregada zanzibariensis, Albizia petersiana, Zanthoxylum chalybeum* and *Cassia abbreviata*. Woodland is also present between the swamp and forest. It contains tree species such as *Strychnos madagascariensis, Thespesia danis, Markhamia obtusifolia, Apodytes dimidiata, Hyphaene coriacea, Margaritaria discoidea, Brackenridgea zanguebarica, Grewia lepidopetala, Clausena anisata, Bourreria nemoralis, Acacia adenocalyx* and *Vitex payos*. The forest holds a small depression containing wetland vegetation, with a diverse sedge and grass flora (Ansell and Dickinson, 1994).

3.1.6 Fauna

The forest has at least 40 mammal species including seven bats and eight rodents. Seventeen forest dependent reptile species and ten amphibian species are also found in the forest. Seventy-one (71) bird species have been recorded in the forest of which ten are classified as globally scarce rendering the site of international importance (Faldborg *et al.*, 1991).

3.1.7 Population adjacent to the forest reserve

The estimated population in 1995 for all villages surrounding Zaraninge Forest was above 6955 people (Senkondo, 1995) who depend on forest resources for their living. Given the national population increase rate of 2.4%, the population in these villages could be more than 7000 individuals today. There are several ethnic groups living in the villages adjacent to the forest reserve. The dominant ones include Doe and Zigua. Others who migrated from distant places include Zaramo, Nyamwezi and Pare. Islamic is a dominant religion and the majority of the people are poor.

3.1.8 Economic activities

Villages surrounding Zaraninge and Mbwebwe forests depend on it for diversified sources of income. Whereas in Mbwebwe, Tumbilini, Mkange, Matipwili and Gongo villages agriculture forms the major source of income and living, fishing is the main source of income in Saadani village. No farming activities are allowed in Saadani village as it is surrounded by the Saadani National Park to the west, south and north and to the east by the Indian Ocean (Senkondo, 1995). Cash crops grown include coconuts, bananas, pineapples, mangoes, oranges, lemons and cashew nuts. In addition maize, millet, sugar cane, cassava, peanuts and okra are grown for home consumption. These activities are mainly performed on individual basis.

3.2 Data Collection

3.2.1 Vegetation sampling

The ecological data aiming at revealing the status of rare plant species composition were carried out through vegetation sampling. Sampling was done in temporary concentric sample plots of size 0.07 ha established systematically along transect that ran parallel to each other. The sampling intensity was 0.02%. The distance between plots was 100m and between transect was 200m. Systematic sampling design were employed to lay transects in such a way that they cover as much variations as possible in the forest including highly disturbed area, partially disturbed area and intact area. The area was estimated as, loss of vegetation or tree cover of >50% to be highly disturbed, 15-50% partially disturbed and <15% as intact forest area.

In each plot the following were assessed;

- Within the 15m radius, all trees with dbh ≥10cm were identified and dbh measured.
- Within the 10m radius, all trees with dbh ≥ 5<10cm were identified and dbh measured.
- Within the 5m radius, all other species not identified in the 10 and 15m radii were identified and recorded.

Most plants were identified in the field. For species that could not be identified, voucher specimens were collected for identification in the herbarium.

3.2.2 Soil seed bank sampling

Soil samples were collected from three different depths; 0-10 cm, 10-20 cm, and 20-30 cm using a standard soil auger. The soil samples for each depth were randomly taken from three different points in the plot and thoroughly mixed in order to obtain composite samples. The collected soil samples were air dried and sieved to remove plant materials/gravel. Each soil sample was spread in the plastic germination trays filled with sterilized sand. The well-labeled germination trays were randomly arranged in a germination room and watered once daily from the top using fine sprays of tap water to stimulate natural rainfall conditions. The germination trays were maintained in the germination room with an average day and night temperature fluctuating, relative humidity ranging from 60% to 80% and light for 12 hours per day. Control trays with only sterilized sand were set alongside the experiment to detect contamination by wind-dispersed seeds.

The emerging seedlings were counted, recorded and identified to species and family level. After identification, the seedlings were immediately uprooted and discarded so as to minimize overcrowding. Those, which could not be identified easily, were left in the germination trays where they were identified at a later. The experiment ended at three months when the seedlings had presumably stopped emerging.

3.3 Data Analysis

3.3.1 Species composition, richness and diversity

The vegetation data were analyzed for species composition, richness and diversity. The species richness is the number of different species in a particular area and was computed as the total number of species. Species Importance Value Index (IVI) was computed based on relative basal area, density and frequency of the identified individuals. Plant species diversity refers to the number of different species in a particular area (i.e., species richness) and their relative abundance (evenness) within a defined area. Diversity indices (DI) provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure (Sanderson *et al.*, 2004). Plant species diversity was computed using Shannon and Wiener and Simpson diversity indices. Sørensen's Similarity Index (SI) was used to test for similarity between species of Zaraninge and Mbwebwe forests for each plot based on species presence/absence (Sørensen's, 1948).

Simpson's Diversity Index

Simpson's diversity index expresses the probability that the next species encountered will be a different species and it ranges from 0 to 1, with values near zero corresponding to highly diverse or heterogeneous ecosystems and values near one corresponding to more homogeneous ecosystems.

The formula is:

$$C = \sum_{i=1}^{s} (p_i)^2$$

Where C = the index number (diversity index)

s = total number of species in the sample

p_i = the proportion of all individuals in the sample that belong to species i.

Shannon–Wiener Diversity Index

This index is a powerful measure since it takes into accounts both abundance and evenness of the species present.

The index represents the "uncertainty" or "information" of a community it would be.

The index is calculated from the relationship

$$\text{Diversity} \quad H' = -\sum_{i=1}^{s} (p_i)(\mathit{ln} p_i)$$

Where pi = the proportion of all individuals in the sample that belong to species i.

*ln*pi = Natural logarithm of pi

s = total number of species in the sample

Sørensen's Similarity Index (SI)

Sørensen's similarity index (SI) was used to test the similarity between species of Zaraninge forest and Mbwebwe forest for each plot based on presence/absence of species.

Sørensen's similarity index (SI) computes the percentage similarity between two forests.

$SI_{jk} = 2a/(2a+b+c)$

Where a = number of species common to plot j and k,

b and c are the numbers of species only found in j and k respectively.

Sørensen's similarity indices normally range from 0 to 1 in case of completely lack of similarity and perfect or 100% similarity, respectively (Sørensen's, 1948).

3.3.2 Soil seed bank

The germinated seeds were segregated by species and density of viable seeds per m^2 computed for each species and by depth. Analysis of Variance (ANOVA) was used to compare the number of viable seeds between soil layers and among growth forms. Analysis was carried out using MS Excel software. Seed bank density was calculated using average depth method (Demel, 1996).

