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Structural, Floristic Composition and Diversity of Vegetation Communities in Mikumi National Park, Tanzania

By

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This work is dedicated to my beloved husband Mr Geoffrey Gallamula, my son William and my parents mum Mrs Ndoliwe Mogha and dad Mr Gideon P. Mogha

ABSTRACT

Structural and floristic study was carried out in Mikumi National Park, Tanzania with the objectives of determine the structural composition of the vegetation communities found in the area; compiling the checklist of plants species found in the area and determination of abundance of vegetation communities in the study area. Data were collected by systematic sampling design, where quadrats were established along transect lines. Nested plot design was used to sample plants of different sizes. The main quadrat for tree and sapling was 25 m x 20 m and within the main quadrat the 5 m x 2 m was used to collect data on shrubs and seedlings. Within a 5 m x 2 m another 0.5 m x 2 m subplot was set for collection of data on herbs and grasses. One hundred seventy four (174) plant species were encountered. Woody species density calculated was 350.67 stem ha^{-1} and total basal area $17.76m^2ha^{\cdot}$. The most abundant tree species recorded in the area were *Dalbergia melanoxylon* (23.07%), *Acacia nigrescens* (8.42), *Lonchocarpus capassa* (7.80%), *Brachystegia boehmii* (6.72%), *combretum zeyheri* (5.75%), *Margaritaria discoidea* (4.59%) and *Acacia sieberiana* (4.18%). The hierarchical cluster analysis using average-linkage strategy provided six distinct plant communities. 1. *Flueggea virosa-Panicum maximum-Acacia sieberiana* community type 2. *Hygrophila auriculata-Sporobolus pyramidalis* community type 3. *Lonchocarpus capassa-Cassia abbreviata* community type 4. *Acacia sieberiana-Hyparrhenia rufa* community type 5. *Acacia nigrescens-Dalbergia melanoxylon* community type and community type 6. *Brachystegia boehmii-Brachystegia spiciformis-Margaritaria discoidea* community types. The following tree species; *Dalbergia melanoxylon*, *Pericopsis angolensis Pterocarpus angolensis*, *Brachystergia spiciformis* and *Brachystergia boehmii* which are mostly used for carvings, music instruments, buildings materials and firewood were found highly poached at the edge of the park. The vegetation in this study area were most disturbed by environmental , animals and human factors which include fire, browsing, grazing, poaching, soil, and water table effects. From this observation, local community participation on conservation of these valuable tree species is encouraged for near by villages which include,Mikumi town, Doma, Mkata, Kilombero and Kisaki. Futhermore, detailed integrated floristic studies of the area, targeting the unknown ecological area of Malundwe forest which is not covered in this study is recommended

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1.0 BACKGROUND

Rangelands are part of the total land system used by mankind. They are the areas of the world where wild and domestic animals graze or browse on natural vegetation. Rangeland vegetation includes grasslands, savannas or open scattered-tree forests, shrublands, and small grassy areas within forests. Range vegetation may never have disturbed, or it may follow changes in land-use, such as bush-clearance or timber-harvesting (Pratt and Gwynne, 1977). Cultivation eliminates rangeland vegetation but abandoned cropland returns to rangeland, especially in areas of shifting cultivation. High demands for different kind's of products from rangeland cause frequent modification of land-use. This results into changing of boundaries between different areas of land-use (Ayuko, 1978).

In East Africa, about 10% of the land area is protected as national parks, reserves and other conservation areas (Kilimanjaro, 2004). Most of the protected areas in rangeland were created where Wildlife congregated in dry season, areas of slightly higher rainfall and around water resources. These sparse but important areas are the means of support of life in rangelands during the most difficult times. Even though protected areas cover a small portion of the East Africa drylands, they contain a disproportionate amount of the key resources, which ensure survival of pastoral people, wildlife, livestock and other organisms in these ecosystems (Kilimanjaro, 2004).

Mikumi National Park which is among the reserves area in Tanzania is a vast and continuous protected area of immense conservation importance in the country (Hawkins *et al.*, 2000). It has diverse biological resources, which are ecologically and economically important. Main vegetation types are woodland, grassland and swamp. The central swamp area is entirely open having only a very sparse tree population of Tamarind and baobabs near the edges, *Hyphaene* and *Borassus* palms. Wildebeest, giraffes, zebras, hippos, wild dogs, lions and elephants are abundant (Mercer and Jafferji, 2005).

Based on the seasonal variations in water availability, Mikumi National Park ecosystem fits a description of a tropical seasonal or hyperseasonal savannah (Sarmiento, 1983, 1992). Generally, a tropical seasonal savannah can be described as one in which drought and fire determines the functioning of the ecosystem. According to Sarmiento (1983), a hyperseasonal savannah is characterized by alteration of two contrasting stresses in each annual cycle. The grasslands experienced a period of water shortage in the dry season and extended period of water excess in the rainy season, which impart waterlogging and asphyxiation to the soil. What has been termed edaphic or secondary savannah (Walker and Noy-Meir 1982, Walter, 1985) is exactly the tropical seasonal savannah sensu Sarmiento (1983). In Mikumi National Park, the Mkata foodplain is a typical example of a hyperseasonal savannah whereas most of the park falls under tropical seasonal or edaphic savannah.

Mikumi National Park was gazetted to be a national park in 1963. Prior to this, it was a game controlled area. The area occupied by the park is 3,230 km^2 which resulted from the extension of the former Mikumi game controlled area to the north and southern to the Selous Game Reserve border from the 1975 government resolution. The move was aimed at facilitating park management as it was observed that quite a good number of animals migrated to these areas from Selous in the dry season in search of pasture and water.

Some of the important man made infrastructure that influences the vegetation of Mikumi National Park includes; the TAZAMA (Tanzania –Zambia Mafuta) pipeline, Tanzania-Zambia highway, TAZARA railway line to the south and a high-tension power transmission line from Kidatu that traverses the park. Unplanned fires, which are more frequent, now, than earlier, caused by careless travelers, plying along the highway and railway have severe impact on the vegetation dynamics of Mikumi National Park. Continued clearing of vegetation along the power line, oil spill from the pipeline and high death rates of wildlife along the highway are some of the factors that greatly influence the Mikumi National Park ecosystem.

Exploration and investigation of diversity, structure and distribution of the grasslands and woodlands of Mikumi National Park in which the larger biological diversity occur is a vital pre-requisite for conservation (Lovett and Norton, 1989). Conservation strategy depends on the knowledge of the botanical composition and the condition of the ecosystem. Exploration of such natural ecosystems will help to utilize its biological resources sustainably (Lovett and Norton, 1989).

1.1 Problem statement and Justification:

Despite the high number of plant species diversity in the Mikumi National Park, only few studies on vegetation have been done. The previous work is more on animals especially on yellow baboon (*Papio cynocephalus*) and includes work done by Rhine *et al.*, (1988), Wasser and Starling, (1988), Lovett and Norton, (1989), Kidung'ho, (1990), Rhine, (1992), Rogers *et al.*, (1993), Drews, (1995), and Hawkins *et al.*, (2000) to mention a few. The few vegetation ecological studies which have been conducted in the Mikumi National park are, vegetation monitoring by Norton *et al.*, (1992), Checklist of vascular plants by (Norton and Lyaruu, (1993), study on *Dalbergia melanoxylon*, which was conducted by Hawkins *et al.*, (1996) and the five year study of the Selous plant species by Jan Vollescen (APU-ABRU, 2004) who barely sampled part of Mikumi National Park. Little is known about the diversity, abundance and structural composition of vegetation communities found in the Mikumi National Park. Assessment of the theoretical potential will help to take measures for appropriate management. This study therefore, will provide data, which will serve as a basis for conservation purposes and for further researches.

2.0 OBJECTIVES OF THE STUDY:

2.1 General objectives.

The general objective of the study was to assess the diversity, abundance, and structural composition of vegetation communities in Mikumi national park.

2.2 Specific objectives.

i. To determine the structural composition of the vegetation communities found in the area.
ii. To prepare the checklist of plants species found in the area.
iii. To determine the abundance of vegetation communities in the study area.

3.0 LITERATURE REVIEW

More than 40 % of Tanzania total land area is covered by indigenous vegetation, which is in turn represented as coastal forest, open woodlands, closed mountain forest, wetlands, scrub and bushlands (Polhill, 1968). Tanzania is a tropical country and contains representatives of many plant formations found in African's main ecological zones (Polhill, 1968). It has about 10,000 species of higher plants (Polhill, 1968) compared to the estimated 30,000 species for the whole of tropical Africa (Brenan, 1978).

Tanzania is endowed with rich plant resources ranking second out of the 48 countries of Afrotropical realms in the number of plants species by having 12, 667 distinct terrestrial plant species in a total of 250 families (URT, 1998) which accounts for more than one third of the total plants species in Africa (Heywood and Davis, 1994 ; URT, 1998). Of the 12,667 species, 1,122 are endemic (Heywood and Davis, 1994) and 4.4% are threatened (Walter and Gillet, 1997). The more alarming situation is the fact that some of these species are at the risk of extinction even before their uses are identified (UNEP, 1991). Besides, the country contains one of the biodiversity hotspot areas in the world: the Eastern Pare Mountains (Mugabe and Clark, 1998).

This diversity is a reflection of the variety of habitats and phytogeographical regions (Phytochoria) that are present in Tanzania. The country falls under five biogeographical regions (Mugabe and Clark, 1998). These are: the Afromontane Archpelago-like Regional Centre of Endemism; the Somali-Masai Regional Center of Endemism; the Zambezian Regional Centre of Endemism; the Zanzibar-Inhambane Regional Mosaic and the Lake Victoria Regional Mosaic (White, 1983). Each of the five photochoria is represented by a number of characteristic plant species and as a result of the large variety of phytochoria.

3.1 Species Diversity

Species diversity is a measure of the variety of different animal and plant species in a community. Specie diversity has been considered as one of the key indices of sustainable land use practices (Shackelton, 2000). Although diversity has been equated with species richness (Peet, 1974); the latter fails to consider the relative abundance, the evenness of species; i.e. two communities with the same number of species but with different relative abundance would have the same level of species richness (Peet, 1974). Shannon-Wiever Index as a measure of information content should be used only on random samples drawn from a large community (Krebs, 1972). According to Magurran (1988) Ludwing and Reydnolds (1998) the species diversity index consists of two components. The first component is species richness and the second component is the relative abundance (evenness or unevenness) of species within the sample or community.

The two components can be measured separately: the actual number of species contained within a community, also called species richness of the community and the spread of individuals between the species (relative abundance of species) within the community, also called evenness or equitability of the community (Putman and Wratten, 1984; Magurran, 1988; Krebs, 1989; Kent and Coker, 1992). The value increases with increasing number of species or when the distributions of individuals among the species become even. H' is zero only and only if there is one species in the sample and maximum only when the same number of individuals represents all species. Shannon Wiever Index has been probably the most widely used in community ecology. It is based on information theory (Shannon and Wiever 1949) and is a measure of the average degree of uncertainty in predicting to what species as individual chosen at random from a group of specie and individuals will belong (Ludwing and Reydnolds, 1998).

3.2 Richness

The number of species per sample is a measure of richness. The more species present in a sample, the 'richer' the sample. Species richness is the simplest measure of biodiversity and is simply a count of the number of different species in a given area. Species richness is basic measure of species diversity (Whittaker, 1970; Krebs, 1998). However, according to Krebs (1998), it is often difficult to enumerate all the species in a natural community. Oösting (1965) noted that species richness is easy to determine only in easily censured communities with few species. In this study, species richness was adopted because not many species were noted per plot. Species richness as a measure on its own takes no account of the number of individuals of each species present. It gives as much weight to those species, which have very few individuals as to those, which have many individuals. However, diversity depends not only on richness, but also on evenness.

3.3 Eveness

Evenness is a measure of the relative abundance of the different species making up the richness of an area. Evenness compares the similarity of the population size of each of the species present.

3.4 Importance of Species Diversity Values

Species diversity is a very useful parameter for comparison of two communities. High species diversity is considered by most ecologists as a desirable property of any community or ecosystem and this criterion has dominated most methods for ecological and conservation evaluation techniques (Kent and Coker, 1992).

Knowledge of species diversity is particularly useful when one wishes to study the influence of biotic disturbances or to know the state of succession and stability in the environment (Misra, 1989). However, the relationship between diversity and stability of a community has raised much controversy among ecologists. For instance, some authors think that species diversity generates community stability (e.g Lewis 1970 cited by

Ambasht, 1988). This is intuitively sound because irregularities within a complex community are easily compensated by minor adjustments elsewhere (Putman and Wratten, 1984). Others (e.g. May, 1973) still attribute species diversity within a community to the environmental stability rather than the other way around. However, many ecologists now question the existence of any relationship between species diversity and stability in a community and think that possibly these two concepts need not necessarily be connected (Putman and wratten, 1984; Kent and Coker, 1992).

3.5 Species Diversity Measures

A large number of indices of diversity have been devised, each of which seeks to express the diversity of a sample or quadrat by a single number. However, according to Magurran (1988), of the various indices of diversity, the most frequently used is the simple adding together of species to give species richness. As for the fair indices which combine both species richness and evenness, the most widely used is the Shannon index of diversity also called Shannon-Wiever index of diversity. This is because it is not affected by the sample size (Pielou, 1975; Krebs, 1989; Kent and Coker, 1992) and in addition it puts more emphasis on rare species (Krebs, 1989). It is a measure of the information content of a sample and since the information content is a measure of the uncertainty, so the larger the value of H', the greater the uncertainty (Krebs, 1989). The Shannon-Wiever function is calculated following (Kent and Coker, 1992):

$H' = -\sum pi \log_a pi$

Where H' is the Shannon index of diversity;

$\sum$ is the summation symbol;

Pi is the proportion of individuals or the abundance of species I in the sample;

Log_a is the logarithm to base a (any base of logarithms may be taken).

If a sample is used, then the true value of pi is unknown but is estimated as ni/N (where ni is the number of individuals of species i and N is total number of individuals in the sample), the maximum likelihood estimator (Pielou, 1975).

The Shannon-Wiever measure (H') increases with the number of species in the community but in practice, for biological communities H' does not exceed 5.0 (Washington, 1984 cited by Krebs, 1989). Holding symbols as defined above, the theoretical maximum value is log (s) and the minimum value is log (N/N-s) (Fager, 1972 cited by Krebs, 1989).

3.6 Species Importance Value Index (IVI)

The Importance Value Index (IVI) is a composite index based on the relative measures of species frequency, density and dominance. The IVI of a species is the sum of the relative frequency, relative density and relative dominance of that species. They are calculated as follows (Ambasht, 1988; Kent and Coker, 1992):

Relative Frequency = (Number of occurrence of the species/Number of occurrences of all species)*100

Relative Density = (Number of individuals of the species /Number of individuals of all species)*100

Relative dominance = (Total basal area of the species/Total basal area of all the species)*100

3.7 Index of Dominance (C)

The dominance index measures the distribution of individuals among the species in a community. It is calculated using the formula below (Krebs, 1989; Misra, 1989):

$C=\sum(ni/N)2$

Where ni is the number of individuals of species i in the sample;

N is the total number of individuals (all species) in the sample.

This index is also called the Simpson's Index of Diversity (Krebs, 1989) and is equal to the probabilities of picking two organisms at random that are of same species. It is inversely related to the probability that two individuals picked at random belong to different species. Therefore the greater the value of dominance index, the lower is the species diversity in community and vice versa.

3.8 Abundance

Abundance is the number of plants per unit area. Measurement of plant abundance requires the counting of individual plants by species in a given are. Abundance can be used to show spatial distributin and ranges over time like mortality. There is a slight correlation between abundance biomass and cover since individuals plants differ greatly in size during growth and as well in different habitats. This implies careful interpretation of abundance when one wants to relate to biomass and cover.

3.9 Frequency

Frequency is the proportion of plots in which a species occurs. It is the measure of occurrence of a given species in a given area. The principal value of frequency is to show distribution of species. This can be important in studying some rangeland problems like impact of invasive species or indicators species as shown by degree of presence or absence.

In national parks, game reserves, rangelands and similar conservation areas of eastern southern and central Africa, the course of plant succession is being halted and reversed, and there is a general trend of woodland types to revert to more open grassland forms (Hamilton, 1972, Sinclair & Norton-Griffiths, 1979). The possible factors which bring about vegetation degradation in Mikumi National Park are animal impact, water table effects and fire(Lyaruu,1997).

3.10 Animal Impact

Browsing, grazing, elephant destruction and trampling are wildlife effects that regulate the habitat properties of an ecosystem (Mwalyosi, 1977). In the central part of Mikumi National park, which covers most of the floodplain, trees are fewer compared to any other area in the park. Wingfied (1975) observed that the sparseness of the woody vegetation in much of the Mikumi National Park was largely due to browsing by wildlife and tree destruction by elephants. He supported his claim by comparing the woody vegetation of Mikumi National Park with the adjacent Mkata ranch where similar land with wild animals replaced by cattle, is much more densely covered with trees and shrubs.

Many researchers have declared that African elephants are major agents of habitat change in Africa. They regulate the balance between the woody overstorey and the underlying grass (Laws, 1970; Hamilton, 1972), by interacting with browsers and grazers in complicated ways (Norton-Griffiths, 1979; McNaughton *et al.*, 1988). Mwalyosi (1977) and WeyerHauser (1982) reported uncontrolled destruction of *Acacia tortilis* populations in Manyara National Park by elephants, to an extent of causing local extinction of the species. In his analysis of the Seronera elephant problem, Croze (1974) which revealed that the woodland thinning was attributed to rising water table and not to elephant destruction as postulated earlier. Elephants have been shown to interact synergistically with fire in northern woodlands of Serengeti by opening up thickets, encourage the growth of grass, which fuels the fire.

