THE DISTRIBUTION OF TWO MAJOR PLANT GROUPS (BRYOPHYTES AND TRACHEOPHYTES) ALONG AN ALTITUDINAL GRADIENT ON NARO MORU TRACK, MOUNT KENYA.

BY

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DECLARATION

I certify that this thesis is my original work and has not been presented in any other University.

Signé é é é é é é é é é é é é é é é é é é é

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DEDICATION

This work is dedicated to my dear husband George, and children David, Yang, Cissie, and Gorrel.

And

To the nation and people of Kenya; to whom the Almighty GOD bestowed the responsibility to conserve its splendor.

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To all I pray that GOD will mightily once again use you in a special way to help others too.

AND TO MY GOD, I AM REALLY GRATEFUL FOR GIVING ME STRENGTH AND COURAGE TO ENDURE, THANK YOU LORD, AMEN.

ABSTRACT

Tropical mountain forests are known as the cradle of flowering plants and have many archaic angiosperm taxa. However processes of climate change and human activities have resulted in massive degradation and loss of mountain biodiversity. In Mt. Kenya, human activities have caused the shifting of the forest base margin to higher altitudes, increased soil erosion with resultant increase in sedimentation of wetlands, rivers and water storage dams down steam posing serious and economic consequences. The presence of cryptogams are known to contribute to the good health of mountain ecosystems, however their composition, abundance and distribution in the face of the ongoing forest destruction in Mt Kenya is not clear. The aim of this study was therefore, to establish the taxonomic and ecological relationship between one group of cryptogams- the bryophytes and tracheophytes along an altitudinal gradient using Narumoru tract of the western slope of Mt. Kenya. Plants were sampled at an interval of 200m from 2400 to 4800m. The higher plants were sampled along a 50 m transect using 10m by 10 m plots while the bryophytes were sampled using 10 x5cm quadrats of the same plots where higher plants were collected. Fine-scale variations in bryophyte communities were investigated in nine microhabitats including the soil surface, humus layer, decaying lignin, stem trunks, rachises, rocks and water edges. All the specimens collected were identified in the field and later confirmed at the University of Nairobi (NAI) and National Museums of Kenya (EA) herbaria. Data analysis and descriptive and inferential measures of species diversity were done using SPSS computer program. The results showed that bryophytes had the highest diversity (50.6%) followed by angiosperms (47.3%), while gymnosperms had the lowest (1.3%). There was a general decrease in the plant species diversity from 2400m to 4600m asl, the optimum levels being at 2400 and 3000m asl (each containing over 350 species). At least five microhabitats were identified with the most diverse bryophytes being the humicolous and corticolous types (80%) while the least was aquatic (0.001%). It is hoped that data accrued from this study will aid in the conservation of the Mt Kenya mountain flora. The aim of this study was to establish the taxonomic and ecological relationship between bryophytes and tracheophytes along western slope of Mt. Kenya and this has been determined whereby the study revealed that NMT of Mt. Kenya harbors a high diversity of bryophytes and tracheophytes 81 and 83 in percentage it is 50 and 49 respectively. The study has also demonstrated that the diversity and distribution of bryophytes and the tracheophytes is influenced firstly by altitude and secondly by the microhabitats provided by natural features such as bogs, rocks and the tracheophytes themselves. Therefore, the taxonomic information of the less studied and less appreciated groups is essential in laying down the strategies to conserve Mt. Kenya.

Key words: Tracheophytes, Bryophytes, Diversity, Distribution, Microhabitat, Angiosperms, Pteridophytes, Gymnosperms.

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CHAPTER ONE

INTRODUCTION

1.1 Significance of Mountain Ecosystem in Africa

Mountains cover 20.4 % of the Earth's land surface and contain 26.5% of the world's forests (Kapos *et al.*, 2000), and are home to 12% of the global human population. They provide protection of watersheds and damage to transport infrastructure, are centers of biodiversity conservation, important sources of timber, fuel wood and places for tourism, recreation and sacredness. Also many mountains are considered as potential carbon sinks and are vital in mitigation of climate change (Myers *et al*., 1988).

Africa has an approximate area of 30.221 million km² which represents 6% of the worldôs land mass with a population of 1.03 billion. Of this population, 2% get their livelihood from the forests. In Africa, mountains contain 12 % of the worldôs forests (Houghton et *al.,* 1993). Almost all mountain ecosystems on the African continent have significantly been decreasing in their natural resources, (UNESCO, 1992) because more than 70% of the African workforce is engaged in deforestation for commercial land use and agriculture (M.A., 1997).