The average depth (AD) was obtained from the following relationship:

$$AD = \frac{(T \times 5.5) + (SM \times 10.5) + (SB \times 15.5)}{N}$$

Where, ST = Number of seeds in the top soil layer i.e. 0-10cm.

SM = Number of seeds in the middle soil layer i.e. 10-20cm.

SB = Number of seeds in the dipper soil layer i.e. 20-30cm.

N = Total number of viable seeds of each species

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Species Composition and Diversity

A total of 62 and 50 vascular plant species were identified in Zaraninge and Mbwebwe forests respectively (Appendix 1 and 2) belonging to 31 and 28 families for Zaraninge and Mbwebwe forests respectively (Table 1). Family Caesalpinioideae contributed the greatest fraction of Zaraninge plants (11 species, 11% of the total). Other important families included Euphorbiaceae (5 species, 8% of the total), Rubiaceae (5 species, 8% of the total), Apocynaceae, Annonaceae and Combretaceae (4 species, 4% of the total each), and other families contributing the rest. In Mbwebwe forest Caesalpinioideae contributed the greatest fraction over other families (6 species, 12% of the total), followed by Apocynaceae (5 species, 10% of the total), Euphorbiaceae and Bombacaceae (4 species each 8% of the total), Rubiaceae and Sapotaceae (3 species each 6% of the total). Other important families included Vitaceae, Papilioneaceae and Adiantaceae (2 species each 4% of the total). Other families each contributed one species and 2% of the total. The species were grouped into trees, shrubs, climbers, herbs and lianas. Trees contributed the greatest fraction (33 species, 53% of the total), shrubs (16 species, 26% of the total), climbers (10 species, 16% of the total), herb (one species, 2% of the total) and lianas (two species, 3% of the total) in Zaraninge forest. Mbwebwe forest had 25 tree species (50%), 12 shrubs (24%), 9 climbers (18%), one herb (2%), two lianas (4%) and one fern species (2%) (Table 1). Of the 62 vascular plants identified in Zaraninge forest, three species were rare plant species, 35 species were common and seven endemic to coastal forests (Appendix 1). On the other hand, Mbwebwe forest had three rare plant species, 26 common plant species and five coastal endemics (Appendix 2). Rare species identified in Zaraninge forest were *Aidia micrantha* (Rubiaceae), *Cynometra suaheliensis* (Caesalpinioideae) and *Monanthotaxis trichocarpa* (Annonaceae). Those identified in Mbwebwe forest were *Cynometra suaheliensis* (Caesalpinioideae), *Hymenaea verrucosa* (Caesalpinioideae) and *Monanthotaxis trichocarpa* (Annonaceae). Some rare species such as *Cynometra suaheliensis* and *Monanthotaxis trichocarpa* appear in both forests.

Table 1: Plant species compositions, diversity and similarity between Zaraninge and Mbwebwe forests Tanzania

Parameter	Zaraninge forest	Mbwebwe forest
Species richness	62	50
Trees	33	25
Shrubs	16	12
Climbers	10	9
Herbs	1	1
Lianas	2	2
Fern	0	1
Number of plant families	31	28
Species Diversity Indices		
Simpson Index	0.093	0.12
Shannon-Winner ndex	2.843	2.5

Zaraninge forest had higher species richness than Mbwebwe forest and this could be due to human disturbances such as land preparation for pineapple plantations within the later forest. It has been argued that coastal forests are species rich and have high woody species diversity and the richness is particularly high for trees, shrubs, herbs, climbers and lianas (Geldenhuys and MacDevette, 1989; Huang *et al.*, 2001; Everard *et al.*, 1994). The protected area supported a richer ground floor community than the burnt area (unprotected area) although the species richness of trec community was similar in both areas (Kafle, 2004).

The results showed that Zaraninge forest had higher species diversity (Simpson and Shannon Indices of 0.093 and 2.843) than Mbwebwe forest (Simpson and Shannon Indices of 0.12 and 2.5) (Table 1). This indicates that the two forests are relatively similar in diversity although Mbwebwe forest is more disturbed by human activities such as charcoal making, fire wood collection and clearing for agriculture. Madoffe *et al.* (2006) and Rogers *et al.* (2008) observed that Ngangao and Chawia forests had basic principle of species area relationship in diversity though Ngangao had more species diversity than Chawia. Mndolwa (1999) observed that tree species diversity is higher in the forest that is managed as a reserve or protected area and the diversity increases as you move from the boundary deep into the forest. Similarly, when studying traditionally protected forest as a conservation area, Mussanhane *et al.* (2000) found that biodiversity indices were higher in the protected areas than in the non protected areas.

4.2 Similarity Between the two Forests in Species Composition

Sørensen's Similarity Index (SI) values calculated for Zaraninge and Mbwebwe forest ranged from 0.58 to 0.15. With an average Sørensen's Similarity Index (SI) of 0.678 implying that there is close similarity in species composition between Zaraninge and Mbwebwe forests (Table 2). The plots which had the closest similarity were found on the border each other in both forests. Økland *et al.* (2003) in Norwegian boreal swamp forest observed that plots which were situated in the boundary of the two forests or in the same forest were similar and more dissimilar to those situated far from each other.

Table 2: Sørensen's Similarity Index (SI) calculated in Zaraninge and Mbwebwe forests for each plot

Plot no	a	b	c	SI
1	5	9	11	0.33
2	7	9	4	0.52
3	5	10	12	0.31
4	3	6	12	0.25
5	3	8	11	0.24
6	2	11	11	0.15
7	8	11	13	0.40
8	8	9	11	0.44
9	7	4	6	0.58
10	6	8	8	0.43
11	5	12	11	0.30
12	7	9	9	0.44
13	5	9	9	0.36
14	6	7	11	0.40
15	3	11	9	0.23
16	5	10	8	0.36
17	5	9	9	0.36
18	4	10	10	0.29
Average				**0.35**

a = Number of species common to Zaraninge and Mbwebwe forest

b = Number of species only found in Zaraninge forest

c = Number of species only found in Mbwebwe forest.

4.3 Species Dominance

The results from the study showed that for all species identified in Zaraninge forest five species were more dominant over other species. The most dominant species in

Zaraninge forest (IVI>0.5) were *Tessmannia martiniana, Scorodolphloeus fischeri, Cynometra suaheliensis, Jubernardia magnistipulata, Baphia kirkii* and *Newtonia paucijuga* and the less dominant species were *Margaritaria sp., Brachylaena huillensis, Dasylepis sp., Adenia sp. Drypetes sp., Caesalpinia coriaria, Uvaria angolensis, Suregada zanzibariensis, Garcinia sp., Monanthotaxis trichocarpa,* and *Vepris lanceolata* (Fig. 1).