The effects of browsers which are many in Mikumi National Park explain the disappearance of adult trees as well as suppression of the juvenile trees to attain adult classes. Browsers prevent vertical growth of saplings, so that they do not become trees of larger, fire resistant size classes. Browsers inhibited saplings are susceptible to grass fires that kill them back to ground level periodically (McNaughton *et al.*, 1988). Habitats heavily grazed and browsed show a corresponding decrease in the herbaceous vegetation (Ruess, 1987). Continued grazing has been associated with decreasing the seed bank size of grasses through partial or total consumption of the inflorescences of the palatable species thereby eliminating them from the seed bank (O'Connor & Picket, 1992). This is accompanied by a marked increase of short lived annuals and unpalatable species. Trampling by grazing animals imparts physical change in soil properties by reducing water infiltration and thereby affecting the water holding capacity of the soil (Ruess, 1987). In terms of regeneration dynamics, trampling can be beneficial in that many seeds are buried into the soil to form the seed bank and also small scale disturbance created patches will allow colonization thereby increasing species diversity (O'connor and Picket, 1992).

3.11 Water Table Effects

Low water table have a direct effect on the vegetation, in that water will not be available to the plants, and when the water table is too high asphyxiation of the plant roots is possible and finally death. Low water table in arid environments determine the type of vegetation that can grow in such areas. A high water table or salinity can cause shallow rooting, the former limiting oxygen supply. The adverse effect of asphyxiation and salinity is to inhibit uptake of nutrients as well as that of water (Russell, 1959).

3.12 Fire

Fire is an effective management tool that is being used to manage rangelands and pastures in order to stimulate sprouting of fresh grass after the dry spell or to check the encroachment of undesired woody species in a pasture or rangeland (Brown & Archer, 1989; Harrington & Driver, 1995). Although fire is known to increase species diversity (McNaughton *et a*l., 1988), frequent fires can influence the composition of grasslands by enhancing domination by annual species over the more permanent perennial species and this may likely cause local extinction of the perennial populations which have both low seed production and dispersability (O'Connor, 1991).

Grasses are not as sensitive to fire as are woody plants. They are better adapted to defoliation, have growing points which are better protected from fire and tend to sprout earlier after a burn has occurred. (Pratt and Gwynne, 1977). Nonetheless, burning also influences the cover, composition and productivity of grassland. For instance, the *Themeda triandra* dominates fire-climax grassland in northern Tanzania and southern Kenya. In the absence of fires, it is gradually replaced by other grasses or by woody vegetation whereas in some areas, if too frequently burnt, even more replaced by the even more fire-tolerant *Heteropogon contortus* (Bogdan, 1977). *Pennisetum purpureum* and some of the more palatable *Hyparrhenia* species are other grasses that are maintained by frequent grass fires (Edwards, 1940; Langdale-Brown, *et al.*, 1964).

Most fires in Mikumi National Park are anthropogenic, caused purely for management practice or set deliberately by travelers or originate from the nearby villages. The most important effect of fire is to inhibit or to cause complete suppression of tree recruitment (Swaine *et al.*, 1992). Fire effectively holds back recruitment of trees into mature age classes and will finally result into populations with uneven age distributions, and such populations are highly unstable. In a rangeland, three causes of fires have been recognized viz spontaneous fires resulting from lightening, accidental bushfires and management planned fires (Valentine, 1972). Fire tends to keep the vegetation open, eliminates certain species and will selectively favour domination by fire resistant species (Russell, 1959). In fire prone areas of Mikumi National Park, the domination by *Diplorhynchus condylocarpon*, *Bridelia cathartica*, *Maprounea africana*, *Pseudolachnostylis maprouneifolia*, *Annona senegalensis*, and *Combretum molle* is evident.

3 .13 Disturbances

Definitions of disturbance, vary from Grimes (1979), view disturbance as a process removing or damaging biomass, to White and Pickett (1985) defining disturbance as any relatively discrete event in time that disrupts ecosystem, community or population structure and changes resources, substrate availability, or the physical environment. Petraltis *et al.*, (1989) expand the definition further to include any process that alters the birth and death rates of individuals present in the patch by directly killing individuals or by affecting resource levels, natural enemies, or competitors in ways that alter survival and fecundity.

Disturbances affecting survivorship can be direct or indirect. Direct disturbance are those affecting the survivorship of individuals directly and indirect disturbance are those affecting resource levels or other conditions that influence individuals in the patch.

Many plant communities and species are dependent on disturbance, especially for regeneration (White and Pickett, 1985). Reserves areas should be large enough to allow the natural regime disturbance to operate and to support a mosaic patches in different stage of disturbance, successional recovery, and community maturation (Pickett and Thompson, 1978). Disturbances in plant communities thus include such events as fires, storms, floods, and trampling, but other changes such as altered grazing regimes, browsing or nutrient inputs would also be classed as disturbance if they affected resource levels and demographic processes.

Disturbances in most cases create a more heterogeneous environment, creating more habitats to be occupied by the plants species. Disturbances by tree cutting and natural death for example, creates a gaps or openings inside the forest which leave the soil surface exposed creates some different local habitats as compared to undisturbed area inside the forest. Creation of local habitats provide room for new colonizer species to grow or allow seeds and seedling which were previously shaded by canopy trees to germinate and grow to cover up the gap (Ndangalasi, 1997). Gap regeneration or succession is known to increase species diversity within the local habitats (Deshmukh, 1986).

While disturbance is important for maintaining diversity both within communities and at a landscape level, it may also have undesirable effects. Disturbance may act to increase the likelihood of invasion of a community. For invasion to occur there must be available propagules of an invasive species capable of dispersing into a given plant community, and there has to be a suitable microsite for germination and establishment to occur (John stone, 1986).

Like the other disturbances, trampling can create openings in vegetation that provide opportunities for new individuals to become established, and it can slow the growth of dominant species sufficiently to allow the persistence of less vigorous species. Again, intermediate levels, of trampling seem most effective at maintaining high species richness because of the suppression of competitive dominants (Liddle, 1975). The season or timing of trampling has a significant effect on the change, rate, and species composition of recovery (Harrison, 1981). Although trampling effects are frequently considered together with those of grazing.

3.14 The impact of disturbance on vegetation dynamics

In response to frequent fires or high intensities of grazing and browsing, trees are known to have very low growth and competitive displacement rates compared to grasses (Huston, 1994). This explains the observed pattern in Mikumi National Park which has been referred to as lack of dynamic regeneration of some important tree species in the Mkata floodplain. Pellew (1983) pointed out that slow regeneration due to fires and browsers may be more important than increased death of mature trees.

In many tropical savannahs, the importance of fire is the maintenance of species diversity. In many ecosytems, fire is the main agent responsible for the maintenance of balance and dominancy between grasses, forbs and woody plants depending on its frequency and intensity. By destroying the dead thatch, fire brings about increased light, an important germination requirement for seeds and also will add mineral nutrients into the soil. This stimulates growth and consequently short term productivity (Collins, 1987), which is associated with a general decrease in species diversity as a result of competitive exclusion (Gibson & Hulbert, 1987).

Fire has been known to change the woodland into grassland (Huston, 1994). Whereas an increase in fire intensity maintains or increases the diversity of grasses and forbs due to their higher resource allocation to below ground biomass than woody species, it reduces the diversity of woody species (Huston, 1994). This fits well the observed pattern that the small size classes of important tree species are absent in Mikumi National Park particularly in the flood plain grassland, which burn at least once every dry season.

Unlike fire which in most cases removes only the dead biomass, grazing and browsing act differently in that they removes the living biomass. In a rangeland, grazing plays an important role in nutrient dynamics by enhancing nitrogen mineralization as well as promoting absorption of mineral nutrients from the soil. The selection of the grazing material by grazers may have a detrimental effect of eliminating the vegetation and the seed bank of the palatable species and increasing the unpalatable species (Dyksterhuis, 1958). Grazing is known to increase species diversity, equitability and richness (Pandey & Singh, 1992). An increase in the level of resources such as water and mineral nutrients, and a decrease in the level of disturbance agent whether it is intrinsic or extrinsic, results in the decrease of diversity of grasses and forbs over woody species (Huston, 1994). This is attributed to competition for light and therefore inability to tolerate shade from the woody plants. Since was also seen in Mikumi National Park where by fewer animals concentrate their activities in the southern part of the National Park and in the higher elevations than in the plains, the soil proportion of these areas are much more improved and will therefore favor woody species colonization over other life forms.

4.0 MATERIALS AND METHODS

4.1 Study Area Description

Mikumi National Park lies between 37°00'-37°30'E; 7°00'S-7°45'S. It is located 96 km from Morogoro Town along the Tanzania-Zambia Highway (Fig. 1). The Park was gazetted in 1964 (Mercer and Jafferji, 2005). Mikumi National Park is the third largest Park in Tanzania having an area of 3,230km^2 after Serengeti and Ruaha National Parks. The altitude ranges from 430m to 1257m a.s.l (Lyaruu, 1997).

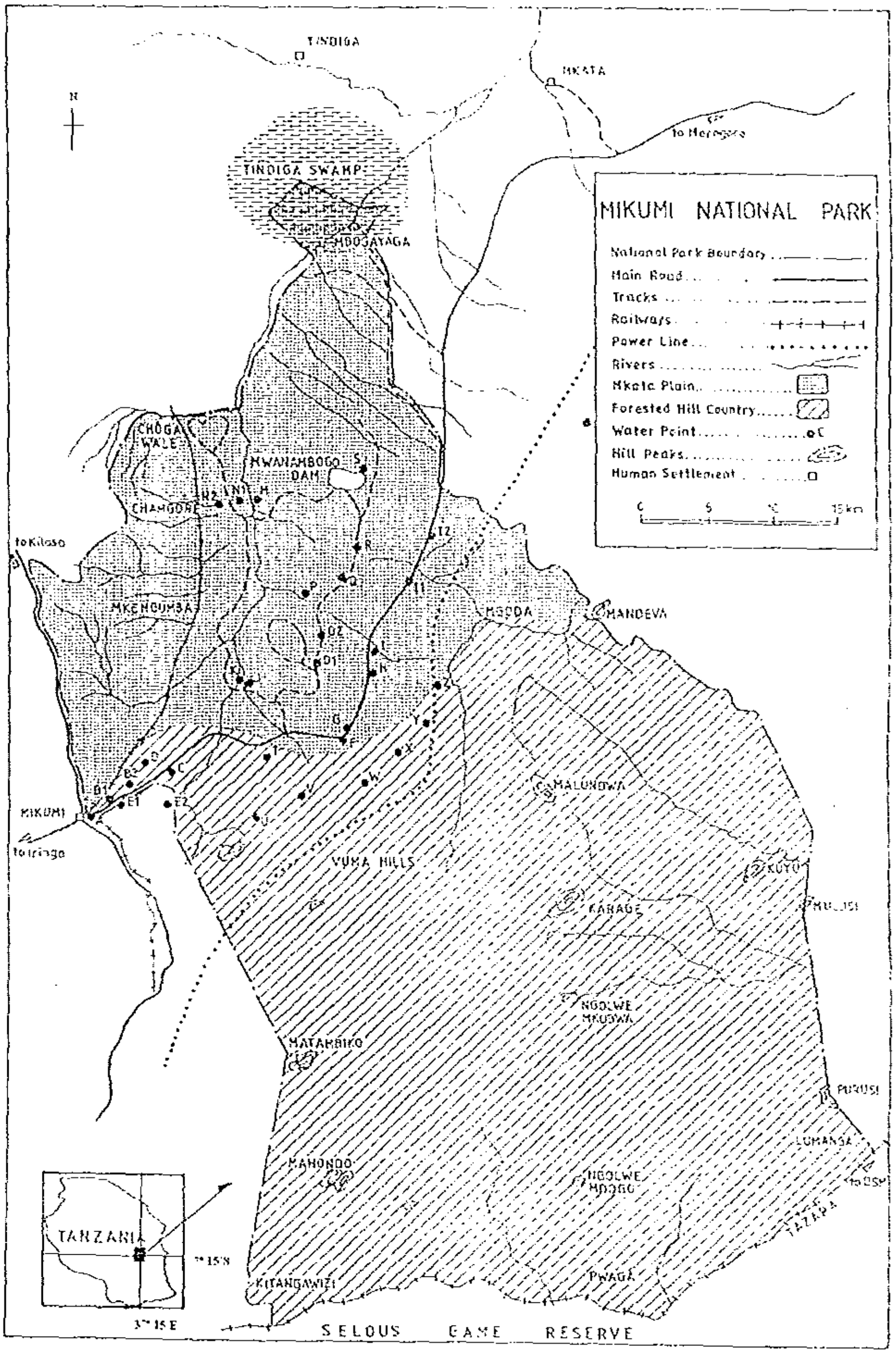

Figure 1: Location of Mikumi National Park with Tanzania (inset)
(Source: Mercer and Jafferji, 2005)

4.1.1 Climate

Mikumi National Park (MNP) experience seasonal variation in rainfall. Based on the seasonal variations in water availability, the MNP ecosystem fits a description of a tropical seasonal or hyperseasonal savannah (Sarmiento 1983, 1992). The area experiences a unimodal rainfall pattern from December to May and occasional flood years of over 1000 mm of rain but on average rainfall is about 750mm. Water drains to Mikumi National Park (MNP) from the Uluguru Mountains and Malundwe Hills. To the north, water drains into the Wami Rivers system and to the South into the Ruaha/Rufiji River system (Norton, 1998). Temperature ranges from 13°C minimum to 41°C Maximum (Norton, 1998).

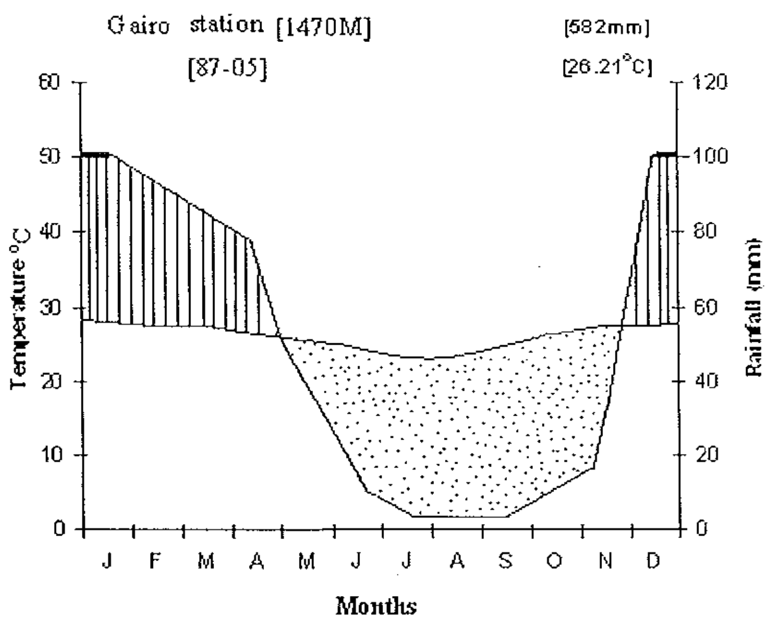

Figure 2: Climatic diagram for Mikumi National Park
(Source: Tanzania meteorological Agency, Gairo station 1987-2005)

4.1.2 Geology

The park is characterized by metamorphic rocks, with alluvial deposits spreading on Mkata Floodplain from hilly areas. Because of their geomorphic and climatic history, in that they are derived from weathering of Precambrian rocks or ancient sedimentary formations, the soils are intrinsically deficient in many macro-and micronutrients (Kang and Osiname, 1985). The floodplain is characterized by black cotton soils whose texture and depth support the growth of trees, shrubs and grasses. However, the areas with montmorillonitic clay soil, which is acidic, support very few trees and have very low diversity compared to the free draining soil on hilly slopes.

4.1.3. Fauna

MNP have various kinds of fauna including large and medium-size mammals such as elephant (*Loxodonta africana*), wildebeest (*Connochaetes taurinus*), impala (*Aepyceros melampus*), leopard (*Panthera pardus*), lion (*Panthera leo*), giraffe (*Giraffa camelopardalis*), waterbuck (*Kobus ellipsiprymnus*), Dik-dik (*Madoqua kirkii*), and reedbuck (*Redunca arundinum*) to mention among others. Small mammals include rodents (*Acomys spp.*) and shrews (*Crocidura spp.*). Common birds include stilt (*Hematopus hematopus*), African plovers (*Charadrius asiaticus*), while common reptiles includes snakes (*Naja mosambica*) and lizards (*Agama agama*). Amphibians, which are commonly seen in MNP, include Frogs (*Xenopus leavis*) and toads (*Bufo guttularis*).

4.1.4 Flora

The vegetation of MNP is divided into seven ecological units namely;

Mkata floodplain: This vegetation type occurs in the Mkata Floodplain along Mkata River covering about 100 km^2; it extends from Doma Game Controlled Area to Vuma Hills. The area is dominated by *Borassus aethiopum*, *Hyparrhenia spp*, *Themeda triandra*, *Vernonia glabra*, and trees such as *Lonchocarpus capassa*, *Tamarindus indica*, *Dalbergia melanoxylon*, and *Acacia spp*.

ii) Miombo (*Brachystegia*) woodland: This ecological unit also referred to as the "dry forest zone". It forms a big portion of the southern extension of MNP. The area is characterized by miombo species such as *Brachystegia spiciformis*, *Brachystegia boehmii*, *Brachystegia microphylla*, *Julbernardia globiflora*, *Pericopsis angolensis* and *Pterocarpus angolensis*.

iii) Mixed woodland: The zone includes "mixed woodland" and wooded grassland. The vegetation type is found in MNP from the main gate to the Park's Headquarters. This area can be described as secondary seasonally savannah proper and it covers the biggest part of the area followed by the miombo woodland. Grasses such as *Panicum maximum*, *Themeda triandra*, and *Hyparrhenia rufa* dominate the area. Common tree species include *Afzelia quanzensis*, *Combretum collinum*, *Xeroderris stuhlmannii*, *Lonchocarpus capassa* and *Terminalia brownii*.

iv) *Acacia- Dalbergia* woodland: This vegetation type is found in the northern part of MNP and it extends to Doma Game Controlled Area from the floodplain. Some parts of floodplain are interspersed with this type of vegetation where *Dalbergia melanoxylon* is dominant. Tree species associated with the *Dalbergia melanoxylon* and *Acacia spp.*.

v) *Acacia –Combretum* woodland: This vegetation type is the continuation of the *Acacia –Dalbergia* woodland to the south. It is dominated by *Combretum* and *Acacia spp.* This vegetation borders the floodplain and therefore it is a good area for grazing although it is heavily infested by tse tse flies. The associated grass species are *Hyparrhenia rufa* and *Dichanthium annulatum*.

vi) Groundwater evergreen forest: A patch of evergreen moist forest forms an island in the miombo woodland to the south. It is very small area (<10 km^2) and it is peculiar in the sense that there is no any other area in MNP with such kind of vegetation. The trees are tall but do not form a closed canopy. Below the tall trees is a kind of vegetation, which forms a closed canopy, mainly with rubiaceous plants dominated by *polysphaeria spp.*

vii) High elevation forest: This is a characteristic vegetation of the Malundwe Hills (which form the highest peak in MNP). The vegetation here is floristically and physiognomically montane. However, since the hills confined to an altitude of 1257m high, an altitude lower than the normal range of montane forests, the vegetation is better described as a high elevation forest.