East African mountain ecosystems are spectacular and rise above the snow line in the equatorial region (Newmark, 2002). They provide habitation to wide range of biodiversity like the giant apes in Bwindi forest and primates and birds in Kibale National Park in Uganda (Rogers *et al.,* 1982). Kenya has a total area of 585,644 km² with forests in altitudes varying from sea level to the forested mountains over 5000m in height. Forests and wildlife are critical natural assets for

Kenya. They are also vital as wildlife habitats and water catchment areas (KWS, 1999). Most of the Kenyan mountains and highland forests stand the risk of degradation because of climate variability and human activities.

Mt. Kenya region which comprises the National Park and the Forest Reserve is among the 17 worldôs biodiversity hotspots (KWS, 1999). Human encroachment through illegal farming (KWS, 1999), grazing of livestock and logging have reduced its original forest zone from 1600m to 1800m. The destruction of Mt. Kenya forests is the highest recorded among Kenyan forests and has contributed upto 25% of the total loss in national forest size. The most targeted species are; *Juniperus procera, Olea africana*, *Vitex keniensis*, Croton *macrostachys* species and *Newbotonia* species which occur mostly on the western slopes (KWS, 2010).

Mt Kenya is reputed for its high biodiversity with the variation in rainfall and altitudinal gradient being the determining factors. The mountain exhibits four vegetation types which are Firstly, the montane forest belt which lies between altitudes 1800 to 3000m asl and has precipitation above 1000mm (Decurtins, 1992). In this vegetation zone, are found majority of tree species many of which are now threatened due to close proximity to the neighboring inhabited region and its gentle terrain. In fact this region is considered to be people friendly and does not cause any type of mountain sickness to climbers (KWS, 2012). The next is the Ericaceous woodland, also referred to as subalpine zone. This zone occurs between altitudes 3000m and 3400m and receives annual rainfall of 1500mm (Decurtins, 1992). As the altitude increases, the vegetation type also changes adapting to the changing soils and lower amount of precipitation available in the area, giving way to third zone- the afro alpine belt at 3450m asl and an annual rainfall of 700mm

(Decurtins, 1992). After this, the Afro-Alpine zone in which tree groundsel and the giant lobelia rise out of a ground vegetation of tussocky grassland and *Helichrysum newii*) and the heath zone Up to the snowline (3500-5195m asl).

According to Kenya Wildlife Service (1999), the total number of indigenous trees that had been felled from all parts of the mountain slopes by the year 2000 was 14,622. Extensive destruction of the Mt. Kenya forests cause long term negative impacts leading to destruction of wildlife habitats, biodiversity and affects flows of river Ewaso Nyiro. Forest destruction impairs water catchment, reducing water supply downstream and effectively killing the forest sector. The various vegetation types play a major role on the mountain in hydrological cycles and their conservation is extremely important. Therefore an understanding of the components of the different vegetation types through monitoring and research is the only way to effect conservation measures to ensure that Mt Kenya is saved from total destruction. In addition if Mt. Kenya is destroyed, the many river tributaries that originate from it and feeding river Tana will dry up leading to a reduction in power production (river Tana is the home of Kenyaĝs power producing stations; Masinga, Kindaruma, Kitaru, Kamburu and Kiambere) (Tourist guide map, 2010).

Mt. Kenya vegetation is rich in biodiversity in terms of ecological systems and plant species (Beentje, 1994) which has attracted many researchers as demonstrated in table (1.1).

Table 1.1 Historical research in Mount Kenya and their areas of emphasis

Author	Location on Mt. Kenya	Area of Emphasis
Moreau, 1944	All vegetation belts	Biodiversity inventory
Fries et *al.,* 1948	All vegetation belts	Vegetation classification
Hedberg, 1969	Montane forest	Vascular Plants and Musci
Agnew, 1985	Montane zone	Population study on two species
Zamierowski, 1975	Montane zone	Foliar leaching of tree species (Nanyuki and Chehe)
Rehder *et al.,* 1981	Alpine Zone	Vegetation analysis
Smith *et al.,* 1987	Alpine Zone	Population studies of *Lobelia* species
Mulkey *et al.,* 1984	Alpine Zone	Predation of *Senecio keniodendron* by elephants
Blackett, 1994	Montane forest	Stocks and volume of 10 common trees
Bussmann, 1994	Montane forest	Inventory, Ecology, Threats, Management

1.2 Mountains as conservation areas for water and soil

Almost all of the worldôs rivers arise in mountains (Bandyopadhyay *et al.*, 1997) and they are therefore the major sources of freshwater for lowland ecosystems and communities. Worldwide, 214 river basins are home to 40 per cent of the world's population; the Ganges River arises from the Himalaya, while rivers Rhine, Rhone and Danube all arise from the Alps providing water to a population of about 400 million people (Bandyopadhyay *et al.,* 1997).