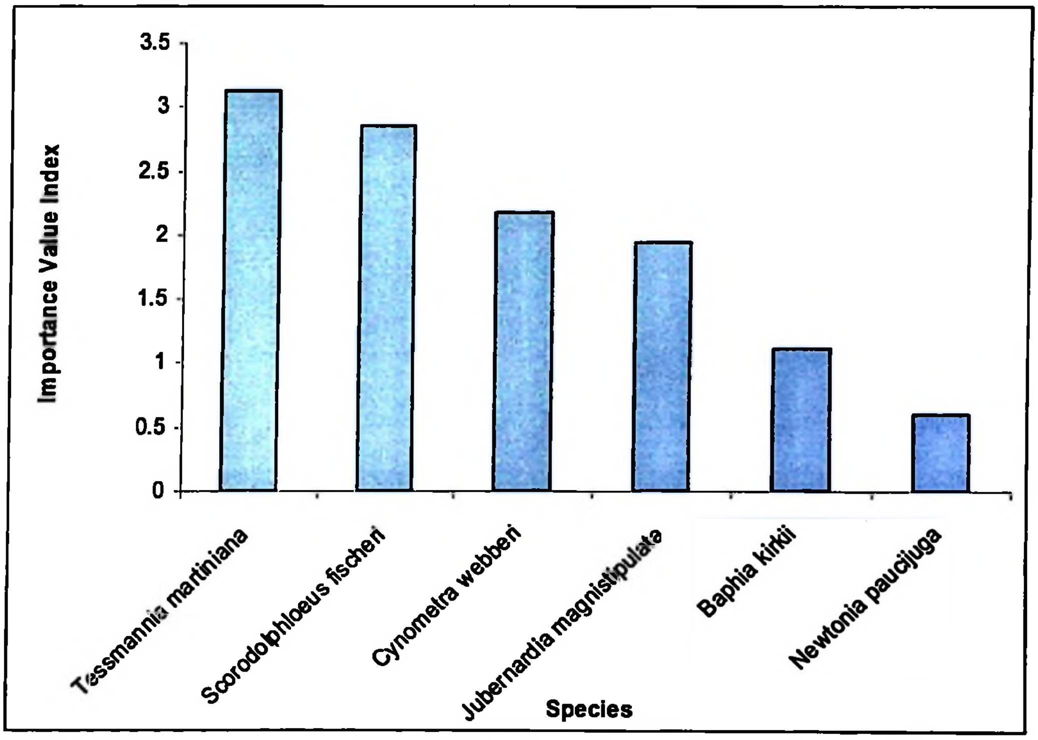


Figure 1: Plant species dominance based on Species Importance Value Index (IVI) in Zaraninge coastal forest Tanzania

The most dominant species in Mbwebwe public forest (IVI>0.5) were *Jubernardia magnistipulata, Cynometra suaheliensis, Tessmannia martiniana, Baphia kirkii, Lannea schweinfurthii, Haplocoelum inoploeum* and *Strychnos madagascariensis* and the less dominant species are *Landolphia sp. Manilkara obovata, Lasiodiscus mildbraedii, Grewia bicolor, Monanthotaris trichocarpa, Ehretia sp, Suregada zanzibariensis* and *Margaritaria sp* (Fig. 2).

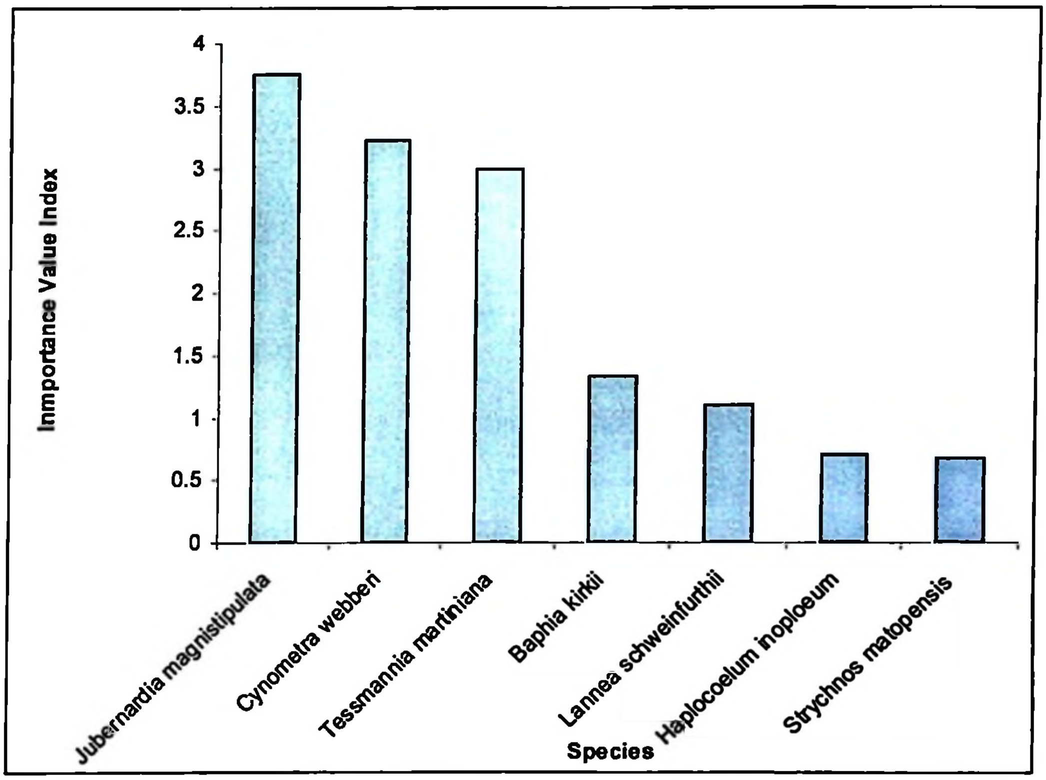


Figure 2: Species dominance based on Species Importance Value Index (IVI) in Mbwebwe coastal forest Tanzania

A total of 36 species were common in both forests of which five species were the most dominant. The most dominant species and common to the two forests were *Jubernardia magnistipulata, Cynometra suaheliensis, Tessmannia martiniana, Baphia kirkii,* and *Strychnos madagascariensis*. The less dominant species in both forests were *Monanthotaxis trichocarpa, Suregada zanzibariensis* and *Margaritaria* *sp.* These results imply that the two forests had more or less similar species composition although the dominance differs. The similarity between the forests may be associated with their closeness with possible dispersal, movement of propagules between the two and similar soil characteristics.