4.1.5 Population and land uses

Before the MNP was announced as the national park area there were several ethnic groups living in what is now southern Mikumi and close to Kikoboga (near the present park gate). The nineteenth century slave trade devastated much of these areas and such people as remained were moved out when Mikumi became a national park and resettled elsewhere (Mercer and Jaffeji, 2005).

The local peoples still living around the park, include the Luguru in the east (around Morogoro), the Sagara to the west, Kaguru and Nguru to the north and the Vidunda and Pogoro to the south- west and Kutu to the southeast. Hunting and logging is licensed in areas bordering the park, although people cultivate, graze cattle, collect grass and firewood, cut hard wood, and hunt illegally in MNP area.

4.2 Data Collection

The data were collected for three months starting in August 2005 to October 2005, using systematic sampling technique where by six transects were laid and fifteen quadrats were allocated on each transect. Voucher specimens were pressed and brought to the Herbarium at the University of Dar Es Salaam Botany Department for identification. Specimen that were identifiable in the field were identified on the spot and recorded in the field notebook with standard information such as growth form, date, area where they were collected. Species that had proved difficult to be identified in the field were taken for identification at the University of Dar Es Salaam Botany Department using manual of Flora of Tropical East Africa and by matching with species specimens available in the Herbarium. Also the identified specimens in the field were also taken to the Herbarium for approval and deposition.

4.2.1 Vegetation sampling

Following a reconnaissance survey, actual sampling of vegetation was done focusing on homogeneity of vegetation. Physiognomic homogeneity was used as criterion for the selection of transect. A modified Whittaker Nested –Quadrant sampling in accordance with Stohlgren *et al.*, (1995) were adopted. In establishing the sampling plots systematic sampling were used. Preferential method was used to sample different vegetation types and subsequent quadrat were established at 100 m intervals on a linear transect

The method had required that trees and sapling to be sampled in rectangular quadrats measuring 20 m x 25 m. Shrubs and seedlings were sampled in 5 m x 2 m quadrats nested into the big quadrats. Within a 5 m x 2 m another 0.5 m x 2 m subplot was set for collection of data on herbs and grasses. The total number of plots laid for the study was 90. The advantage of employing rectangular quadrats over square or spherical quadrat rests on its ability to minimize edge effect as well as increasing the chances of including most species during sampling. According to Greig-Smith (1983) rectangular plots have been shown to yield more accurate results than circular plots. The plots were temporarily marked with wooded pegs and biodegradable flagging tape.

All trees with diameter at breast height (DBH) ≥ 10 cm were identified, counted, recorded and their heights were measured using hypsometer. Where this was not applicable a calibrated pole of bamboo tree were used to estimate the heights when there are many tree crowded and it is impossible to use hypsometer. Circumferences of trees at 1.3m above the ground were measured using tapes and then converted into dbh. The trees that were found to have multiple stems, the stems were measured separately. Shrub species were identified, recorded and heights of shrubs were measured using calibrated bamboo pole. Species of wood climbers were recorded; data on wood climbers were on the scale of presence /absence. Sapling were identified and recorded from the main plots together with tree and the diameter of sapling was taken from >1<10 cm. Data on the seedling were obtained from the 5m x 2m quadrat where by the seedling were considered to have the dbh ≤1 cm. The estimated relative cover of grasses and herbs were obtained by using percentage cover. The species occurring outside the plots were recorded for floristic completion. Plant identification was done both in the field and in the herbarium, and voucher specimens were collected and placed in the University of Dar es salaam Botany Department.

4.2.2 Frequency and abundance

Frequency and abundance of trees and shrub were summarized on plot basis.

Abundance was expressed as the number of individual plants per plot.

Estimation of percentage cover abundance for all vegetation types was done visually and the modified 1-9 Braun-Blanquet scale (Van der Maarel, 1979) was used to present the data as follows:

1= rare, generally one individual

2= Occasional or sporadic with less than 5% cover of the total area.

3= Abundant with less than 5% cover of the total area.

4= Very abundant, with less than 5% cover of the total area.

5= 5-12% cover of the total area.

6= 12.5-25% cover of the total area.

7= 25-50% cover of the total area.

8= 50-75% cover of the total area.

9= >75% cover of the total area.

4.2.3 Environmental data

The following environmental parameters were measured in each plot these include, aspect, and soil texture through physical observation, altitude and geographic co-ordinates. The co-ordinates of each sample stand were determined using GPS (Geographical Position System).

4.3 Data Analysis

The enumerative data collected from all the 90 sample plots were compiled and analyzed for the following measures of ecological importance.

1. Diversity Index was calculated according to Shannon-Wiever (1949).

$$H' = -\sum_{i=1}^{s} pi \ln (pi)$$

Whereby: H = Shannon-Wiever Diversity Index

Σ = Summation symbol

s = Number of species

pi =the proportion of individuals or the abundance of species i^{th} as a proportional of total cover in the sample

ln = log $base_n$

2. Species richness – was expressed as number of species per unit area.

3. Dominance Index was calculated according to Krebs (1989)

$$C = \Sigma (ni/N)^2$$

Where by: ni = the number of individuals of species i^{th} in the sample

N = total number of individuals of all species in the sample

4. Evenness was calculated after Shannon-Wiever (1949)

$$E = H'/\log (S)$$

Whereby: E = Evenness

H' = Shannon-Wiever Diversity Index

S = total number of species in the sample

5. Basal area of tree was calculated by using diameter at breast height as follows:-

Basal area=Π $(d^2)/4$

Where d= diameter at breast height

Π= 3 .14

6. Dominance=mean basa area per species x number of trees in species

7. Similarity between the Community Types

The Sorensen's Coefficient was used to calculate the similarity between the six community types. The Sorensen's Coefficient of similarity (Ss) was defined using the following symbolism, as:-

Ss=2a/2a+b+c

Ss= Sorensen's similarity coefficient

a= Number of species common to both sample

b= Number of species in sample 1

c= Number of species in sample 2

Sorensen's Coefficient is preferred to the Jaccard because it gives weight to the species that are common to the quadrats or sampling rather to those that only occur in either sample (Kent and Coker, 1992).

8. Species Importance Value Index (IVI)

The importance value index (IVI) of each species was calculated as the sum of the relative frequency, density and dominance values of the species (Ambasht, 1988; Kent and Coker, 1992).

5.0 RESULTS

5.1 Floristic Composition

A total of 174 plant species representing 47 different families were recorded (Appendix 1). The family Fabaceae had the highest species number (35 species, 20.11%) followed by the family Poaceae (19 species, 10.92%), Euphorbiaceae (12 species, 6.90%), Capparidaceae (10 species, 5.75%), Combretaceae (8 species, 4.60%) Asteraceae (8 species, 4.60%), Rubiaceae (7 species, 4.02%) Boraginaceae (6 species, 3.45%), Acanthaceae (5 species, 2.87%), Labiatae (5 species, 2.87%), Sterculiaceae (5 species, 2.87%), Malvaceae (4 species, 2.30%). Other families were represented by one to three species (Appendix 2).

Six community types were obtained from this study; community types were *Flueggea virosa-Panicum maximum-Acacia sieberiana* community type, *Hygrophila auriculata-Sporobolus pyramidalis* community type, *Lonchocarpus capassa-Cassia abbreviata* community type, *Acacia sieberiana-Hyparrhenia rufa* community type, *Acacia nigrescens-Dalbergia melanoxylon* community type and *Brachystegia boehmii-Brachystegia spiciformis–Margaritaria discoidea* community type. The study area had woody species density of 350.67 stems.ha^{-1}, basal area 17.75837m^2 ha^{-1}, Shannon - Wiever diversity for community type 1. *Flueggea virosa-Panicum maximum* community type was 2.576, community type 2. *Hygrophila auriculata-Sporobolus pyramidalis* community type 2.583, community type 3. *Lonchocarpus capassa-Cassia abbreviata* community type 3.216, community type 4. *Acacia sieberiana-Hyparrhenia rufa* community type 3.176, community type 5 *Acacia nigrescens-Dalbergia melanoxylon* community type 3.125 and community type 6 *Brachystegia boehmii-Brachystegia spiciformis-Margaritaria discoidea* 3.325.

The most abundant tree species recorded in the area were *Dalbergia melanoxylon* (23.07%), *Acacia nigrescens* (8.42), *Lonchocarpus capassa* (7.80), *Brachystegia boehmii* (6.72%), *combretum zeyheri* (5.75%), *Margaritaria discoidea* (4.59%) and *Acacia sieberiana* (4.18%). Families Fabaceae had 31 woody species, Combretaceae 8 woody species, Euphorbiaceae 8 woody species, Sterculiaceae 4 woody species, Ebenaceae 3 woody species, Palmae 3 woody species, Bignoniaceae, Capparidaceae, Rubiaceae, Ochnaceae, and Verbenaceae had 2 woody species, and the remaining families had one woody species each.

5.2 DBH Size

Brachystegia microphylla, *Burkea africana*, *Xeroderris stuhlmanii*, *Brachystegia spiciformis*, *Margaritaria discoidea*, *Acacia nigrescens*, *Brachystegia boehmii*, *Pteleopsis myrtifolia*, *Dalbergia melanoxylon* and *Diplorhynchus condylocarpon* had the highest mean basal areas hence contribute much on total mean dbh size in the study area.

Table 1: Woody species with highest dbh (± Standard Error of the Mean and SD Standard Deviation of the Mean)

Species	DBH	SD	95% CI
Acacia nigrescens	25.64±1.06	11.75	23.57≥DBH≤27.71
Brachystegia boehmii	25.58±2.23	22.04	21.16≥DBH≤30.01
Brachystegia spiciformis	29.08±2.20	18.39	24.69≥DBH≤33.47
Dalbergia melanoxylon	19.31±0.43	8.17	18.47≥DBH≤20.16
Brachystegia microphylla	57.57±6.41	23.10	43.61≥DBH≤71.53
Burkea africana	49.64±8.49	22.47	28.86≥DBH≤70.42
Margaritaria discoidea	27.60±1.83	15.01	23.94≥DBH≤31.26
Xeroderris stuhlmannii	35.04±3.51	25.10	27.97≥DBH≤42.10
Pteleopsis myrtifolia	21.32±1.52	11.08	18.26≥DBH≤24.38
Diplorhynchus condylocarpon	18.27±1.31	6.91	15.59≥DBH≤20.95

The tree species, which had highest height, were *Burkea africana Brachystegia microphylla, Brachystegia spiciformis, Brachystegia boehmii, Margaritaria discoidea,* *Xeroderris stuhlmannii, Julbernardia globiflora, Pteleopsis myrtifolia, Diplorhynchus condylocarpon* and *Acacia nigrescens*.

Table 2: Selected tree species with highest mean height in Mikumi National Park (± Standard Error of Mean and SD Standard Deviation of the Mean)

Species	Mean height	SD	95% Confident limit
Acacia nigrescens	9.55±0.28	3.098	9.01≥ H≤10.10
Brachystegia boehmii	11.80±0.38	3.73	11.05≥ H≤12.55
Brachystegia spiciformis	13.20±0.51	4.25	12.19≥ H≤14.22
Brachystegia microphylla	16.65±1.28	4.62	13.86≥ H≤19.45
Burkea Africana	17.14±1.08	2.85	14.50≥ H≤19.78
Margaritaria discoidea	11.70±0.47	3.84	10.76≥ H≤12.63
Xeroderris stuhlmannii	11.50±0.79	5.67	9.91≥ H≤13.10
Pteleopsis myrtifolia	10.02±0.60	4.36	8.81≥ H≤11.22
Julbernardia globiflora	10.78±0.53	3.16	9.71≥ H≤11.85
Diplorhynchus condylocarpon	9.64±0.54	2.84	8.54≥ H≤10.75

5.3 The population structure of Woody species

The population structure of woody species was drawn in the graph by using ten woody species which were considered as multipurpose woody species selected from the different use of the people near by the study area. The seedling, sapling and mature woody species of these multipurpose trees were collected and the graph of the seedling, sapling and tree species were obtained below.

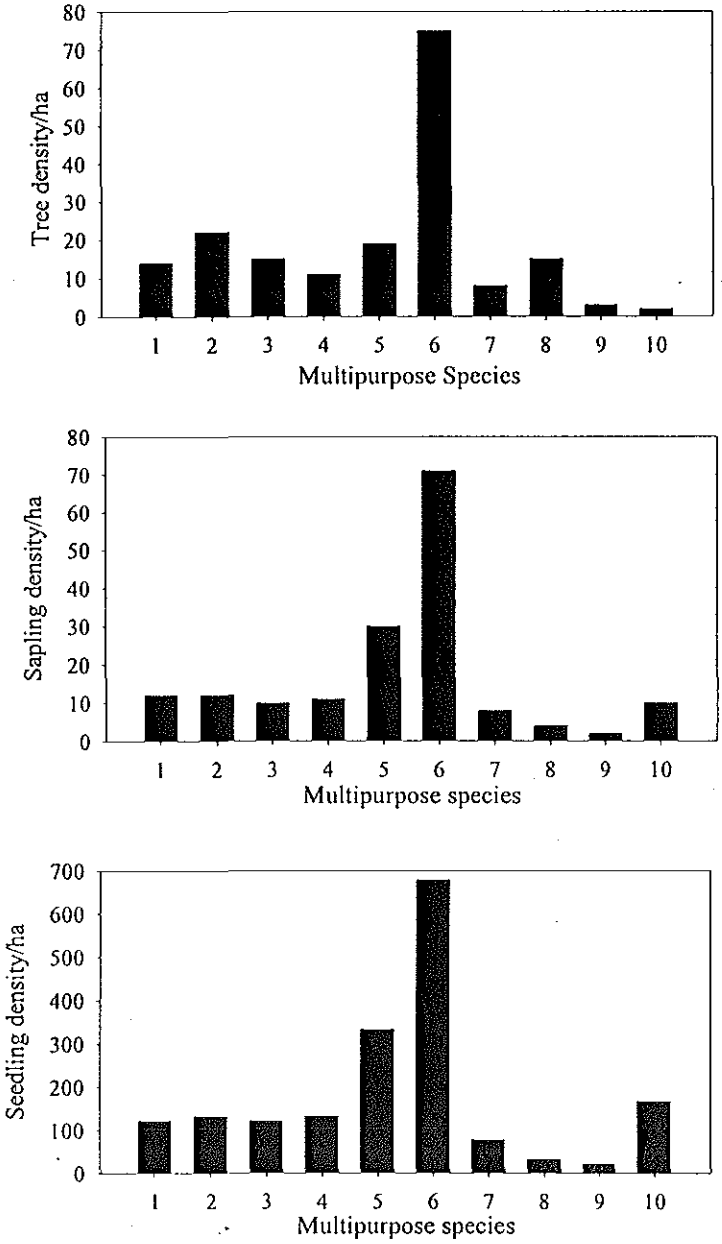

Figure 3: population structure of multipurpose trees.
1= *Acacia sieberiana;* 2 = *Brachystegia boehmii;* 3= *Brachystegia spiciformis;* 4= *Combretum collinum;* 5 = *Combretum zeyheri;* 6= *Dalbergia melanoxylon;* 7= *Jubernardia globiflora;* 8= *Marganitaria discoidea;* 9= *Pterocarpus angolensis* and 10=*Tamarindus indica*