4.4 Diameter Distribution of Tree Species

Fig. 3 and 4 shows the diameter distribution of tree species in Zaraninge and Mbwebwe forests respectively. The frequency of trees with small diameter classes in all forests were high and the distribution in the two forests showed a reverse J shape curve implying more trees of smaller diameters hence actively expanding population. On the other hand the reverse J shape curve distribution in this may be a result of harvesting of large diameter trees though it would be more pronounced in Mbwebwe which is a public free access forest. The fact that the frequency of trees with smaller diameters in Mbwebwe is relatively higher while the trees with large diameter for Mbwebwe is smaller than Zaraninge signifies the fact that Mbwebwe is more intensively used than Zaraninge. This type of diameter distribution follows the usual reverse J shape which is an indication of good regeneration in the forests (Nduwamungu, 1997).

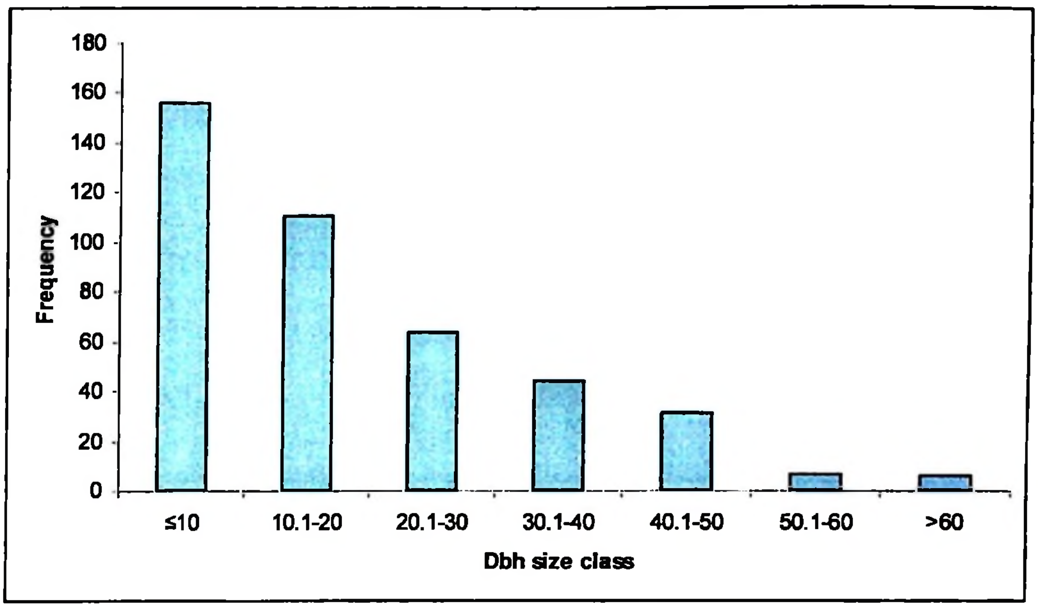


Figure 3: Tree diameter distribution of species in Zaraninge forest Bagamoyo District, Tanzania

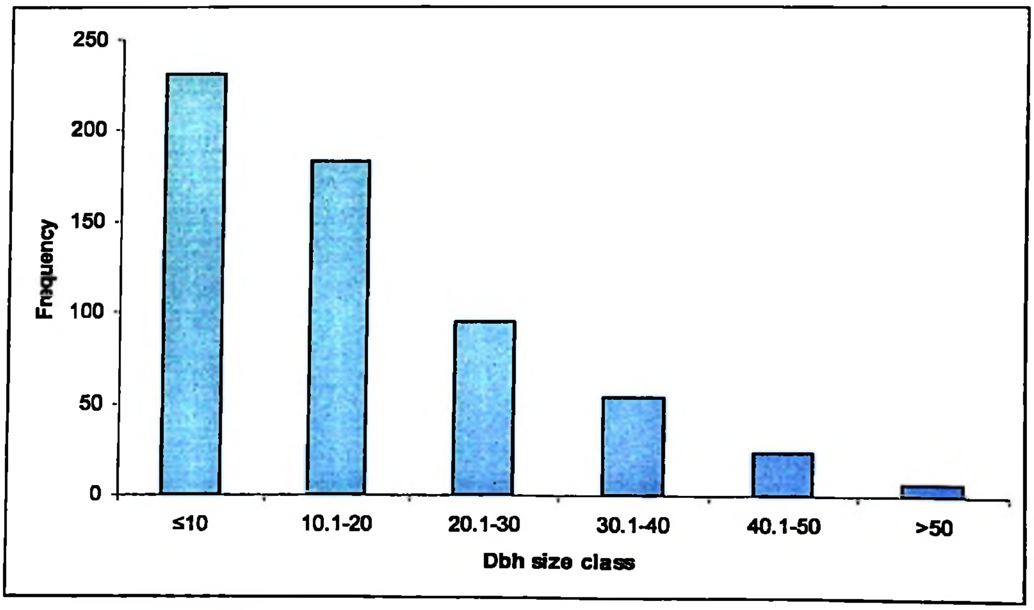


Figure 4: Tree diameter distribution in Mbwebwe Forest Bagamoyo District, Tanzania

4.5 Soil Seed Bank

4.5.1 Seed bank density

The average density of seeds in the soil seed bank was 2782 seeds m^{-2} in Zaraninge forest and 1170 seeds m^{-2} in Mbwebwe forest (Table 3). The seed bank density of rare plant species were 103 seeds m^{-2} and 68 seeds m^{-2} for Zaraninge and Mbwebwe forests respectively. *Monanthotaxis trichocarpa* was the only rare species that emerged at 0-10 cm and 10-20 cm depth both in Zaraninge and Mbwebwe forests respectively which could have been due to these plots being adjacent to each other. Zaraninge had higher soil seed density compared to Mbwebwe forest which may be an influence of differential disturbances, mechanisms of seed dispersal, seed predation and soil fauna in the two forests. Since Zaraninge forest was currently not disturbed, most soil fauna could occur in this forest. Roberts and Heithaus (1986) reported that, soil fauna are known to play an important role in predation of seeds that are buried in the soil. Seeds may be eaten or damaged or moved by soil fauna. Seed abundance in the soil and its nature is assumed to be a useful guideline for vegetation management and restoration (Lema, 2000).

Table 3: Number of seeds recorded from soil seed bank, their average depth (cm) distribution and densities (seeds m $^{-2}$) in Zaraninge and Mbwebwe forests

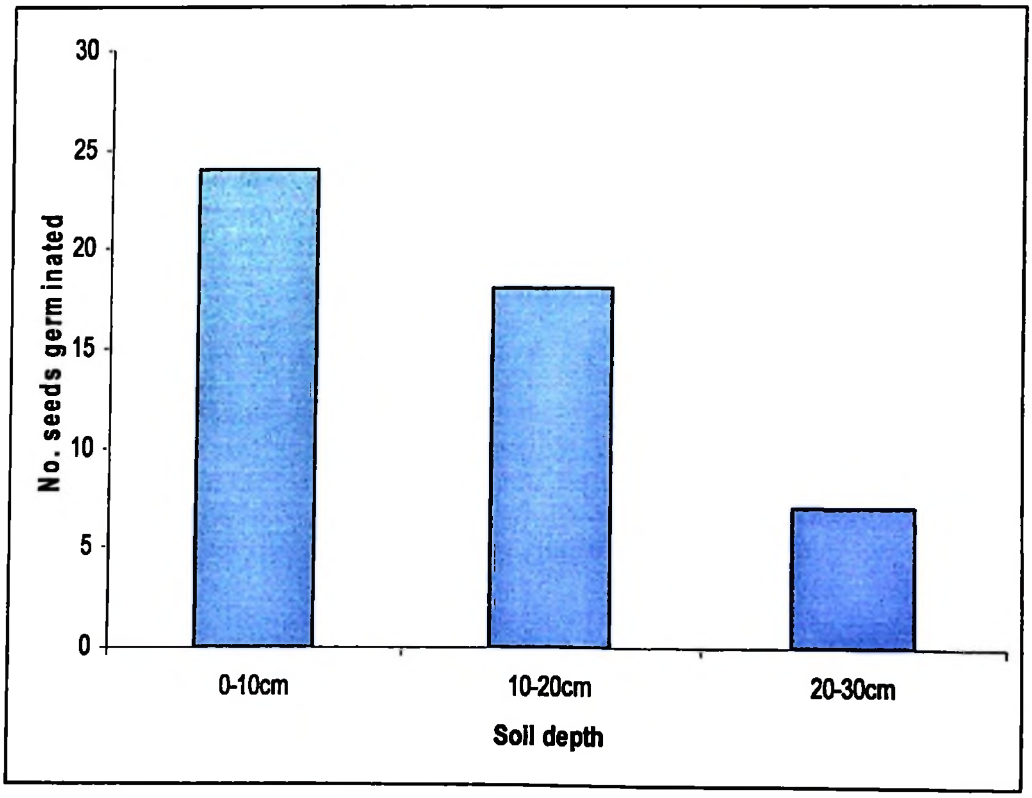
Forest type	Plot No	Depth 0 -10cm	10-20cm	20-30cm	Total No. of seeds	Average Density	DENSITY (seeds/m-^{2})
	1	0	1	0	1	20.5	68*
	2	2	0	0	2	10.5	70
	3	1	1	0	2	15.5	103
	4	1	0	0	1	10.5	35
	5	2	2	1	5	18.5	308
	6	6	5	4	15	19.2	958
Zaraninge	7	1	0	0	1	10.5	35*
	8	0	0	0	0	0	0
	9	3	1	0	4	13	173
	10	1	1	1	3	20.5	205
	11	1	1	0	2	15.5	103
	12	3	2	0	5	14.5	242
	13	0	0	0	0	0	0
	14	0	2	0	2	20.5	137
	15	1	0	0	1	10.5	35
	16	2	1	0	3	13.8	138
	17	0	1	1	2	25.5	170
	18	0	0	0	0	0	0
Total							**2782**
	1	0	0	1	1	30.5	102
	2	2	0	0	2	10.5	70
	3	2	1	1	4	18	240
	4	0	2	0	2	20.5	137
	5	1	0	0	1	10.5	35
	6	0	1	0	1	20.5	68
	7	1	0	0	1	10.5	35
Mbwebwe	8	0	1	0	1	20.5	68*
	9	2	0	0	2	10.5	70
	10	2	0	0	2	10.5	70
	11	1	0	0	1	10.5	35
	12	0	0	0	0	0	0
	13	0	0	0	0	0	0
	14	0	1	1	2	25.5	170
	15	0	0	0	0	0	0
	16	2	0	0	2	10.5	70
	17	0	0	0	0	0	0
	18	0	0	0	0	0	0
Total							**1170**

* Rare plant species density

4.5.2 Seed germination from different soil strata

Seed abundance declined with soil depth with most seeds germinating from the 0-10 cm soil depth and least in 20-30 cm stratum in both forests (Fig. 5a & b). High seed germination in the upper soil layer has also been reported by other researchers (Kiirikki, 1993; Bakker *et al.*, 1996; Demel, 1996; Lema, 2000; Bossuyt *et al.*, 2002; Olano *et al.*, 2002; Godefroid *et al.*, 2005). This pattern can be attributed to historical changes in above-ground vegetation and seed bank regime (McGraw, 1987), seed and shape (Bekker *et al.*, 1998), the vertical transport of seeds by earthworms as well as the accessibility of seed disperser to the forest area especially animals and birds.

(a)



(b)