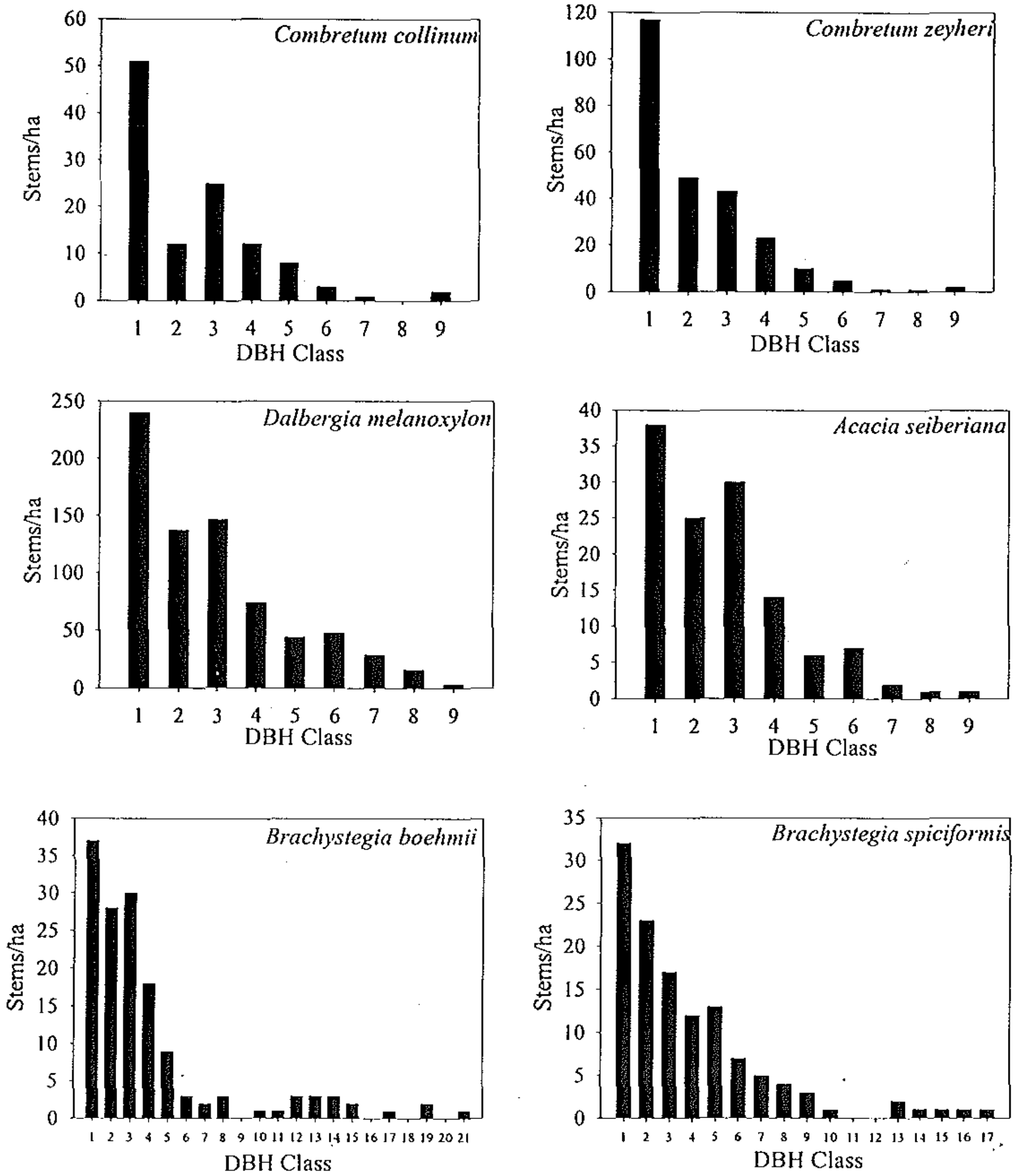

Figure 4: .Population structure dbh classes size (cm)
1=0-4.9, **2**=5-9.9, **3**= 10-14.9, **4**=15-19.9 **5**= 20-24.9, **6**=25-29.9, **7**=30-34.9, **8**=35-39.9, **9**= 40-44.9, **10**=45-49.9, **11**= 50-54.9, **12**=55-59.9, **13**=60-64.9, **14**=65-69.9, **15**=70-74.9, **16**=75-79.9, **17**=80-84.9, **18**=85-89.9, **19**=90-94.9, **20**=95-99.9 and **21**=100-104.9.

5.3 Plant Community Types

Six plant community types (clusters) were identified (Fig 5). The Plant communities were named after two or three of the dominant species, which occur in each group using the relative magnitude of mean cover abundance, defined as the mean cover abundance value of a species in different quadrats that occurs in a given community according to Teshome *et al.*, (2004) (Table3 and Appendix 3). The six community types were *Flueggea virosa –Panicum maximum-Acacia sieberiana, Hygrophila auriculata - Sporobolus pyramidalis, Lonchocarpus capassa - Cassia abbreviata, Acacia sieberiana - Hyparrhenia rufa, Acacia nigrescens -Dalbergia melanoxylon and Brachystegia boehmii – Brachystegia spiciformis -Margaritaria discoidea.*

Table 3: Mean cover abundance of major species in the community types.

Community types	**1**	**2**	**3**	**4**	**5**	**6**
Community size*	**4**	**9**	**14**	**16**	**30**	**13**
Flueggea virosa	5.00	1.11	0.64	0.38	0.33	1.38
Panicum maximum	3.75	0.00	0.43	0.13	0.37	0.54
Acacia sieberiana	3.25	0.00	1.14	3.94	0.00	0.00
Diospyros mespiliformis	2.50	0.00	0.00	0.00	0.00	0.00
Strychnos innocua	2.25	0.00	0.00	0.00	0.00	0.31
Hygrophila auriculata	0.00	4.22	0.00	0.00	0.00	0.00
Sporobolus pyramidalis	0.00	3.11	0.00	0.94	0.00	0.00
Pennisetum mezianum	0.00	2.22	0.00	0.38	0.07	0.00
Harrisonia abyssinica	0.00	1.89	0.21	0.00	0.00	0.00
Monochma debile	0.75	1.78	0.14	0.63	0.13	0.00
Themeda triandra	0.00	1.56	0.50	0.88	2.80	2.23
Lonchocarpus capassa	1.00	0.67	7.36	2.25	0.27	0.00
Cassia abbreviata	0.00	0.00	3.29	0.31	0.43	0.00
Combretum zeyheri	0.25	0.11	2.50	0.31	3.87	0.38
Combretum fragrans	0.00	0.00	2.36	0.38	0.00	0.00
Diospyros usambarensis	0.00	0.00	1.93	1.00	0.53	0.00
Hyparrhenia rufa	0.00	1.33	1.50	4.13	1.40	2.69

Table 3 Cont.

Community types	1	2	3	4	5	6
Community size*	**4**	**9**	**14**	**16**	**30**	**13**
Hyparrhenia rufa	0.00	1.33	1.50	4.13	1.40	2.69
Acacia sieberiana	3.25	0.00	1.14	3.94	0.00	0.00
Lonchocarpus capassa	1.00	0.67	7.36	2.25	0.27	0.00
Urochloa pullulans	0.50	1.22	1.07	1.75	0.33	0.00
Acacia nigrescens	0.00	0.00	0.00	0.00	5.60	0.00
Dalbergia melanoxylon	0.00	0.00	0.21	0.31	5.03	0.38
Combretum zeyheri	0.25	0.11	2.50	0.31	3.87	0.38
Themeda triandra	0.00	1.56	0.50	0.88	2.80	2.23
Commiphora africana	0.00	0.00	0.43	0.00	2.17	0.00
Combretum collinum	0.00	0.00	0.50	0.00	2.13	0.00
Brachystegia boehmii	0.00	0.00	0.00	0.00	0.00	6.15
Brachystegia spiciformis	0.00	0.00	0.00	0.00	0.00	5.15
Margaritaria discoidea	0.00	0.00	0.36	0.00	0.27	4.77
Annona senegalensis	0.00	0.00	0.00	0.00	0.00	3.00
Hyparrhenia rufa	0.00	1.33	1.50	4.13	1.40	2.69
Julbernardia globiflora	0.00	0.00	0.00	0.00	0.00	2.62
Pericopsis angolensis	0.00	0.00	0.00	0.00	0.00	2.62
Diplorhynchus condylocarpon	0.00	0.00	0.36	0.00	0.00	2.46
Themeda triandra	0.00	1.56	0.50	0.88	2.80	2.23
Crossopteryx febrifuga	0.00	0.00	0.00	0.00	0.00	2.15
Piliostigma thonningii	0.00	0.00	0.00	0.00	0.00	2.15
Bridelia cathartica	0.00	0.00	0.00	0.00	0.00	2.00
Brachystegia microphylla	0.00	0.00	0.00	0.00	0.00	1.92

1. *Flueggea virosa-Panicum maximum –Acacia sieberiana* community type

This community type was described from MNP headquarters area toward the Vuma hills and the dominant tree species were *Flueggea virosa*, *Acacia sieberiana* and *Diospyros mespiliformis*. Other dominant tree species were small trees of *Strychnos innocua* and *Ziziphus mucronata*. *Panicum maximum* dominated the ground flora of the community. *Salacia madagascariensis* was the climber, which, associated with the community although not dominant.

2 .*Hygrophila auriculata-Sporobolus pyramidalis* community type

This community type was found in MNP flood plain area, and the dominant species includes *Hygrophila auriculata* and *Sporobolus pyramidalis*, which dominated the ground flora of the community. Other dominant species included; P*ennisetum mezianum*, *Monochma debile* and *Themeda triandra*. The flood plain had only few tree species due to high water logging capacity, which results into anoxic condition of the roots. Hence only few woody species of *Harrisonia abyssinica, Flueggea virosa, Combretum zeyheri,* and small tree of *Lonchocarpus capassa* species were observed. *Capparis tomentosa* and *Cadaba farinosa* were the shrubs associated with this community. One climber species associated with this community although it was not dominant. This climber was *Rhynchosia minima*.

3 .*Lonchocarpus capassa- Cassia abbreviata* community type

This community type was described from MNP in Chamgore –Mwanambogo area. The tree layer of this community was dominated by *Lonchocarpus capassa*, *Cassia abbreviata* and *Combretum zeyheri*. Other dominant tree species included; *Combretum fragrans*, *Diospyros usambarensis*, *Xeroderris stuhlmannii*, *Combretum mole*, *Combretum collinum* and *Kigelia africana*. *Hyparrhenia rufa* dominated the ground flora of the community.

4. *Hyparrhenia rufa-Acacia sieberiana* community type

This community type was described in MNP between Chamgore and floodplain area. The dominant tree species was *Acacia sieberiana*. Other dominant tree species included; *Lonchocarpus capassa*. *The Hyparrhenia rufa* was the species, which dominated the ground flora of the community followed by *Urochloa pullulans*. *Rhynchosia minima* was the climber species associated with this community.

5. *Acacia nigrescens-Dalbergia melanoxylon* community type

This community type was stretched from the Doma controlled reserve area- Mbogayaga area. The tree layer of this community was dominated by *Acacia nigrescens*, *Dalbergia melanoxylon* and *Combretum zeyheri*. Other dominant tree species included; *Combretum collinum*, *Commiphora africana* and *Xeroderris stuhlmannii*. *Acacia senegal*, *Markhamia obtusifolia* and *Pteleopsis myrtifolia* were also associated with this community. *Themeda triandra* and *Hyparrhenia rufa* dominated the herbaceous layer. *Panicum coloratum* was also an important herbaceous species associated with this community.*Salacia madagascariensis* was a climber associated with community, although not dominant.

6. *Brachystegia boehmii- Brachystegia spiciformis-Margaritaria discoidea* (Miombo) community type

This community type occurred in south of MNP in Mahondo area. *Brachystegia boehmii*, *Brachystegia spiciformis* and *Margaritaria discoidea* formed the tree layer of this community. A small tree of *Annona senegalensis* was also a dominant species associated with this community. Other woody species included; *Pericopsis angolensis*, *Piliostigma thonningii*, *Julbernardia globiflora*, *Diplorhynchus condylocarpon*, *Bridelia Cathartica*,*Crosspteryx febrifuga*, *Brachystegia microphylla*, *Stereospermum kunthianum*, *Xeroderris stuhlmannii*, *Catunaregam spinosa* and *Flueggea virosa*. One climber species, *Rottboellia exaltata* was also associated with this community although it was not dominant. *Hyparrhenia rufa* and *Themeda triandra* were the most dominant herbaceous layer species. Other herbaceous layer species associated with this community was *Heteropogon contortus*.

Results from the classification of plant community types of this study also produced outliers from both study sites, represented by quadrat numbers 30,74,75,and 77 (fig 5). These quadrats did not show sufficient similarity with any of the six plant community types. They were, therefore, considered as a group by themselves or outgroup.

The species composition of quadrat 30 included *Chloris gayana*, *Flueggea virosa*, *Hyparrhenia rufa*, *Kigelia africana*, *Macrotyloma axillare*, *Markhamia obtusifolia* and *Panicum coloratum*. The species of this quadrat also occurred in community types 1, 2, 3, 4, 5 and 6. However, this quadrat was not used in the demacartion of the six plants communities. This was because, it was considered as an outlier as its entire species occurred in the six communities.

Quadrat 74 composed of, *Acacia robusta*, *Annona senegalensis*, *Brachystegia spiciformis*, *Cissampelos pareira*, *Stereospermum kunthianum*, *Triumfetta rhomboidea*, *Vitex doniana*, *Xeroderris stuhlmannii*, *Burkea africana*, *Brysocarpus orientalis*, *Pseudolachnostylis maprounefolia*, *Dalbergia melanoxylon*, *Margaritaria discoidea* and *Deinbollia borbonica*. *Cissampelos pareira* and *Deinbollia borbonica* were not found in any of the six communities while the other species occurred in community types 3, 4, 5 and 6 and that could be a reason this quadrat to be an outlier.

The quadrat 75 composed of *Annona senegalensis*, *Hyparrhenia rufa*, *Bridelia cathartica*, *Themeda triandra*, *Triumfetta rhomboidea*, *Catunaregam spinosa*, *Margaritaria discoidea*, *Xeroderris stuhlmannii*, *Markhamia obtusifolia*, *Panicum trichocladum*, *Xylotheca tettensis*, *Pennisetum polystachion*, *Piliostigma thonningii*, and *Pteleopsis myrtifolia*. Although this quadrat had species which occurred in community types 2 ,3 ,4 ,5 and 6, it also had unique species, which did not occurred in any other quadrats and in any other communities and this might be the reason why this quadrat was an outlier. The unique species included *Xylotheca tettensis*, *Panicum trichocladum*, and *Pennisetum polystachion*.

The species composition of quadrat 77 included *Albizia amara*, *Combretum molle*, *Combretum zeyheri*, *Diospyros usambarensis*, *Flueggea virosa*, *Heteropogon contortus*, *Hyparrhenia rufa*, *Kigelia africana* , *Maerua edulis* , *Pseudolachnostylis maprounefolia*, *Urochloa pullulans* and *Xeroderris stuhlmannii*. This quadrat was sampled near Mwanambogo area where *Combretum mole, Combretum zeyheri, Albizia amara, Pseudolachnostylis maprounefolia, Kigelia africana* and *Urochloa pullulans* were so abundant to dominate the plot.

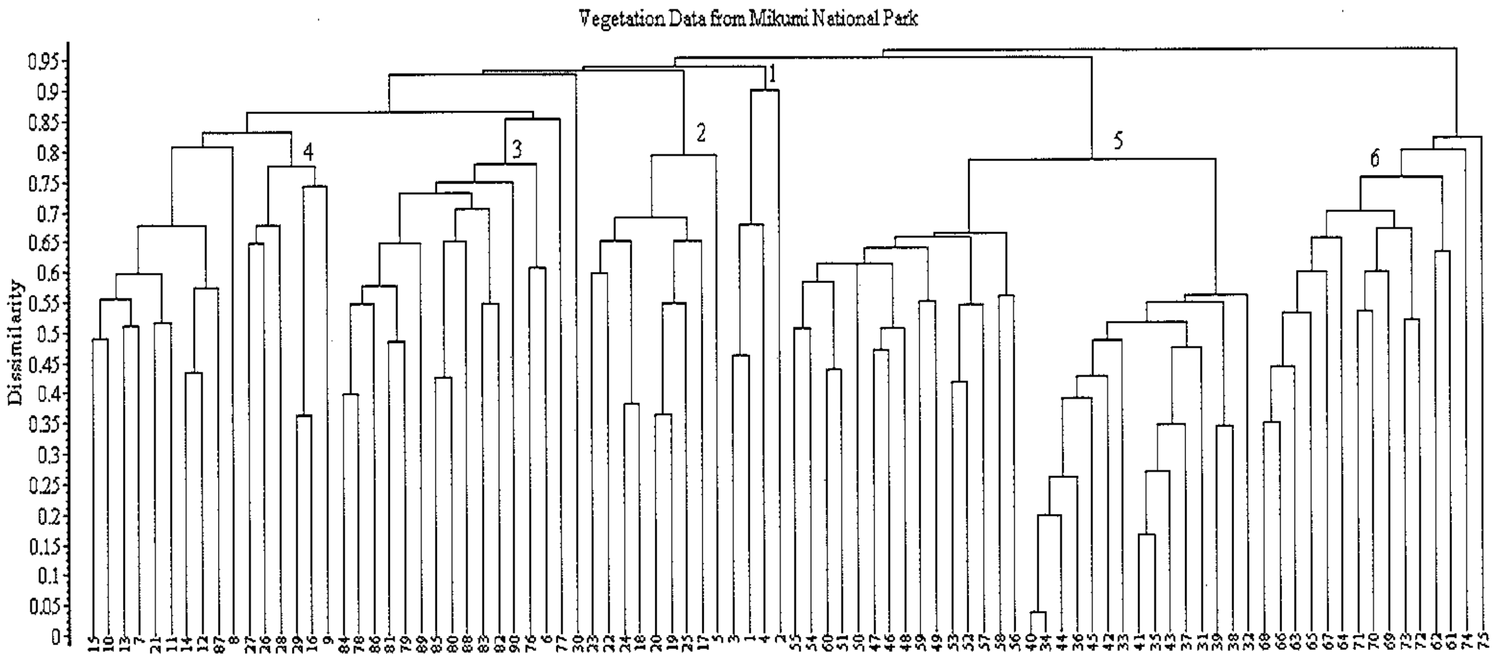

Figure 5: Dendrogram of the vegetation data using similarity ratio.

5.4 Species Richness, Evenness and Diversity of the Plant Community Types

The species richness, evenness and diversity of the six plant community types were calculated following Shannon program for computing Shannon Diversity Index using H= -ä p(i)*ln p(i) by Zerihun Woldu, 1989, 1997,2005. The results obtained were summarized in the table 4.

Table 4: Species richness, evenness and diversity in the six plant community types

Community types	Species richness	Diversity	Evenness	H/HMAX
1	20	2.576	2.996	.861
2	19	2.583	2.996	.862
3	42	3.216	3.761	.855
4	44	3.176	3.807	.834
5	46	3.125	3.850	.812
6	42	3.325	3.738	.890

5.5 Comparison of Specied diversity between the six community types

Species diversity comparison between the six community types were calculated by Tukey-Kramer Multiple Comparison test and the following results below were obtained.