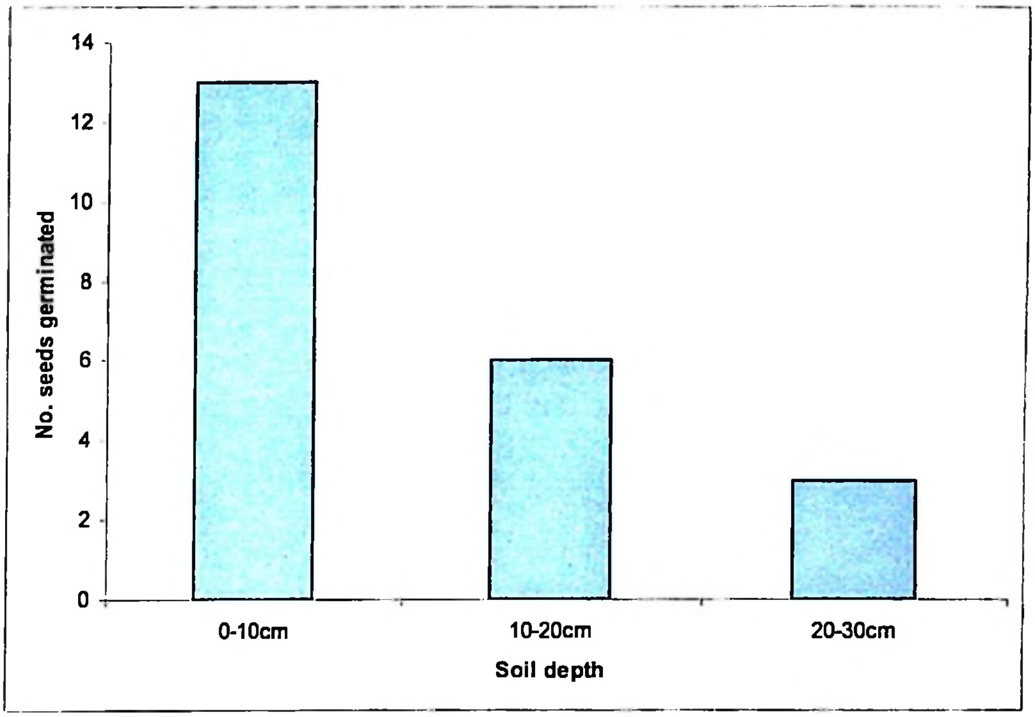


Figure 5: Number of seeds germinating within 90 days from soils sampled from (a) Zaraninge and (b) Mbwebwe forests Bagamoyo District Tanzania

There was a significant difference in seed distribution with depth in both forests ($p>0.05$). The decline in the number of seeds in the soil with depth has very strong implication in the ecology of soil seed bank, for it is an indication that most seeds in the soil seed banks are confined to the superficial soil layers (Munyanziza and Oldeman, 1996). The density and distribution of buried seeds in the soil according to soil layer may be associated with frequency and intensity of disturbance, seed disperser, predation and pathogens and micro site conditions affecting dormancy and germination (Simpson *et al.*, 1989). As there is some evidence that deeply buried seeds are older than shallow ones (Thompson *et al.*, 1997) results from this study therefore suggest that not all forest species form a transient seed bank and that at least some of them (e.g. *Baphia kirkii*) appear to form a long term persistent seed bank, as they were still recorded in the lower soil layers (Table 4). The vegetation history of the study area is related to seed distribution in the soil layers and to some extent prevalence of secondary dispersers such as earthworms and rodents. Herbaceous and pioneer species are known to colonize most disturbed areas (Binggeli, 1989).

A total of 71 seedlings representing 17 species and 10 families emerged from all samples of the two forests. The species were grouped into trees, shrubs, climbers, herbs and grasses (Table 4 and 5). Out of 49 and 22 seeds that emerged in Zaraninge and Mbwebwe forests respectively; one species (*Monanthotaxis trichocarpa*) (5%) was identified to be a rare plant species from each forest. In Zaraninge forest, there were three tree species, 14 herbs, seven shrubs, 10 climbers and 15 grasses. On the other hand Mbwebwe forest had one tree, three climbers, six herbs and 12 grasses. Most herbs and grasses were found in the upper soil strata where as tree was found in deep soil strata. Only five out of the 17 species were common to all forests. These are *Isoglosa sp, Monanthotaxis trichocarpa, Panicum maximum, Panicum tricholabum* and *Uvaria tanzaniae.* It was further revealed that most germinants from the seed bank were herbs and grasses (annual plants) with limited number of woody species. Large number of annual herbs and grasses reflect various characteristics of these species such as their efficient dispersal mechanisms, large number of dormant seeds in the soil, rapid germination of these species and also copious seed production. Dominance of annual species in the soil seed bank has also been documented by Lyaruu (1998).

Table 4: Plant species that germinated at different soil layers from Zaraninge forest Bagamoyo District, Tanzania

Species name	Family	Life form	Soil depth (cm)		
			0-10	10-20	20-30
Scorodophloeus fischeri	Caesalpinioideae	Tree	1	0	0
Baphia kirkii	Papilionaceae	Tree	1	1	0
Phyllanthus nummularifolins	Euphobiaceae	Shrub	3	2	2
Millettia impressa	Papilionaceae	Climber	3	0	0
Uvaria tanzaniae	Annonaceae	Climber	3	0	0
Monanthotaxis trichocarpa	Annonaceae	Climber	1	1	0
Landolphia sp	Caesalpinioideae	Climber	0	1	1
Panicum maximum	Poaceae	Grasses	8	3	0
Panicum tricholabum	Poaceae	Grasses	2	2	0
Isoglosa sp	Acanthaceae	Herb	2	8	4

Table 5: Plant species that germinated at different soil layers from Mbwebwe forest Bagamoyo District, Tanzania

Species name	Family	Life form	Soil depth (cm)		
			0-10	10-20	20-30
Ficus sycomorus	Moraceae	Tree	1	0	0
Uvaria tanzaniae	Annonaceae	Climber	2	0	0
Monanthotaxis trichocarpa	Annonaceae	Climber	0	1	0
Panicum maxima	Poaceae	Grasses	2	3	2
Panicum tricholabum	Poaceae	Grasses	2	0	0
Panicum heterotrichium	Poaceae	Grasses	2	1	0
Isoglosa sp	Acanthaceae	Herb	4	1	1

Several factors have contributed to fewer numbers of woody species in the soil. Among them are seed predation, fungal decay, deep burial by ants and termites and rodents (Lyaruu, 1998). Many tropical tree seeds are recalcitrant and trees have irregular seed production (Demel, 1996). Several internal and external factors could prevent seed germination. Among the internal factors are: the presence of a hard seed coat, which is a barrier to penetration of water and oxygen, presence of biochemical inhibitors in the seed, and immature embryo. Among the external factors are soil water content and temperature. Also, germination of seeds in the seed bank largely depends on its viability which can make seed bank either transient or persistent. The former occur in the soil over relatively short period while the later show seasonal peak of abundance but are present throughout the year (Thompson and Grime, 1979).

Although contribution of the seed bank to regeneration is variable, a wide knowledge on the contribution of seed bank in ecological restoration especially in forests depends on persistent seed bank. Bakker (1989) suggested that species capable of forming persistent seed bank have a better chance of recolonizing disturbed sites than those with transient seed bank. Lyaruu and Backeus (1999) reported that the property of seeds to remain dormant in the soil for a long time following disturbance is important because such seeds form future vegetation in the process of secondary succession. Most dominant species particularly canopy species of some vegetation communities do not accumulate persistent seed bank. The longevity of the seeds is an important aspect in restoration ecology. The ability to build up a permanent seed bank is a means for plants to "disperse in time" and to survive unfavorable conditions. Germinable seeds in the soil are part of the population of a species even if it has already disappeared from the actual vegetation. Since species differ greatly in germination requirements, the greenhouse conditions are not always suitable for the germination of all species (Galinato and Van der Valk, 1986).

4.5.3 Relationship between the seed bank and the standing vegetation

There was no close relationship between species composition of the standing vegetation based on the number of germinated seeds and composition of seed banks in the study forests (Appendix 1 and 2, Table 4 and 5). Previous studies of soil seed bank of various ecosystems have also shown that seeds of woody species are relatively scarce in the soil seed bank of most ecosystems including natural forests (Demel and Granstrom, 1995; Demel, 1996; Feyera *et al.,* 2002; Mulugeta and Demel, 2006). Other researchers have observed lack of correspondence between the soil seed bank and above ground vegetation in many plant communities (Pratt *et al.*, 1984; Thompson *et al.*, 1993; Milberg, 1994; Grandin and Rydin, 1998; Feyera and Demel, 2001). This is often ascribed to disturbance, with closer relationships found in more stable communities (Williams, 1984). Nevertheless, even in plant communities with a long history of stable species composition, it is well known that species present in the vegetation may be absent or few in the seed bank (Thompson, 2000). The fact that some seed bank species (e.g. *Ficus sycomorus*) was not found in the vegetation can be related to its historic occurrence during the early stages of succession and/or its present occurrence in the vicinity (Hopkins *et al.*, 1990). This means that the seed bank contains not only species from the existing vegetation but also species from the surrounding forest stands (*Ficus sycomorus*) and species that were previously present in the area as suggested by Falinska (1999).

The study further revealed that seed bank density varied between different plant types. Perennial plants were most abundant in the vegetation, while annual plants were most abundant in the seed bank. This is the reflection of severe disturbance in the past and the seed bank of the study site could be a good source of future annual vegetation, but not of perennial vegetation. There are several factors known to influence relationship between the seed bank and the above ground vegetation. These include: loss of seeds from parent plants caused by deep burial (Hopkins and Graham, 1987), death from genetically controlled physiological responses to environmental factors (Simpson *et al.*, 1989) and extreme events such as drought conditions (Bakker *et al.*, 1996) and heavy predation of seeds. Secondly, the seed bank is only partly derived from the above ground vegetation. To some extent the seed bank is also enriched through imported seeds. Seeds can be imported by biological agents such as animals including human beings (Parker and Kelly, 1989) and by physical agents such as rain and wind. Thirdly, most of the above ground vegetation are secondarily derived either as a result of continued disturbance (Monela and Solberg, 1998) in case of Mbwebwe forest or progressive succession, and the seed bank could be part of former vegetation. Fourthly, succession might have reached a climax where no rapid changes take place. In this study, low correspondence might be due to heavy and partial disturbance in case of Mbwebwe forest and in pristine area like Zaraninge forest, transient seed might be missed in the soil samples or they might have been absent because of dominant forest trees which often do not have soil stored seed banks.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Results obtained from this study lead to the following conclusions;

- Zaraninge and Mbwebwe forests have high species richness and diversity which is an evidence of the potential for plant population after disturbances.
- Rare plant species though small in number are common to all forests and there is a close similarity between the two forests in terms of species composition.
- Based on the number of germinated seeds, there was no close relationship between species composition of the standing vegetation and the seed bank in the two forests studied. Perennial plants dominated the standing vegetation, while annual plants were mostly abundant in the seed bank.
- From this study, it is evident that human disturbances in Mbwebwe forest is likely to shift species composition to small seeded species, often dominated by herbs and grasses, as primary forest species do not accumulate persistent seed bank.
- Forest restoration through soil seed bank in the coastal forests may greatly depend on soil seed bank at the surface soil horizons.
- The soil seed bank may as well be a major repository of rare plant species.

5.2 Recommendations

Based on the results obtained in this study and experiences from similar or closely related studies, it is recommended that:

- Further research should be done to cover the whole Zaraninge and Mbwebwe coastal forests in order to identify whether other rare plant species exist in reasonable abundances.
- The study forests should be maintained in its natural system although the recovery from seed bank is very low.
- Any management activity that destroys forest floor should be avoided because it impairs the regenerative capacity of the forest particularly the representation of big seeded species.
- A longer germination trial should be conducted in order to capture the full soil seed bank potential especially for rare plants.

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APPENDICES

Appendix 1: List of plant species identified in Zaraninge forest, life forms and their biological status

Species code	Scientific name	Family	Life form	Biological Status
1	*Acalypha fruticosa*	Euphorbiaceae	Shrub	Common
2	*Adenia sp*	Passifloraceae	Climber	XXXXX
3	*Aidia micrantha*	Rubiaceae	Tree	Rare
4	*Albizia gummifera*	Mimosaceae	Tree	Common
5	*Argomuellera macrophylla*	Euphobiaceae	Shrub	Common
6	*Asparagus setaceus*	Liliaceae	Climber	Common
7	*Baphia kirkii*	Papilionaceae	Tree	Endemic
8	*Bombax rhodognaphalon*	Bombacaceae	Tree	Common
9	*Brachylaena huillensis*	Compositae	Tree	Common
10	*Brachystegia boehmii*	Caesalpinioideae	Tree	Common
11	*Caesalpinia coriaria*	Caesalpinioideae	Climber	Exotic
12	*Canthium mombazense*	Rubiaceae	Shrub	Common
13	*Canthium sp.*	Rubiaceae	Shrub	XXXXX
14	*Cassipourea malosana*	Rhizophoraceae	Tree	Common
15	*Cissus quadrangularis*	Vitaceae	Climber	Common
16	*Cola microcarpa*	Sterculiaceae	Tree	Common
17	*Combretum butyrosum*	Combretaceae	Climber	Common
18	*Combretum molle*	Combretaceae	Tree	Common
19	*Cremaspora triflora*	Rubiaceae	Tree	Common
20	*Cynometra suaheliensis*	Caesalpinioideae	Tree	Rare
21	*Dasylepis sp.*	Flacourtiaceae	Shrub	XXXXX
22	*Diospyros verrucosa*	Ebenaceae	Shrub	Common
23	*Drypetes sp.*	Euphorbiaceae	Shrub	XXXXX
24	*Garcinia sp.*	Guttiferae	Tree	XXXXX
25	*Garcinia sp.*	Guttiferae	Tree	XXXXX
26	*Gardenia resiniflua*	Rubiaceae	Shrub	Common
27	*Grewia forbesii*	Tiliaceae	Shrub	Common
28	*Haplocoelum inoploeum*	Sapindaceae	Tree	Common
29	*Holarrhena febrifuga*	Apocynaceae	Tree	Common
30	*Isoglosa sp*	Acanthaceae	Herb	XXXXX
31	*Jubernardia magnistipulata*	Caesalpinioideae	Tree	Endemic
32	*Landolphia buchananii*	Apocynaceae	Climber	Common