Table 5: Comparison of the species diversity of the six community types

Comparison	Mean Rank Differences	Significance
1 vs 2	0.038	ns P>0.05
1 vs 3	0.28	*P<0.05
1 vs 4	0.31	*P<0.05
1 vs 5	0.41	*p<0.05
1 vs 6	0.24	ns p>0.05
2 vs 3	0.24	ns p>0.05
2 vs 4	0.27	nsp>0.05
2 vs 5	0.37	*p<0.01
2 vs 6	0.21	nsp>0.05
3 vs 4	0.028	nsp>0.05
3 vs 5	0.12	ns P>0.05
3 vs 6	-0.03	nsp>0.05
4 vs 5	0.095	ns P>0.05
4 vs 6	-0.062	ns p>0.05
5 vs 6	-0.16	ns p>0.01

*** = significant difference**

6.0 DISCUSSION

6.1 Floristic Composition

Mikumi National Park was floristically diverse and heterogeneous species composition. The most dominant families encountered in the Park were Fabaceae (35 species, 20.11%) followed by the family Poaceae (19 species, 10.92%), Euphorbiaceae (12 species, 6.90%), Capparidaceae (10 species, 5.75%), Combretaceae (8 species, 4.60%), Asteraceae (8 species, 4.60%) Rubiaceae (7 species, 4.02%) and Boraginaceae (6 species, 3.45%). The moderately dominant families were Acanthaceae (5 species, 2.87%), Labiatae (5 species, 2.87%), Sterculiaceae (5 species, 2.87%) and Malvaceae (4 species, 2.30%). Four families were represented by three individuals (Bignoniaceae, Ebenaceae, Palmae, and Verbenaceaea had 1.72%). Seven families were represented by 2 individuals (Amaranthaceae, Anthericaceace, Celastraceae, Dioscoreaceae, Loganiaceae, Ochnaceae and Tiliaceae had 1.15%). The remaining 24 families were represented by only one individual hence contributed 0.57% each (Appendix 2).

The dominant families might have developed mechanisms which helped them to survive in the area. These include fire resistance morphological and phenological characters such as fire-resistant thick barks which protects the plant transportation systesm, xerophytic leaves, and protected buds by fire resistance scales, translocation of nutrients to underground tissues prior to the onset of the dry season and fire occurance (Medina *et al.*, 1990). According to Groome *et al.*, (1957) *Pterocarpus angolensis* translocate nutrients to underground tissues prior to the onset of the dry season and fire occurance. For example it takes at least 7 years before seedlings of *Pterocarpus angolensis* to pass into sapling stage (Groome *et al.*, 1957). During this period, reserves are stored in the root system until the plant can grow strong enough to withstand fire; the taproot builds up even if the seedlings shoot is killed by fire. This gives the seedling a lot of vigour after the fire: such that root systems become well established and saplings grow fast to escape subsequent fires. Other mechanisms include, coppicing, abundant seed crops, hard seed coat, seeds that bury themselves and vigorous stem elongation and maturation followed by dry season dormacy (Child and heady, 1994). For grasses these are also adapted to withstand fires by translocating much food to shoot bases which are usually protected by fire resistant scales. The moderately and rare families might had been affected by the frequent fire occurrences in the study area , fluactuating of water table, browsing and grazing animals and elephants destruction due to their habit of toppling the woody species. The results showed that most of the tree species were found in the Miombo woodland. Other tree species were found in the *Dalbergia* woodland mixed woodland and wooded grassland. There were only few trees in the flood plain since flooding causes suffocation of tree roots by causing anoxic conditions of the roots.

6.2 DBH Size

The first three woody species with highest mean dbh size were *Brachystegia microphylla*, 57.57 ± 6.41, *Burkea africana*, 49.64 ± 8.49 and *Xeroderris stuhlmannii* 35.04 ± 3.51(Table 1). The reason for these three species having highest mean dbh size compared to the others woody species could be unpalatibility to wildlife animals, not preferred for near by villagers for timber, charcoal and fire wood compared to the others which are illegally cut. This is evident from the ten multipurposes woody species which were selected by the near park villagers for multipurpose uses did not include the three species. The reason for other species which had moderately mean dbh size could be frequently fire which make the species to have constant growth, illegal logging of selected dbh size especial big size could be a contributing factor for having moderate dbs size . Illegal logging seems to increase day after day this is mainly done with individuals especially at the edges of the Park.

Most people involve themselves in this illegal activity so as to earn income (FRMP, 1997; Temu, 1980). Selective tree harvesting could be also a reason for moderate and small mean dbh size since this is commonly practiced to popular timber species like *Pterocarpus angolensis* and *Brachystegia spiciformis*. These are extracted by saw milling industries and illegal pit sawyers. Debarking also contributes to this since the barks of *Brachystegia spiciformis* are used for making containers, ropes and local beehives. *Dalbergia melanoxylon* had mean dbh size of 19.31 ± 0.43 which is small and the reasons for this could be illegal cut by poachers and toppling of this woody species by elephants and death of many species of *Dalbergia melanoxylon* in the park although the cause of it is not known (per. Observ.). Also *Dalbergia melanoxylon* is illegally harvested for carving.

6.3 Height size

The first two top woody species with highest mean dbh size are also the two top highest heights: *Burkea africana,* 17.14 ± 1.08 and *Brachystegia microphylla* 16.65 ± 1.28 (Table 2). The reason for this could be unpalatibility to wildlife animals, not preferred for timber, charcoal and fire wood compared to other ten woody species. *Acacia nigrescens* which was the six positions in mean dbh size is the last in the top ten woody species with highest mean height with mean height of 9.55 ± 0.28. The reason for this could be its palatability to browsers especially Gazelles.

6.4 Population structure of Woody species

Dalbergia melanoxylon had highest number of species in both stages followed by *Combretum zeyheri* compared to other multipurposes speces. The reason for this could be its presence in the central area of the park which makes it not easily poached. However, in the past a number of *Dalbergia melanoxylon* existed in flood plain and in other areas of the Park, evidence from satellite images 1957-1985; Lyaruu,1997. Although the presence of *Dalbergia melanoxylon* currently in Doma game control area, and few species in Miombo woodland can be explained by the death of this species. This was true because through personal observation a lot *Dalbergia melanoxylon* species were found dead per plot in Doma area, though the cause was not known. Other reason for this could be attributed to toppling of tree by elephants.

Individuals of *Brachystegia boehmii, Brachystegia spiciformis Acacia sieberiana and Combretum collinum* seemed to be moderate regenerated compared to *Dalbergia melanoxylon*, and *Combretum zeyheri*. The reasons could browse animals that browse on *Acacia sieberiana* and frequently fires which can influence the composition of these species in the area. Fire is known to increase species diversity (McNaughton *et al.*, 1988). Although frequently fire effectively holds back recruitment of trees in savanna habitats into mature age classes and finally result into populations with uneven age distributions and such populations are highly unstable (Swaine, *et al.*, 1992). Fire tends to keep the vegetation open, eliminates certain species and will selectively favor domination by fire resistant species (Russell 1959). In constrast, in drier areas fire exclusion tends to reduce tree recruitment rates (Brookman-amissah *et al.*, 1980; Chidumayo, 1988). Other reason could be illegal poaching of *Brachystegia boehmii* and *Brachystegia spiciformis* which are found in Miombo woodland area in southern part of the park boardering Kilombero, Mahondo and Kisaki villagers. Since these species are used for timber, charcoal making, local beehives, ropes and making containers.

Tamarindus indica is the only tree species which showed growing population among the ten multipurpose trees. It had many seedlings and this could be attributed to its seed dispersal, which is by animals and has copious regeneration. This species is mostly liked by baboons, elephants and other herbivores and that could be a reason to have very few matured trees compared to other ten multipurpose trees.

Pterocarpus angolensis which is the most used tree for construction and carvings was represented by few seedlings, saplings and tree compared to other nine tree species. The species is valuable since it produce the best timber compared to *Brachystegia spiciformis*, *Brachystegia boehmii* and *Margaritaria discoidea*. According to Bruce (1967), *Pterocarpus angolensis* is the most important timber species harvested in miombo and it is known as premier timber of East Africa. The reasons for having few numbers of representatives in the area could be regeneration of the species. *Pterocarpus angolensis* are threatened and vulnerable for extinction because their regeneration potential is low (Wingfied, 1979). For instance, Groome *et al.*, (1957) reports that, it takes at least 7 years before seedlings of *Pterocarpus angolensis* to pass into sapling stage. During this period, reserves are stored in the root system until the plant can grow strong enough to withstand fire. The absence of regeneration from the seed bank suggests that either the seeds (which are usually produced by these trees) do not reach maturity before they are shed, or the habitat for this plant is still unfavourable for seedling established. Another reason could be the cutting of the mature trees for timber purposes which is done illegally (per observation) since I found a lot of timber were kept in Mahondo ranger post and they were collected from the forest while they were doing joint patrol.

6.5 Species Richness, Evenness and Diversity of the Plant Community Types

The six plant community types can be divided into two groups in term of species richness, evenness and species diversity (Table 4). Group one included community types 1 and 2. In this group, the species richness, diversity and evenness is more or less the same and it is low. The two communities were recorded in the flood plain and headquarters areas. The low species richness and low diversity of these two communities could probably be attributed to the environmental and anthropogenic factors. The fluctuating water table could be a direct effect on the vegetation in this group. Since low water table will not be enough available to the plants and too high water table result into roots asphyxiation and finally death of the plants. This explains the death of many tree species from the flood plain. Research elsewhere has shown that root growth is markedly affected by aeration, soil compaction and nutrient supply (Russell, 1959) and all three have an effect on the growth of vegetation in a rangeland.

The area with montmorillonitic clay soils, which are acidic, support very few trees and have very low diversity compared to the free draining soils on hills slopes (Russell, 1959). This could be the same in the flood plain where by there was high water logging capacity, clay soil and hence death of root which resulted to the death of many tree species resulting to low species diversity and richness. Also the absence of *Panicum maximum* and invasive of *Vernonia glabra* in the flood plain is the sign of high disturbance in this zone. The absence of *Panicum maximum* in the flood plain was the sign for high intensive fire in the area, and high concentration of grazing activities in the flood plain. Research from other area has shown that *Panicum maximum* is fire sensitive and is unable to withstand intensive defoliation (Horrell and Bredon, 1963). This explains the absence of *Panicum maximum* from the flood plain grassland where there were many ungulates.

Community types 3, 4, 5 and 6 which had more or less the same species richness, evenness and diversity formed the second group. Although community types 3, 4, and 5 which were sampled in mixed woodland and wooded grassland found in the northern part of MNP had shown high species richness and evenness with low species diversity compared to the community type six which was sampled in miombo woodland in the southern part of MNP which showed high species diversity, same richness as community type 3 and low evenness. The reason for this could probably be fire since the southern part of MNP was severely affected by regular fires set by the nearly villagers. Therefore, regeneration of the miombo and other important trees was very low except for the fire resistant species. *Diplorhynchus condylocarpon*, *Margaritaria discoidea*, *Maprounea africana*, *Pseudolachnostylis maprouneifolia*, *Bridelia cathartica*, *Annona senegalensis* and *Combretum molle* are fire resistant species associated with miombo vegetation. Most of these fire resistant species were members of the family Euphorbiaceae and Apocynaceae and produce copious latex. The reason for community type 6 having high species diversity compared to other community type may be frequent fire which is known to increase species diversity (McNaughton *et al.*, 1988).

6.6 Comparison of species diversity between the six community types

Tukey-Kramer Multiple Comparison test in (table 5) showed that community 1and 3, 1and 4, 1 and 5 and 2 and 5 were significant different in species diversity. The reasons for this could be the areas where the sampled quadrats forming these communities had different species composition. To support this, Community 1 and 2 where sampled in headquarters area and flood plain where most of the species encountered in community 1 were *Acacia sieberiana*, *Flueggea virosa*, *Strychnos innocua*, *Diospyros mespiliformis* and *Ziziphus mucronata* and ground layer was dominated by *Panicum maximum* where as community type 2 species included *Hygrophila auriculata*, *Themeda triandra*, *Flueggea virosa*, *Combretum zeyheri*, *Capparis tomentosa*, *Cadaba farinosa* and *Rhynchosia minima*. These species were different from those found to be abundantly in community type 3 which was described from Chamgore-Mwanambogo area. Dominant species *Lonchocarpus capassa*, *Cassia abbreviata* and *Combretum zeyheri*. Others *Combretum fragrans*, *Diospyros usambarensis*, *Xeroderris stuhlmannii*, *Combretum mole*, *Combretum collinum* and *Kigelia africana* and *Hyparrhenia rufa* dominated the ground flora of the community. Also 4 and 5 which were described in Doma controlled area and Mbogayaga area. Community type 4 and 5 included *Acacia sieberiana*, *Urochloa pullulans*, *Rhynchosia minima*, *Hyparrhenia rufa*, *Acacia nigrescens*, *Dalbergia melanoxylon*, *Xeroderris stuhlmannii*, *Acacia senegal*, *Commiphora africana*, *Combretum collinum*, *Markhamia obtusifolia* and *Pteleopsis myrtifolia* hence significantly difference in species diversity.

6.7 Similarity between the Six Community Types

From the results of Sorensen's Similarity Coefficient Index between the six community types (Table 6), it was observed that the similarity of the six community types were less than 50% which implies that there were few common species between communities. The reason for this could be the heterogeneity and patchiness of the vegetation in Mikumi National Park which is a common feature of many tropical savannahs (Huston, 1994) and is attributed to several factors. The most important factors include spatial variations in soil water due to variations in altitude and drainage patterns, soil mineral nutrients as well as temporal variations in water availability resulting from climatic variability. The intensity and timing of grazing and browsing activities together with the frequency of fires modify the observed spatial pattern in the vegetation in an ecosystem.

There was a distinct pattern in the vegetation zonation in the park in all directions that was from the north to the south and from east to west across the floodplain. Viewing the vegetation of MNP from east to west across the flood plain, very few scattered trees in the grassland which dominate the floodplain was witnessed, except along the seasonal rivers and gorges. The vegetation becomes denser progressively away from the plain with open woodland, mixed woodland, and finally culminates into pure stands of *Brachystegia* woodland as the land rises from the plain. Likewise, the situation is more or the same moving from north to south suggesting major differences in the precipitation of the area. For example, it can be assumed that the occurrence of several *Acacia spp.* and very short grass of *Dichanthium annulatum* to the north is an indication of arid conditions while thick closed forest to the south, is an indication that precipitation increases progressively towards south.

It has been observed that the community structure in tropical savannahs is determined by the highly variable low amount of rainfall and that it forms a continuum from treeless grassland to closed forest (Walter, 1971; Walker & Noy-Meir, 1982). This pattern can be applied to Mikumi ecosystem where the Mkata flood plain is almost treeless and a gradual transition to closed forest in the southern part of the park and in high elevations. Though not documented, it can be predicted that the southern part of Mikumi which is densely forested, receive more intense and less erratic rains than the north which is dominated by xerophytes. Facts from elsewhere and research support this hypothesis, In his study, Vessy-Fitz Gerald (1963) concluded that, where rainfall exceeds 1270 mm per annum, the vegetation likely to occur is a forest, or secondary vegetation probably grassland that has been actively induced by human activities. At medium rainfall level between 760 and 1270 mm, the predominant vegetation is wooded grassland and valley grassland. At low rainfall below 760 mm, plant formations typical of Somalia-Maasai phytochorion sensu White (1983), notably *Acacia spp.* And *Commiphora spp.* woodland occurs.

Soil texture and the depth of soil free of soluble salts or excess water; appear to be the main factors determing the rooting pattern, percentage foliage cover and the height of grasslands (Russell, 1959). The areas with montmorillonitic clay soils which are acidic support very few trees and have very low diversity compared to the free draining soils on hilly slopes. This could be true in community type 2 which was described from the MNP in flood plain area where the soil type is black cotton soil imparts water loggedness and asphyxiating properties to the soil, due to its low percolation rate and results in the formation of crumbs during the dry season. In this zone, most trees, appearred to be more or less of the same age class indicating that there has been no dynamic regeneration due to the land degradation which was caused by high concentration of wildlife activities and waterlogging which cause anoxic condition of the roots. This is true especially for the elephants (*Loxodonta africana*) which were forced to flee to this area from the periphery of the national park, when poaching for ivory was in force.

6.8 Importance Value Index (IVI)

The *Dalbergia melanoxylon* was the most dominant species in the study area and had highest species Importance Value Index (IVI) in the study area followed by *Acacia nigrescens, Brachystegia boehmii* and *Xeroderris stuhlmannii.* These species were abundant, frequent and dominant in the National Park. Although *Dalbergia melanoxylon* was the most dominant species in the area its existence in the future is threatened. This is so because during the field work a number of individuals of *Dalbergia melanoxylon* were found dead; although the causes were unknown. Also the species is mostly toppled by elephants. Other evidence is from the satellite images of 1975-1985 which showed the presence of *Dalbergia melanoxylon* in the flood plain although now the species is currently found in Doma controlled game area and only few species of *Dalbergia melanoxylon* were observed in miombo woodland. This suggested that this species is in danger and if these disturbances are continued in future, *Dalbergia melanoxylon* will not be dominant species in the park and even it will disappear in the park despite its low regeneration capacity. Notebly the species is valuable in the most African countries and it is known as African Blackwood or Black Ebony and in IUCN redlist it is indicated as threaten species (IUCN, 1994). Bases on the IVI, the most dominat species have the highest IVI (Curtis and McIntosh, 1951; Lamprecht, 1989). This was true with the present study were the dominant species; *Dalbergia melanoxylon, Acacia nigrescens, Brachystegia boehmii* and *Lonchocarpus capassa* had highest IVI (Appendix 4).