33	*Landolphia kirkii*	Apocynaceae	Climber	Common
34	*Landolphia sp.*	Apocynaceae	Climber	XXXXX
35	*Landolphia sp.*	Mimosoideae	Climber	XXXXX
36	*Lasiodiscus mildbraedii*	Rhamnaceae	Tree	XXXXX
37	*Lecaniodiscus holtzii*	Sapindaceae	Tree	Endemic
38	*Manilkara obovata*	Sapotaceae	Tree	XXXXX
39	*Manilkara sulcata*	Sapotaceae	Tree	Common
40	*Margaritaria sp.*	Euphorbiaceae	Shrub	XXXXX
41	*Markhamia obtusifolia*	Bignoniaceae	Tree	Common
42	*Memecylon sansibaricum*	Melastomataceae	Tree	Common
43	*Memecylon sp*	Meastomataceae	Tree	XXXXX
44	*Milletia impressa*	Papilionaceae	Climber	Common
45	*Monanthotaxis trichocarpa*	Annonaceae	Liana	Rare
46	*Monorora sp cf. grandidieri Baill*	Annonaceae	Shrub	XXXXX
47	*Nesogordonia holtzii*	Sterculiaceae	Tree	Common
48	*Newtonia paucijuga*	Mimosoidea	Tree	Endemic
49	*Ochna sp.*	Ochnaceae	Tree	XXXXX
50	*Phyllanthus nummulariifolins*	Euphorbiaceae	Shrub	Common
51	*Pteleopsis myrtifolia*	Combretaceae	Tree	Common
52	*Scorodolphloeus fischeri*	Caesalpinioideae	Tree	Common
53	*Sloetiopsis sp*	Moraceae	Shrub	XXXXX
54	*Strychnos madagascariensis*	Loganiaceae	Tree	Common
55	*Suregada zanzibariensis*	Euphobiabeae	Shrub	Common
56	*Synaptolepis kirkii*	Thymelaceae	Liana	Common
57	*Terminalia kilimandscharica*	Combretaceae	Tree	Common
58	*Tessmannia martiniana*	Caesalpinioideae	Tree	Endemic
59	*Uvaria tanzaniae*	Annonaceae	Shrub	Endemic
60	*Vepris lanceolata*	Rutaceae	Tree	Common
61	*Whitfieldia sp.*	Acanthaceae	Shrub	XXXXX
62	*Xylopia arenaria*	Annonaceae	Tree	Endemic

XXXXX = Unknown biological status

Appendix 2: List of plant species identified in Mbwebwe public forest, life forms and their biological status

Species code	Species name	Family	Life Form	Biological Status
1	*Asparagus setaceus*	Liliaceae	Climber	Common
2	*Baphia kirkii*	Papilionaceae	Tree	Endemic
3	*Bombax rhodognaphalon*	Bombacaceae	Tree	Common
4	*Brachenridgea sp*	Ochnaceae	Shrub	XXXXX
5	*Brachylaena huillensis*	Compositae	Tree	Common
6	*Caesalpinia coriaria*	Caesalpinioideae	Climber	Exotic
7	*Canthium mombazense*	Rubiaceae	Shrub	Common
8	*Canthium sp.*	Rubiaceae	Shrub	XXXXX
9	*Capparis tomentosa*	Capparidaceae	Shrub	Common
10	*Cassipourea mallosana*	Rhizophiraceae	Tree	XXXXX
11	*Cissus quadrangularia*	Vitaceae	Climber	Common
12	*Cola greenwayi*	Sterculiaceae	Tree	Common
13	*Combretum butyrosum*	Combretaceae	Climber	Common
14	*Commuphora africana*	Burseraceae	Tree	Common
15	*Croton pseudopulchellus*	Euphorbiaceae	Tree	Common
16	*Cynometra suaheliensis*	Caesalpinioideae	Tree	Rare
17	*Diospyros verrucosa*	Ebenaceae	Tree	Common
18	*Drypetes sp*	Euphorbiaceae	Shrub	XXXXX
19	*Ehretia sp*	Euphorbiaceae	Tree	XXXXX
20	*Garcinia sp.*	Guttiferae	Tree	XXXXX
21	*Gardenia resiniflua*	Rubiaceae	Shrub	Common
22	*Grewia bicolor*	Tiliaceae	Shrub	Common
23	*Haplocoelum inoploeum*	Sapindaceae	Tree	Common
24	*Holorrhena febrifuga*	Apocynaceae	Tree	Common
25	*Hymenaea verrucosa*	Caesalpinioideae	Tree	Rare
26	*Isoglosa sp*	Acanthaceae	Herb	XXXXX
27	*Jubernardia magnistipulata*	Caesalpinioideae	Tree	Endemic
28	*Landolphia buchananii*	Apocynaceae	Climber	Common
29	*Landolphia kirkii*	Apocynaceae	Climber	Common
30	*Landolphia sp.*	Apocynaceae	Climber	XXXXX
31	*Lannea schweinfurthii*	Anacardiaceae	Tree	Common
32	*Lasiodiscus mildbraedii*	Rhamnaceae	Tree	XXXXX
33	*Manilkara obovata*	Sapotaceae	Tree	XXXXX

34	*Manilkara sulcata*	Sapotaceae	Tree	Common
35	*Margaritaria sp*	Euphobiaceae	Tree	XXXXX
36	*Memecylon sansibaricum*	Melastomataceae	Tree	Common
37	*Millettia impressa*	Papilionaceae	Climber	Common
38	*Monanthotaxis trichocarpa*	Annonaceae	Liana	Rare
39	*Monodora sp cf.*	Annonaceae	Shrub	XXXXX
40	*Pellaea sp*	Adiantaceae	Fern	XXXXX
41	*Rhoicissus tridentate*	Vitaceae	Climber	Common
42	*Strychnos madagascariensis*	Loganiaceae	Tree	Common
43	*Suregada zanzibariensis*	Euphobiaceae	Shrub	Common
44	*Synaptolepis kirkii*	Thymelaceae	Liana	Common
45	*Tessmannia martiniana*	Caesalpinioideae	Tree	Endemic
46	*Uvaria angolensis*	Annonaceae	Shrub	Endemic
47	*Uvariodendron sp C.F.U pycnophyllum*	Annonaceae	Shrub	XXXXX
48	*Vepris lanceolata*	Rutaceae	Tree	Common
49	*Whitfieldia sp.*	Acanthaceae	Shrub	XXXXX
50	*Xylopia arenaria*	Annonaceae	Tree	Endemic

XXXXX = Unknown biological status