6.9 The Index of Dominance

Very small indices of dominance imply high community diversity (Ambasht, 1988; Krebs, 1989). Similar finding were obtained in this study, thus indicating high community diversity in MNP (Appendix 5).

7.0 CONCLUSION

One hundred and seventy four plant species were encountered in the Mikumi National Park. Fabaceae family followed by Poaceae were found to be the most abundant families in the study area.

Heterogenous vegetation types characterize Mikumi National Park. Cluster analysis of the vegetation data of the park revealed six distinct community types, *Flueggea virosa – Panicum maximum-Acacia sieberiana, Hygrophila auriculata - Sporobolus pyramidalis, Lonchocarpus capassa - Cassia abbreviata, Acacia sieberiana - Hyparrhenia rufa, Acacia nigrescens -Dalbergia melanoxylon* and *Brachystegia boehmii – Brachystegia spiciformis -Margaritaria discoidea*. The distribution of these plant community types is highly influenced by environmental factors and water table effects. The vegetation of Mikumi National Park is interrupted by the repeated fire, browsers, grazers, elephant destruction, and illegal poaching of logging which take place in the peripheral of the park. Notwithstanding the fact that trees are destroyed by fire, wind, lightening and changes in soil salinity.

The factors, which govern the distribution and loss of species in Mikumi National Park ecosystem, do not necessarily operate singly but in most cases they operate synergistically. As an example, browsing on saplings and juvenile trees by wildlife will have an effect of keeping the browsed individuals low and render them more vulnerable to bushfire killing. Likewise, elephants, fire and precipitaton can operate together such that elephants will open woodlands, while rainfall will encourage accumulation of a lot of grass biomass that will result into more severe and destructive bushfires hence species abundance of the MNP is generally low.

8.0 RECOMMENDATION

Plant species are potential stocks for future genetic resource. Therefore, efforts should be made by both the government and local communities to conserve the rich plant biodiversity of the park before it is destroyed by human exploitation. Particular conservation emphasis should be given to some valuable species which were formerly abundant but now are found in few places.

Some economically and ecologically important species had population structures that showed abnormal patterns with no or few individuals at lower size classes. Therefore, there is a need to develop and implement effective management regimes in the area to facilitate healthy regeneration and, eventually, guarantee the sustainable use of these species.

Increase public awareness on the values of reserves areas and the problems related to loss of genetic resources and device mechanisms by which human impacts can be minimized through discussion and consultation with the local people around the national park.

Carry out further studies on the population distribution of *Dalbergia melanoxylon*, *Pterocarpus angolensis*, *Pericopsis angolensis*, *Brachystegia boehmii*, *Brachystegia spiciformis* and *Sclerocarya birrea* which are the important species.

Futhermore detailed integrated floristic studies of the area; targeting the unknown ecological area of Malundwe forest, which is not covered in this study, is recommended.

9.0 REFERENCE

Ambasht, R. S. (1988). *A textbook of plant Ecology*. 10th Ed. Students' Friends & Co., Varansai, India.

APU-ABRU (2004). *Animal Behaviour Research unit: Mikumi National park, Tanzania* http://www.apu.ac.uk/appsci/lifesci/abru/infor.htm. Accessed on 10/12/2004.

Ayuko, L. J. (1978). *Management of rangelands in Kenya to increase beef production: social –economic constraints and policies. In*: Inter. Rangeland Congr. Denver, Colorado, U.S.A.

Bogdan, A. V. (1977). *Tropical pasture and fodder plants* (grasses and legumes). Longman, London

Brenan, J. P. M. (1978). Some Aspects of Phytogeography of Tropical Africa. *Annals of the Missouri Botanical Garden* **65** (2): 437-478.

Brookman-Amissah, J., Hall, J. B., Swaine, M.D. & Attakorah, J. Y. (1980). A reassessment of a fire protection experiment in northeastern Gahan savanna. *Journa of Applied Ecology* **17**: 85–89.

Brown, J. R. and Archer, S. (1989). Woodland invasion of grasslands: establishment of honey mesquite (*Prosopis glandulosa* var. *glandulosa*) on sites differing in herbaceous biomass and grazing history. *Oecologia* **80**: 29-26.

Bruce, J. M. (1967). *The commercial timbers of Tanzania*. Forestry Division, Ministry of Natural Resources, Moshi.

Chidumayo, E .N. (1988). A re-assessment of effects of fire on miombo regeneration in the Zambian Copperbelt. *Journal of Tropical Ecology* **4**: 361–372

Child, R. D. and Heady, H. F. (1994). *Rangeland Ecology and Management.* Westview press. Boulder. San Francisco. Oxford.

Collins, S. L. (1987). Interaction of disturbances in tall grass prairie: A Normal Field Experiment. *Ecology* **68**: 1243-1250.

Croze, H. (1974). "The Seronera Bull Problem . II. The trees". *East African Wildlife Journal* **12**: 29-48.

Curtis, J. T. and Mclntosh, R.P. (1951). An Upland continuum in the Praine Forest Border region of Wisconsin. *Ecology* **32**: 476 - 496

Deshmukh, I. (1986). *Ecology and Tropical Biology.* Blackwell Scientific publication.

Drews, C. (1995). Road kills of animals by public transport in Mikumi National Park, Tanzania, with notes on baboon mortality. *African Journal of Ecology* **33**: 89-100.

Dyksterhuis, E. J. (1958). Ecological principles in range evaluation. *Botanical Reviews* **24**: 253 - 272.

Edwards, D. C. 1940. A vegetation map of Kenya with particular reference to grassland types. *Journal of Ecology* **28**: 377 – 385

Forest Resources Management Project (1997). *Strategic Forest Resource Management Plan, Tabora Region.* (Unpublished).

Gibson, D. J. and Hulbert, L. C. (1987). Effect of fire, topography and year-to-year climatic variation on species composition in tallgrass Prairie. *Vegetation* **72**: 175 - 185.

Greig-Smith, P. (1983). *Quantative Plant Ecology*, 2nd edition. Butterworth, London.

Grime, J. P. (1979). *Plant Strategies and Vegetation Processes.* Wiley, New York.

Groome, J. S., Less, H. M. N. and Wigg, L. T. (1957). A summary of information on *Pterocarpus angolensis. Forestry Abstracts* **18:** 3-8,153-162.

Hamilton, D. I. (1972). *On the ecology and behaviour of the African elephant.* PhD Thesis, Oxford University , Uk.

Harrington, G. N. and Driver, M. A. (1995). The Effect of Fire and Ants on The Seed-Bank of a Shrub in a Semi-Arid Grassland. *Australian Journal of Ecology* **20**: 538 - 547

Harrison, C. (1981). Recovery of lowland grassland and healthland in Southern England from disturbance by seasonal trampling. *Biological Conservation* **19**: 119 - 130.

Hawkins, D. M., Lyaruu, H . V. & Norton, G .W. (1996). *Dalbergia melanoxylon* in Mikumi National Park.: Towards Conservation and Responsible Use of *Dalbergia melanoxylon*, in *Proceedings of The Maputo Workshop 6-9 November 1995* Flora & Fauna International, Cambridge.

Hawkins, D. M., Norton, G. W. and Cunneyworth, P. (2000). Causes and Consequences of Troop Fusion in the Mikumi Yellow Baboons. *Primate Eye* **73**: 9

Heywood, V. H. and Davis, S. D. (1994). *Importance of Plant Diversity.* In: *Centers of Plant Diversity* Vol. 1. Europe, African, Southwest Asia and the Middle East. Scandinavian University Press, Oslo.

Horrell, C. R. and Bredon, R. M. (1963). Management studies with *Panicum maximum* in Uganda. I. Effect of cutting interval and nitrogen fertiliser on yield. *Journal of Experimental Agricutural* **31**: 334 - 342

Huston, M. A. (1994). *Biological Diversity . The Coexistence of Species on Changing Landscapes.* Cambridge University Press. London.

IUCN (1994). *IUCN Red List Categories.* IUCN, Gland, Switzerland.

Johnstone, I. M. (1986). Plant invansion windows: a time-based classification of invasio potential. *Biological Reviews* **61**: 369-394.

Kang, B. T. and Osiname, O. A. (1985). Micronutrient problems in tropical Africa. *Fertilizer Research* **7**:131-150.

Kent, M. & Cóker, P. (1992). *Vegetation description and analysis: A practical approach.* Belhaven Press, 25 Floral Street, London.

Kidung'ho, C. (1990). Nyani wa majano wa Mikumi. *Miombo* **5**: 6.

Kilimanjaro (2004). *Kilimanjaro Adventure Travel*: Tanzania National Parks and Reserves.http://www.Kilimanjaro.com/Tanzania/park_tan.htm. Accessed in 2/1/2005.

Krebs , C. J. (1972). *Ecology; The experimental analysis of distribution and disturbance* . Harper and Row. London.

Krebs, C. J. (1989). *Ecological methodology.* Addison Wisley Longman, 2nd Ed. Harper & Row Publishers. New York.

Krebs, C. J. (1998). *Ecological Methodology.* Addison Wisley Longman, Second Ed. Menlo Park. Califonia.

Lamprecht, H. (1989). *Silviculture in the tropics-Tropical forest ecoststems and their tree species-Possibilities and methods for their long-term utilization-T2-Verlagsgesells chaft mbH, postatch 1164, D-6101 RoBdort*, Germany .

Langdale-Brown, I., Osmaston, H. A. and Wilson, J. G. (1964). *The Vegetation of Uganda and Its Bearing on LandUse.* Government printer, Entebbe.

Laws, R. M. (1970). Elephants as agents of habitat and landscape change in East Africa. *Oikos* **21**: 1-15.

Liddle, M. J. (1975). A selective review of the ecological effects on human trampling on natural ecosystems. *Biological Conservation* **7**: 17-36.

Lovett, J .C. & Norton, G .W. (1989). Afromontane Rainforest on Malundwe Hill in Mikumi National Park, Tanzania. *Biological Conservation* **48**: 13-19

Ludwing J .A. and Reynolds, J. F. (1998). *Statistical Ecology. A Primeron Methods and Computing*. John Wiley & Sons, Inc. Canada.

Lyaruu H.V. (1997). *Plant Community Structure and Land Degradation in Mikumi National Park, Tanzania.* Department of Ecological Botany Uppsala University, Sweden.

Magurran, A. E. (1988). *Ecological Diversity and Its Measurements.* Princeton University Press. Princeton, NewJersey.

May, R .M. (1973). Qualitative stability in model ecosystems. *Ecology* **54**: 638-641.

McNaughton, S. J., Ruess, R .W. and Seagle, S. W. (1988). Large mammals and process dynamics in African ecosystems. *Bioscience* **38**: 794-800.

Medina, E., Silva, F. J. and Solbring, O. T. (1990). Species Diversity , Fire and Herbivory. In: *Biodiversity and Savana Ecology.* Processes. Global Perspectives.

Mercer, G. and Jafferji, J. (2005). *Mikumi National Park* . Gallery Publications Zanzibar, Tanzania.

Misra, K. C. (1989). *Manual of plant ecology.* 3rd Ed. Oxford & IBH Publishing Co. Pvt Ltd, New Delhi.

Mugabe J. and Clark N. (1998). *Managing Biodiversity: National Systems of Conservation and Innovation in Africa.* African Centre for technology studies (ACTS), Nairobi Kenya.

Mwalyosi, R. B. B. (1977). *Vegetation changes in Lake Manyara National Park.* MSc. Thesis. University of Dar es Salaam (Unpublished).

Ndangalasi, H. J. (1997). *Studies on canopy gap characteristics and regenerating species composition in Pugu Forest Reserve,* Tanzania Unpublished Msc. Thesis University of Dar-es-Salaam, Botany Department.

Norton, G. W. (1998). *Mikumi National Park the Unknown Negleted National Park.* Wildlife Conservation Society of Tanzania Dar Es Salaam.

Norton, G. W. & Lyaruu, H. V. (eds.) (1993). *'Wingfields' Checklist of Vascular Plants of Mikumi National Park,* Tanzania (6th edition), Special report Cambridge.

Norton, G. W., Lyaruu, H. V., Wasser, S. K. & Hawkins, D. M. (1992). *Vegetation Monitoring,* Mikumi National Park Special report Cambridge.

Polhill, R. M. (1968). *Tanzania vegetation.* In Inga and Olov Herdberg (eds.). *Conservation of vegetation in Africa South of Sahara.* Alniquist &Wikseils Boktykeri AB, Uppsala, Sweden.

Pratt, D. J. and Gwynne, M. D. (eds.) (1977). *Rangeland management and ecology in East Africa.* Hodder & Stoughton, London.

Putman R. J. and Wratten S. D. (1984). *Principles of Ecology.* Croom Helm Ltd, London and Sydney.

Rhine, R. J. (1992). Estimating reproductive success of primates and other animals with long and incompletely-known life spans. *American Journal of Primatology* **27**: 245-259.

Rhine, R. J., Wasser, S. K and Norton, G. W. (1988). Eight-year study of social and ecological correlates of mortality among immature baboons of Mikumi National Park, Tanzania. *American Journal of Primatology* **16**: 199-212.

Rogers, J. & Kidd, K. K (1993). Nuclear DNA polymorphisms in a wild population of yellow baboons (*Papio hamadryus cynocephalus*) from Mikumi National Park, Tanzania *American Journal of Physical Anthropology* **90**: 477-486.

Ruess, R. W. (1987). *The role of large herbivores in nutrient cycling of tropical savannahs.* In: Walker, B.H. (ed.): Determinants of tropical savannahs. ICSU press, Miami.

Russell, M. B. (1959). *Water and its relations to soils and crops.* Academic Press, Newyork.

Sarmiento, G. (1983). *The savannas of tropical America.* In: Bourliere, F. (ed.): Ecosystems of the world 13. Tropical savanna. Elsevier Scientific Publishing Company-Amsterdam, Oxford and New York.

Sarmiento, G. (1992). Adaptive strategies of perennial grasses in South American savannas. *Journal of Vegetation Science* **3**: 325-336.

Shackelton, C. M. (2000). Comparison of plant diversity in protected and communal lands in the Bushbuckridge Lowveld savanna, South Africa. *Biological Conservation* **94**: 273-285.

Shannon, C. I. and Wiever, W. (1949). *The mathematical theory of communication.* University of Illinois press, urbana, Illinois.

Sinclair, A. R. E. and Norton-Griffiths, M (eds.) (1979). *Serengeti: Dynamics of an ecosystem*, University of Chicago press, Chicago.

Stohlgren, T. J., Falker, M. B. and Schell, L. D. (1995). A modified Whittaker nested vegetation sampling method. *Vegetation* **17**: 113-121.

Swaine, M. D., Hawthorne, W.D. & Orgle, T.K. (1992) The effects of fire exclusion on savanna vegetation at Kpong, Ghana. *Biotropica* **24**: 166–172.

Temu, A. B. (1980). *Miombo Woodland Inventory Design: A Response to Fuel Wood Scarcity in Tabora*, Tanzania. (PhD Thesis).

Teshome Soromessa, Demel Teketay and Sebsebe Demissew. (2004). Ecological Study of the Vegetation in Gamo Gofa zone, southern Ethiopia. *Tropical Ecology* **45** (2): 209-221.

United Nations Environmental Programme (UNEP) (1991). *The State of the World Environment*, UNEP, Nairobi, Kenya.

URT (1998). *Country Study on Biological Diversity.* UNEP/GEC/NORAD

Valentine, D. H. (1972). *Taxonomy, phytogeography and evolution.* Academic Press, London and New York.

Van der Maarel, E. (1979). Transformation of cover abundance value in phytosociology and its effects on community similarity. *Vegetation* 9: 97-114.

Vesey-FitzGerald, D. F. (1963). Central African grasslands. *Journal of Ecology* **51**: 243-274.

Walker, B. H. and Noy-Meir, I. 1982. *Aspects of the stability and resilience of savannah ecosystems.* In: *Huntley, B.J, and Walker, B.H.(eds.): Ecology of tropical savannahs.* Springer-Verlag, Hidelberh.

Walter, H. (1971). *Ecology of tropical and subtropical vegetation.* Trans. Mueller-Dombois, D., Oliver Boyd, Edinburgh.

Walter, H. (1985). *Vegetation of the earth and ecological systems of the geo-biosphere.* 3rd edn., Trans. Muise, O., Springer-Verlag, Berlin.

Walter, R. T. and Gillet, J. H. (1997). The IUCN Species Survival Commission. 1997 IUCN Red List of Threatened Plants.

Wasser, S. K. & Starling, A. K. (1988). Proximate and ultimate causes of reproductive suppression among female yellow baboons at Mikumi National Park, Tanzania. *American Journal of Primatology* 16 (2): 97-121.

WeyerHauser, G. J. (1982). *On the ecology of Lake Manyara elephant.* MSc. Thesis, Yale University , USA.

White, F. (1983). *Vegetation of Africa.* National Resources Research No 20 UNESCO, Paris .

White, P. S. and Pickett, S.T.A. (1985). *Natural Disturbance and Patch Dynamics*: An Introduction. Pages 3.13 In: Pickett S.T.A and White P. S. editors. *The Ecology of Natural Disturbance and Patch Dynamics.* Academic Press, Orlando, Florida.

Whittaker, H. G. (1970). *Communities and Ecosystems.* Collier-Macmillan Ltd. London

Wingfield, R. C. (1975). *Checklist of Mikumi National Park (mimeo)*, University of Dares Salaam.

Wingfield R. C. (1979). Tanzania. In Inga Hedberg (ed) Systematic Botany, *Plant Utilization and Biosphere Conservation.* Proc. of a symposium in commemoration of the 50th anniversary of the University Institute of Systematics. Botany Uppasala, Sweden .

10.0 APPENDICES

Appendix 1: Tree, Shrub, Herb, and grass species identified at Mikumi National Park, Tanzania.

S/No	Scientific name and authority	Family	Habit
1	*Abutilon mauritianum* (Jacq.) Medic	Malvaceae	Herb
2	*Acacia nigrescens* Oliv.	Fabaceae	Tree
3	*Acacia nilotica* (L.) Willd. ex Del.	Fabaceae	Tree
4	*Acacia robusta* Burch.	Fabaceae	Tree
5	*Acacia* zanzibarica (S.Moore) Taub.	Fabaceae	Tree
6	*Acacia senegal* (L.) Willd	Fabaceae	Tree
7	*Acacia sieberiana* DC.	Fabaceae	Tree
8	*Acacia tortilis* (Forssk.) Hayne	Fabaceae	Tree
9	*Adansonia digitata* L.	Bombacaceae	Tree
10	*Afzelia quanzensis*Welw.	Fabaceae	Tree
11	*Ageratum conyzoides* L.	Asteraceae	Herb
12	*Albizia amara* (Roxb.) Boiv.	Fabaceae	Tree
13	*Albizia lebbek* (L.) Benth	Fabaceae	Tree
14	*Amaranthus hybridus* L.	Amaranthaceae	Herb
15	*Amaranthus viridis* L	Amaranthaceae	Herb
16	*Annona senegalensis* Pers.	Annonaceae	Tree
17	*Anthericum corymbosum* Bak.	Anthericaceae	Herb
18	*Anthericum caulescens* Bak.	Anthericaceae	Herb
19	*Antidesma venosum* Tul.	Euphorbiaceae	Tree
20	*Asparagus falcatus* L.	Asparagaceae	Climber
21	*Aspilia mossambicensis* (Oliv.) Wild	Asteraceae	Herb
22	*Balanites aegyptiaca* (L.) Del.	Balanitaceae	Tree
23	*Bidens pilosa* L.	Asteraceae	Herb
24	*Boerhavia diffusa* L.	Nyctaginaceae	Herb
25	*Borassus aethiopum* Mart.	Arecaceae	Tree

Appendix 1 Cont.

S/No.	Scientific name and authority	Family	Habit
26	*Boscia angustifolia* A.Rich.	Capparidaceae	Tree
27	*Brachystegia boehmii* Taub.	Fabaceae	Tree
28	*Brachystegia microphylla* Harms	Fabaceae	Tree
29	*Brachystegia spiciformis* Benth	Fabaceae	Tree
30	*Bridelia cathartica* Bertol.f.	Euphorbiaceae	Shrub
31	*Burkea africana* Hook.	Fabaceae	Tree
32	*Byrsocarpus orientalis* (Baill.) Baker	Connaraceae	Shrub
33	*Cadaba farinosa* Forssk.	Capparidaceae	Shrub
34	*Capparis tomentosa* Lam.	Capparidaceae	Shrub
35	*Cassia abbreviata* Oliv.	Fabaceae	Tree
36	*Catunaregam spinosa* (Thunb.) Tirveng.	Rubiaceae	Tree
37	*Chloris gayana* Kunth	Poaceae	Grass
38	*Cissampelos pareira* L.	Menispermaceae	Climber
39	*Combretum apiculatum* Sond.	Combretaceae	Tree
40	*Combretum collinum* Fres.	Combretaceae	Tree
41	*Combretum fragrans* F.Hoffm.	Combretaceae	Tree
42	*Combretum hereroense* Schinz.	Combretaceae	Tree
43	*Combretum molle* G.Don	Combretaceae	Tree
44	*Combretum zeyheri* Sond.	Combretaceae	Tree
45	*Commelina africana* L.	Commelinaceae	Herb
46	*Commiphora africana* (A.Rich.) Engl.	Burseraceae	Shrub
47	*Cordia africana* Lam.	Boraginaceae	Tree
48	*Cordia monoica* Roxb.	Boraginaceae	Tree
49	*Crabbea velutina* S. Moore	Acanthaceae	herb
50	*Crossopteryx febrifuga* (G.Don) Benth.	Rubiaceae	Tree
51	*Crotalaria retusa* L.	Fabaceae	Herb
52	Cucumis sp.	Cucurbitaceae	Climbers

Appendix 1. Cont.

S/No.	Scientific name and authority	Family	Habit
53	*Cynodon dactylon* (L.) Pers.	Poaceae	Grass
54	*Cyphostemma adenocaule* Wild. & Drumm.	Vitaceae	Herb
55	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	Grass
56	*Dalbergia melanoxylon* Guill. & Perr.	Fabaceae	Tree
57	*Dalbergia nitidula* Bak.	Fabaceae	Tree
58	*Dalechampia parvifolia* L.	Euphorbiaceae	Tree
59	*Deinbollia borbonica* Scheff.	Sapindaceae	Tree
60	*Desmodium barbatum* (L.) Benth.	Fabaceae	Herb
61	*Dichanthium annulatum* (Forssk.) Stapf	Poaceae	Grass
62	*Dichrostachys cinerea* (L.) Wight & Arn.	Fabaceae	Tree
63	*Dioscorea crenata* Vell.	Dioscoreaceae	Herb
64	*Dioscorea buchananii* Benth.	Dioscoreaceae	Herb
65	*Diospyros kirkii* Hiern	Ebenaceae	Tree
66	*Diospyros mespiliformis* A.DC.	Ebenaceae	Tree
67	*Diospyros usambarensis* Gürke	Ebenaceae	Shrub
68	*Diplorhynchus condylocarpon* (Müll. Arg.) Pichon	Apocynaceae	Tree
69	*Dombeya cincinnata* K. Schum ex Engl.	Sterculiaceae	Tree
70	*Dombeya shupangae* K. Schum	Sterculiaceae	Tree
71	*Ehretia amoena* Kl.	Boraginaceae	Tree
72	*Eragrostis racemosa* Steud.	Poaceae	Grass
73	*Euphorbia candelabrum* Kotschy.	Euphorbiaceae	Tree
74	*Euphorbia hirta* L	Euphorbiaceae	Herb
75	*Ficus sur* Forssk.	Moraceae	Tree
76	*Flueggea virosa* (Willd.) Voigt	Euphorbiaceae	Shrub
77	*Grewia bicolor* Juss.	Tiliaceae	Tree
78	*Harrisonia abyssinica* Oliv.	Simaroubaceae	Shrub
79	*Heliotropium indicum* L.	Boraginaceae	Herb

Appendix 1. Cont.

S/No.	Scientific name and authority	Family	Habit
80	*Heliotropium strigosum* Willd	Boraginaceae	Herb
81	*Heliotropium supinum* L.	Boraginaceae	Herb
82	*Heteropogon contortus* (L.) Roem. & Schult.	Poaceae	Grass
83	*Hibiscus cannabinus* L.	Malvaceae	Shrub
84	*Hoslundia opposita* vahl	Lamiaceae	Shrub
85	*Hygrophila auriculata* (Schumach.) Heine	Acanthaceae	Herb
86	*Hyparrhenia rufa* (Nees) Stapf	Poaceae	Grass
87	*Hyphaene petersiana* Mart.	Arecaceae	Tree
88	*Indigofera volkensii* Taub.	Fabaceae	Herb
89	*Isoberlinia scheffieri* (Harms) Greenway	Fabaceae	Tree
90	*Jasminum fluminense* Vell.	Oleaceae	Climber
91	*Julbernardia globiflora* (Benth.) Troupin	Fabaceae	Tree
92	*Justicia betonica* L.	Acanthaceae	Herb
93	*Justicia flava* Vahl	Acanthaceae	Herb
94	*Kigelia africana* (Lam.) Benth.	Bignoniaceae	Tree
95	*Launaea cornuta* (Hochst. ex Oliv. & Hiern) C.Jeffrey	Asteraceae	Herb
96	*Leucas deflexa* Hook.f.	Lamiaceae	Shrub
97	*Leucas nepetaefolia* Benth.	Lamiaceae	Shrub
98	*Lippia Plicata* Bak.	Verbenaceae	Shrub
99	*Lonchocarpus capassa* Rolfe	Fabaceae	Tree
100	*Macrotyloma axillare* (E.Mey.) Verdc.	Fabaceae	Climber
101	*Maerua angolensis* DC.	Capparidaceae	Tree
102	*Maerua edulis* (Gilg & Bened.) DeWolf	Capparidaceae	Shrub
103	*Maerua triphylla* A.Rich.	Capparidaceae	Shrub
104	*Maprounea africana* F. Müll.	Euphorbiaceae	Tree
105	*Margaritaria discoidea* (Baill.) Webster	Euphorbiaceae	Tree

Appendix 1. Cont.

S/No.	Scientific name and authority	Family	Habit
106	*Markhamia obtusifolia* (Baker)Sprague	Bignoniaceae	Tree
107	*Maytenus senegalensis* (Lam.) Excell.	Celastraceae	Shrub
108	*Monechma debile* (Forssk.) Nees	Acanthaceae	Herb
109	*Monotes africana* A.DC.	Dipterocarpaceae	Tree
110	*Ochna mossambicensis* Klotzsch	Ochnaceae	Tree
111	*Ochna holstii* Engl.	Ochnaceae	Tree
112	*Ocimum basilicum* L.	Lamiaceae	Herb
113	*Ocimum suave* Willd.	Lamiaceae	Herb
114	*Panicum coloratum* L.	Poaceae	Grass
115	*Panicum maximum* Jacq.	Poaceae	Grass
116	*Panicum trichocladum* Hack.ex Engl.	Poaceae	Grass
117	*Pavetta gracilipes* Hiern	Rubiaceae	Shrub
118	*Pavetta schumanniana* K.Schum.	Rubiaceae	Shrub
119	*Pennisetum mezianum* Leeke	Poaceae	Grass
120	*Pennisetum polystachion* (L.) Schult.	Poaceae	Grass
121	*Pericopsis angolensis* (Bak.)Van Meeuwen	Fabaceae	Tree
122	*Phoenix reclinata* Jacq.	Arecaceae	Tree
123	*Piliostigma thonningii* (Schumach.) Milne-Redh.	Fabaceae	Tree
124	*Pluchea dioscorides* (L.) DC.	Asteraceae	Shrub
125	*Polygala erioptera* DC.	Polygalaceae	Herb
126	*Polysphaeria braunii* K. Krause	Rubiaceae	Shrub
127	*Polysphaeria parvifolia* Hiern.	Rubiaceae	Shrub
128	*Pseudolachnostylis maprouneifolia* Pax	Euphorbiaceae	Tree
129	*Pteleopsis myrtifolia* (Laws.) Engl. & Diels	Combretaceae	Tree
130	*Pterocarpus angolensis* DC.	Fabaceae	Tree
131	*Rhynchosia minima* (L.) DC	Fabaceae	Climber
132	*Rottboellia cochinchinensis* (Lour.) Clayton	Poaceae	Grass

Appendix 1 Cont.

S/No.	Scientific name and authority	Family	Habit
133	*Rottboellia exceltata* L.F	Poaceae	Grass
134	*Salacia madagascariensis* (Lam.) DC.	Celastraceae	Shrub
135	*Sclerocarya birrea* (A.Rich.) Hochst.	Anacardiaceae	Tree
136	*Senna petersiana* (Bolle) Lock.	Fabaceae	Tree
137	*Senna singueana* (Del.) Lock	Fabaceae	Tree
138	*Setaria sphacelata* (Schumach.) Moss	Poaceae	Grass
139	*Sida acuta* Burm.f.	Malvaceae	Herb
140	*Sida alba* L.	Malvaceae	Herb
141	*Solanum incanum* L.	Solanaceae	Shrub
142	*Spermacoce arvensis* (Hiern) Good	Rubiaceae	Herb
143	*Spirostachys africana* Sond	Euphorbiaceae	Tree
144	*Sporobolus pyramidalis* P.Beauv.	Poaceae	Grass
145	*Sterculia appendiculata* K.Schum. ex Engl.	Sterculiaceae	Tree
146	*Sterculia quinqueloba* Sim	Sterculiaceae	Tree
147	*Stereospermum kunthianum* Cham.	Bignoniaceae	Tree
148	*Strychnos innocua* Del.	Loganiaceae	Shrub
149	*Strychnos spinosa* Lam.	Loganiaceae	Shrub
150	*Swartzia madagascariensis* Desv.	Fabaceae	Shrub
151	*Tamarindus indica* L.	Fabaceae	Tree
152	*Terminalia brownii* Fres.	Combretaceae	Tree
153	*Themeda triandra* Forssk.	Poaceae	Grass
154	*Thilachium africanum* Lour.	Capparidaceae	Shrub
155	*Thilachium macrophyllum* Gilg	Capparidaceae	Shrub
156	*Thilachium paradoxum* Gilg	Capparidaceae	Shrub
157	*Thilachium sp.*	Capparidaceae	Shrub
158	*Tragia furialis* Bojer	Euphorbiaceae	Herb
159	*Tridax procumbens* L.	Asteraceae	Herb
160	*Triumfetta rhomboidea* Jacq.	Tiliaceae	Shrub

Appendix 1 Cont.

S/No.	Scientific name and authority	Family	Habit
161	Tylosema argentea (Chiov.)Brenan	Fabaceae	Climber
162	*Uapaca nitida* Müll.Arg.	Euphorbiaceae	Tree
163	*Urochloa pullulans* Stapf	Poaceae	Grass
164	*Urochloa trichopus* (Hochst.) Stapf	Poaceae	Grass
165	*Vernonia glabra* (Steetz) Vatke	Asteraceae	Herb
166	*Vernonia poskeana* Vatke & Hildeb.	Asteraceae	Herb
167	*Vitex doniana* Sweet	Verbenaceae	Tree
168	*Vitex mombassae* Vatke	Verbenaceae	Tree
169	*Waltheria indica* L.	Sterculiaceae	Herb
170	*Xeroderris stuhlmannii* (Taub.)Mendonca & Sousa	Fabaceae	Tree
171	*Ximenia caffra* Sond.	Olacaceae	Shrub
172	*Xylotheca tettensis* (Klotzsch) Gilg	Flacourtiaceae	Shrub
173	*Zanthoxylum chalybeum* Engl.	Rutaceae	Tree
174	*Ziziphus mucronata* Willd.	Rhamnaceae	Tree

Appendix 2: Summary of the species and their percentage calculated from Mikumi National Park, Tanzania

Family	**No. of species**	**%**
Fabaceae	35	20.11
Poaceae	19	10.92
Euphorbiaceae	12	6.90
Capparidaceae	10	5.75
Asteraceae	8	4.60
Combretaceae	8	4.60
Rubiaceae	7	4.02
Boraginaceae	6	3.45
Acanthaceae	5	2.87
Lamiaceae	5	2.87
Sterculiaceae	5	2.87
Malvaceae	4	2.30
Bignoniaceae	3	1.72
Ebenaceae	3	1.72
Arecaceae	3	1.72
Verbenaceae	3	1.72
Amaranthaceae	2	1.15
Anthericaceae	2	1.15
Celastraceae	2	1.15
Dioscoreaceae	2	1.15
Loganiaceae	2	1.15
Ochnaceae	2	1.15
Tiliaceae	2	1.15
Anacardiaceae	1	0.57
Annonaceae	1	0.57
Apocynaceae	1	0.57

Appendix 2 Cont.

Family	No. of species	%
Asparagaceae	1	0.57
Balanitaceae	1	0.57
Bombacaceae	1	0.57
Burseraceae	1	0.57
Commelinaceae	1	0.57
Connaraceae	1	0.57
Cucurbitaceae	1	0.57
Dipterocarpaceae	1	0.57
Flacourtiaceae	1	0.57
Menispermaceae	1	0.57
Moraceae	1	0.57
Nyctaginaceae	1	0.57
Olacaceae	1	0.57
Oleaceae	1	0.57
Polygalaceae	1	0.57
Rhamnaceae	1	0.57
Rutaceae	1	0.57
Sapindaceae	1	0.57
Simaroubaceae	1	0.57
Solanaceae	1	0.57
Vitaceae	1	0.57

Appendix 3: Mean cover abundance of major species in the community types.

Community types	**1**	**2**	**3**	**4**	**5**	**6**
Community size*	**4**	**9**	**14**	**16**	**30**	**13**
Abutilon mauritianum	0.00	0.00	0.00	0.31	0.00	0.00
Acacia nigrescens	0.00	0.00	0.00	0.00	**5.60**	0.00
Acacia nilotica	0.00	0.00	0.14	0.31	0.00	0.00
Acacia robusta	0.00	0.00	0.00	0.00	0.67	0.00
Acacia zanzibarica	0.00	0.00	0.00	0.00	0.07	0.00
Acacia sieberiana	**3.25**	0.00	1.14	**3.94**	0.00	0.00
Acacia senegal	0.00	0.00	0.00	0.00	**1.20**	0.00
Ageratum conyzoides	0.00	0.78	0.00	0.19	0.00	0.00
Albizia amara	0.00	0.00	0.36	0.00	0.17	0.00
Annona senegalensis	0.00	0.00	0.00	0.00	0.00	**3.00**
Anthericum corymbosum	0.00	0.00	0.00	0.06	0.00	0.00
Antidesma venosum	0.00	0.00	0.00	0.00	0.00	0.92
Aspilia mossambicensis	0.00	0.00	0.00	0.00	0.07	0.00
Balanites aegyptiaca	0.00	0.00	0.43	0.31	0.20	0.00
Boscia angustifolia	0.00	0.00	0.00	0.00	0.17	0.00
Brachystegia boehmii	0.00	0.00	0.00	0.00	0.00	**6.15**
Brachystegia microphylla	0.00	0.00	0.00	0.00	0.00	**1.92**
Brachystegia spiciformis	0.00	0.00	0.00	0.00	0.00	**5.15**
Bridelia cathartica	0.00	0.00	0.00	0.00	0.00	**2.00**
Brysocarpus orientalis	0.00	0.00	0.00	0.00	0.40	0.38
Burkea africana	0.00	0.00	0.00	0.00	0.00	0.46
Cadaba farinosa	0.25	0.22	0.00	0.00	0.17	0.00
Capparis tomentosa	0.75	0.33	0.00	0.00	0.00	0.00
Carchorus sp.	0.00	0.00	0.00	0.13	0.00	0.00
Cassia abbreviata	0.00	0.00	**3.29**	0.31	0.43	0.00
Catunaregam spinosa	0.00	0.00	0.00	0.00	0.17	**1.54**
Chloris gayana	0.00	0.00	0.00	0.44	0.00	0.00

Appendix 3. Cont.

Community types	1	2	3	4	5	6
Community size*	**4**	**9**	**14**	**16**	**30**	**13**
Cissampelos pareira	0.00	0.00	0.00	0.00	0.00	0.00
Combretum apiculatum	0.00	0.00	0.43	0.00	0.50	0.00
Combretum collinum	0.00	0.00	0.50	0.00	**2.13**	0.00
Combretum fragrans	0.00	0.00	**2.36**	0.38	0.00	0.00
Combretum hereroense	0.00	0.00	**1.29**	0.50	0.00	0.00
Combretum molle	0.00	0.00	**1.29**	0.31	0.03	1.00
Combretum zeyheri	0.25	0.11	**2.50**	0.31	**3.87**	0.38
Commelina africana	0.00	0.00	0.21	0.00	0.00	0.00
Commiphora africana	0.00	0.00	0.43	0.00	**2.17**	0.00
Cordia monoica	0.75	0.00	0.00	0.00	0.00	0.00
Crossopteryx febrifuga	0.00	0.00	0.00	0.00	0.00	**2.15**
Cynodon dactylon	0.00	0.00	0.07	0.38	0.00	0.00
Cyphostemma adenocaule	0.00	0.00	0.00	0.13	0.00	0.00
Dactylectenium aegyptiaca	0.00	0.00	0.00	0.00	0.07	0.00
Dalbergia melanoxylon	0.00	0.00	0.21	0.31	**5.03**	0.38
Deinbollia borbonica	0.00	0.00	0.00	0.00	0.00	0.00
Desmodium barbatum	0.00	0.00	0.00	0.00	0.00	0.23
Dichanthium annulatum	0.00	0.33	0.00	0.06	0.00	0.00
Dichostachys cinerea	0.00	0.00	0.00	0.00	0.17	0.00
Diospyros kirkii	0.00	0.00	0.00	0.00	0.00	0.23
Diospyros mespiliformis	**2.50**	0.00	0.00	0.00	0.00	0.00
Diospyros usambarensis	0.00	0.00	**1.93**	1.00	0.53	0.00
Diplorhynchus condylocarpon	0.00	0.00	0.36	0.00	0.00	**2.46**
Ehretia amoena	0.00	0.00	0.00	0.06	0.00	0.00
Euphorbia hirta	0.00	0.00	0.14	0.06	0.00	0.00
Ficus sur	0.00	0.00	0.43	0.00	0.00	0.00

Appendix 3 Cont.

Community types	**1**	**2**	**3**	**4**	**5**	**6**
Community size*	**4**	**9**	**14**	**16**	**30**	**13**
Flueggea virosa	**5.00**	1.11	0.64	0.38	0.33	1.38
Grewia bicolor	0.00	0.00	0.00	0.00	0.97	0.00
Harrisonia abyssinica	0.00	**1.89**	0.21	0.00	0.00	0.00
Heteropogon contortus	0.75	0.00	0.71	0.56	0.50	1.38
Hibiscus cannabinus	0.00	0.00	0.00	0.19	0.00	0.00
Hoslundia opposita	0.00	0.00	0.50	0.38	0.90	0.38
Hygrophila auriculata	0.00	**4.22**	0.00	0.00	0.00	0.00
Hyparrhenia rufa	0.00	1.33	**1.50**	**4.13**	**1.40**	**2.69**
Jasminum fluminense	0.75	0.00	0.00	0.00	0.00	0.00
Julbernardia globiflora	0.00	0.00	0.00	0.00	0.00	2.62
Justicia betonica	1.00	0.11	0.00	0.00	0.07	0.00
Justicia flava	0.25	0.00	0.00	0.00	0.00	0.00
Kigelia africana	0.00	0.00	**1.43**	0.38	0.00	0.00
Launaea cornuta	0.00	0.00	0.14	0.13	0.00	0.00
Leucas deflexa	0.00	0.00	0.07	0.00	0.00	0.00
Lonchocarpus capassa	1.00	0.67	**7.36**	**2.25**	0.27	0.00
Macrotyloma axillare	0.75	0.00	0.00	0.00	0.00	0.00
Maerua angolensis	0.00	0.00	0.00	0.00	0.30	0.00
Maerua edulis	0.00	0.00	0.86	0.00	0.07	0.00
Maerua triphylla	0.50	0.00	0.00	0.00	0.00	0.00
Margaritaria discoidea	0.00	0.00	0.36	0.00	0.27	**4.77**
Markhamia obtusifolia	0.00	0.11	0.36	0.00	**1.23**	0.00
Monochma debile	0.75	**1.78**	0.14	0.63	0.13	0.00
Monotes africana	0.00	0.00	0.00	0.00	0.00	0.69
Ochna holstic	0.00	0.00	0.00	0.00	0.00	0.62
Ochna mossambicensis	0.00	0.00	0.00	0.00	0.00	0.54
Ocimum basilicum	0.00	0.00	0.00	0.13	0.00	0.00

Appendix 3. Cont.

Community types	1	2	3	4	5	6
Community size*	**4**	**9**	**14**	**16**	**30**	**13**
panicum coloratum	0.00	0.00	0.00	0.50	1.03	0.23
Panicum maximum	**3.75**	0.00	0.43	0.13	0.37	0.54
Panicum trichocladum	0.00	0.00	0.00	0.00	0.00	0.00
Pavetta schumanniana	0.00	0.00	0.00	0.00	0.00	0.08
Pennisetum mezianum	0.00	**2.22**	0.00	0.38	0.07	0.00
Pennisetum polystachion	0.00	0.00	0.00	0.00	0.00	0.00
Pericopsis angolensis	0.00	0.00	0.00	0.00	0.00	**2.62**
Piliostigma thonningii	0.00	0.00	0.00	0.00	0.00	**2.15**
Pluchea dioscorides	0.00	0.00	0.00	0.31	0.00	0.00
Pseudolachnostylis maprouneifolia	0.00	0.00	0.00	0.00	0.00	0.46
Pteleopsis myrtifolia	0.00	0.00	0.00	0.00	**1.13**	0.00
Rhynchosia minima	0.00	0.22	0.00	0.06	0.00	0.00
Rottboellia exceltata	0.00	0.00	0.00	0.00	0.00	0.38
Salacia madagascariensis	0.25	0.00	0.00	0.00	0.20	0.00
Sclerocarya birrea	0.00	0.00	0.00	0.31	0.17	0.00
Setaria sphacelata	0.00	0.00	0.00	0.19	0.00	0.00
Sida acuta	0.00	0.00	0.29	0.31	0.00	0.00
Spermacoce arvensis	0.00	0.00	0.00	0.00	0.00	0.38
Sporobolus pyramidalis	0.00	**3.11**	0.00	0.94	0.00	0.00
Sterculia appendiculata	0.00	0.00	0.43	0.00	0.00	0.00
Sterculia quinqueloba	0.00	0.00	0.00	0.00	0.50	0.00
Stereospermum kunthianum	0.00	0.00	0.00	0.00	0.03	**1.77**
Strychnos innocua	**2.25**	0.00	0.00	0.00	0.00	0.31
Strychnos spinosa	0.00	0.00	0.00	0.00	0.00	0.31
Swartzia madagascariensis	0.00	0.00	0.00	0.00	0.00	0.38
Tamarindus indica	0.00	0.00	0.93	0.00	0.17	0.00

Appendix 3. Cont.

Community types	**1**	**2**	**3**	**4**	**5**	**6**
Community size*	**4**	**9**	**14**	**16**	**30**	**13**
Terminalia brownii	0.00	0.00	0.43	0.00	0.00	0.00
Themeda triandra	0.00	**1.56**	0.50	0.88	**2.80**	**2.23**
Tragia furialis	0.00	0.22	0.00	0.25	0.00	0.00
Triumfetta rhomboidea	0.00	0.00	0.00	0.00	0.00	0.38
Uapaca nitida	0.00	0.00	0.00	0.00	0.00	0.69
Urochloa pullulans	0.50	1.22	1.07	**1.75**	0.33	0.00
Vernonia glabra	0.00	0.00	0.79	0.94	0.00	0.00
Vernonia poskeana	0.00	0.00	0.00	0.06	0.00	0.00
Vitex doniana	0.00	0.00	0.00	0.00	0.00	0.77
Xeroderris stuhlmannii	0.00	0.00	**1.43**	0.00	**1.47**	**1.77**
Ximenia cafra	0.00	0.00	0.07	0.00	0.00	0.00
Xylotheca tettensis	0.00	0.00	0.00	0.00	0.00	0.00
Zanthoxylum chalybeum	0.00	0.00	0.00	0.00	0.27	0.00
Ziziphus mucronata	**1.25**	0.00	0.00	0.00	0.00	0.00

***Number of quadrats grouped to form each community type; Highlighted numbers in the table represent the dominant species in each plant community.**

Appendix 4: Summary of Relative Frequency, Dominance and Density and Importance Value Indices of Woody species found Mikumi National Park, Tanzania.

Species name	Freq	Density	Bain m2	RF	RDsp	Rba	IVI
Acacia nigrescens	27.00	123.00	7.73	8.31	8.47	9.07	25.84
Acacia nilotica	2.00	2.00	0.04	0.62	0.14	0.05	0.80
Acacia robusta	5.00	10.00	0.97	1.54	0.69	1.14	3.37
Acacia zanzibarica	2.00	5.00	0.05	0.62	0.34	0.06	1.02
Acacia sieberiana	14.00	61.00	1.81	4.31	4.20	2.12	10.63
Acacia senegal	7.00	12.00	0.28	2.15	0.83	0.33	3.31
Albizia amara	2.00	3.00	1.22	0.62	0.21	1.43	2.25
Annona senegalensis	9.00	41.00	0.70	2.77	2.82	0.82	6.41
Balanites aegyptiaca	3.00	4.00	0.62	0.92	0.28	0.72	1.92
Brachystegia boehmii	11.00	98.00	8.73	3.38	6.74	10.24	20.37
Brachystegia microphylla	4.00	10.00	3.89	1.23	0.69	4.56	6.48
Brachystegia spiciformis	8.00	69.00	6.48	2.46	4.75	7.60	14.81
Burkea africana	3.00	7.00	1.59	0.92	0.48	1.87	3.27
Cassia abbreviata	11.00	20.00	0.71	3.38	1.38	0.83	5.59
Caturegam spinosa	1.00	1.00	0.01	0.31	0.07	0.01	0.39
Combretum collinum	12.00	50.00	1.82	3.69	3.44	2.13	8.72
Combretum fragrans	4.00	5.00	0.05	1.23	0.34	0.06	1.63
Combretum hereroense	3.00	17.00	0.24	0.92	1.17	0.28	2.37
Combretum molle	10.00	14.00	0.29	3.08	0.96	0.34	4.38
Combretum zeyheri	17.00	84.00	2.29	5.23	5.78	2.68	13.69
Commelina africana	3.00	6.00	0.13	0.92	0.41	0.16	1.49
Cordia monoica	1.00	5.00	0.20	0.31	0.34	0.23	0.89
Crossopteyx febrifuga	5.00	10.00	0.22	1.54	0.69	0.26	2.49
Dalbergia melanoxylon	23.00	337.00	15.59	7.08	23.19	18.29	48.56
Diospyros kirkii	1.00	1.00	0.02	0.31	0.07	0.02	0.40

Appendix 4 Cont.

Species name	Freq	Density	Bain m2	RF	RDsp	Rba	IVI
Diplorhynchus condylocarpon	3.00	5.00	0.83	0.92	0.34	0.98	2.25
Diospyros mespiliformis	2.00	5.00	1.06	0.62	0.34	1.24	2.20
Ficus sur	1.00	1.00	0.98	0.31	0.07	1.14	1.52
Grewia bicolor	5.00	7.00	0.12	1.54	0.48	0.14	2.16
Julbernardia globiflora	5.00	36.00	1.39	1.54	2.48	1.64	5.65
Kigelia africana	3.00	5.00	1.73	0.92	0.34	2.02	3.29
Lonchocarpus capassa	18.00	114.00	1.54	5.54	7.85	1.81	15.19
Maerua angolensis	2.00	2.00	0.02	0.62	0.14	0.02	0.78
Margaritaria discoidea	17.00	67.00	5.17	5.23	4.61	6.07	15.91
Markhamia obtusifolia	2.00	6.00	0.08	0.62	0.41	0.09	1.12
Monotes africana	2.00	7.00	0.25	0.62	0.48	0.29	1.39
Ochna holstic	1.00	1.00	0.01	0.31	0.07	0.01	0.39
Ochna mossambicensis	1.00	2.00	0.03	0.31	0.14	0.04	0.48
Pericopsis angolensis	6.00	15.00	1.39	1.85	1.03	1.63	4.51
Piliostigma thonningii	7.00	17.00	0.86	2.15	1.17	1.01	4.34
Pseudolachnostylis maprouneifolia	3.00	14.00	0.43	0.92	0.96	0.51	2.39
Pteleopsis myrtifolia	8.00	53.00	2.39	2.46	3.65	2.81	8.92
Pterocarpus angolensis	3.00	13.00	0.48	0.92	0.89	0.57	2.39
Sclerocarya birrea	1.00	1.00	0.17	0.31	0.07	0.20	0.58
Sterculia appendiculata	1.00	1.00	0.35	0.31	0.07	0.41	0.79
Sterculia quinqueloba	3.00	7.00	0.49	0.92	0.48	0.58	1.98
Stereospermum kunthianum	4.00	6.00	0.59	1.23	0.41	0.69	2.33
Strychnos innocua	1.00	3.00	0.07	0.31	0.21	0.09	0.60
Swartzia madagascariensis	1.00	3.00	0.07	0.31	0.21	0.08	0.60
Tamarindus indica	4.00	7.00	1.12	1.23	0.48	1.31	3.02

Appendix 4 Cont.

Species name	Freq	Density	Bain m2	RF	RDsp	Rba	IVI
Terminalia brownii	1.00	2.00	0.22	0.31	0.14	0.25	0.70
Uapaca nitida	2.00	5.00	0.10	0.62	0.34	0.12	1.08
Vitex doniana	3.00	5.00	0.04	0.92	0.34	0.05	1.32
Xeroderris stuhlmannii	24.00	50.00	7.39	7.38	3.44	8.66	19.49
Zanthoxylum chalybeum	2.00	3.00	0.15	0.62	0.21	0.18	1.00
Ziziphus mucronata	1.00	3.00	0.03	0.31	0.21	0.04	0.55
Total	325.00	1461.00	85.26	100.00	100.00	100.00	300.00

Key to the abbreviations used in the headings of Appendix 4.

Freq is the frequency (occurrences) of species

Rf is the Relative Frequency of species

RD is the Relative Density of Species

Bainm^2 is the Basal Area in m^2

RDom is the Relative Dominance of species

IVI is the Important Value Index of species

Appendix 5: The Index of Dominance of the woody species in Mikumi National Park

Species Name	**Numberofindividuals**	**Index of Dominance**
Acacia nigrescens	123	0.00708777
Acacia nilotica	2	0.00000187
Acacia robusta	10	0.00004685
Acacia zanzibarica	5	0.00001171
Acacia sieberiana	61	0.00174325
Acacia senegal	12	0.00006746
Albizia amara	3	0.00000422
Annona senegalensis	41	0.00078753
Balanites aegyptiaca	4	0.00000750
Brachystegia boehmii	98	0.00449937
Brachystegia microphylla	10	0.00004685
Brachystegia spiciformis	69	0.00223048
Burkea africana	7	0.00002296
Cassia abbreviata	20	0.00018740
Catunaregam spinosa	1	0.00000047
Combretum collinum	50	0.00117122
Combretum fragrans	5	0.00001171
Combretum hereroense	17	0.00013539
Combretum molle	14	0.00009182
Combretum zeyheri	84	0.00330566
Commelina africana	6	0.00001687
Cordia monoica	5	0.00001171
Crossopteryx febrifuga	10	0.00004685
Dalbergia melanoxylon	337	0.05320585
Diospyros kirkii	1	0.00000047

Appendix 5 Cont.

Species Name	**No.of individuals**	**Index of dominance**
Diplorhynchus condylocarpon	5	0.00001171
Diospyros mespiliformis	5	0.00001171
Ficus sur	1	0.00000047
Grewia bicolor	7	0.00002296
Julbernardia globiflora	36	0.00060716
Kigelia africana	5	0.00001171
Lonchocarpus capassa	114	0.00608849
Maerua angolensis	2	0.00000187
Margaritaria discoidea	67	0.00210305
Markhamia obtusifolia	6	0.00001687
Monotes africana	7	0.00002296
Ochna holstii	1	0.00000047
Ochna mossambicensis	2	0.00000187
Pericopsis angolensis	15	0.00010541
Piliostigma thonningii	17	0.00013539
Pseudolachnostylis maprouneifolia	14	0.00009182
Pteleopsis myrtifolia	53	0.00131599
Pterocarpus angolensis	13	0.00007917
Sclerocarya birrea	1	0.00000047
Sterculia appendiculata	1	0.00000047
Sterculia quinqueloba	7	0.00002296
Stereospermum kunthianum	6	0.00001687
Strychoa innocua	3	0.00000422
Swartzia madagascariensis	3	0.00000422
Tamarindus indica	7	0.00002296
Terminalia brownii	2	0.00000187
Uapaca nitida	5	0.00001171

Appendix 5 Continued.

Species Name	**No.of individuals**	**Index of dominance**
Vitex doniana	5	0.00001171
Xeroderris stuhlmanniii	50	0.00117122
Zanthoxylum chalybeum	3	0.00000422
Ziziphus mucronata	3	0.00000422
Total	1461	1.00000000