The peaks of Africa's highest mountains, namely Mt. Kilimanjaro 5,895m, Kenya 5199m, and the Ruwenzori 5109m range, are snow caped. These three mountains act as crucial all-year water reservoirs and are sources of water for the regionsô world-famous game parks and also for the irrigation of millions of hectares downstream (Newmark, 2002).

Mt. Kenya is the most important of Kenyaôs five major ówater towersô (the others being Aberdare range, Mau complex, Cherengôani Hills and Mt. Elgon), and is the main water catchment for the Ewaso Nyiro ecosystem. It provides more than 40% of the country's water requirement and for the country's most important hydro-electric power plants such as the Seven Forks Hydropower plants that produce over 50% of Kenya's total electricity output (UNCED, 1992). The peaks of Mt. Kenya (Figure 1.1) are constantly covered with clouds that fall back as rain. Ewaso Nyiro River which originates from the mountain is the only river supplying water to Samburu County, Shaba Buffalo springs national reserves in north eastern region (Bussmann, 1994).

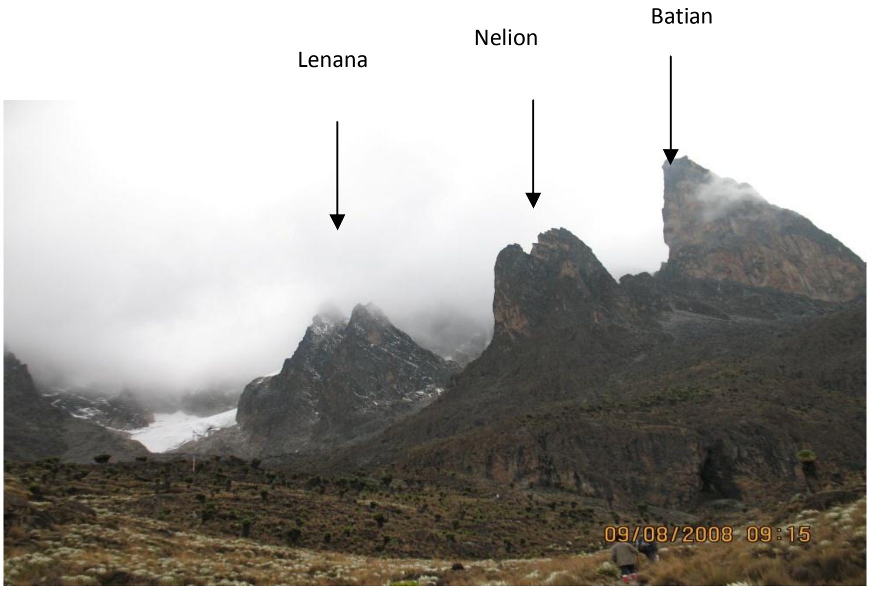


Figure 1.1 Three cloud-covered peaks of Mt Kenya: Lenana, Nelion and Batian

(Taken by author, 2008)

1.3 Mountain effects on climatic zonation

Mountains are significant field laboratories for the resolution of many problems associated with global warming (Kundzewicz & Robson., 2000). Precipitation that forms on the mountains has a great impact on the distribution of the worldôs climatic zones (Kattelmann *et al.,* 1993). Watanabe et al., (1994) found out that when thin mountain soils are saturated, frozen or replaced by bare rock, overland flow is enhanced, while Fritts & Rodda (1998) discovered that vegetation type, area coverage, and canopy density can affect hydrological interactions of a given area. Groundwater affects surface hydrology according to land gradient, geology, land cover and rainfall pattern.

1.4 Mountains as recreation areas for urbanized societies

In developed countries, more than half of the population lives in urban areas (Price *et al.,* 1997). The rapid increase in global urbanization demands for leisure and recreational areas (Williams *et al.*, 1991) and mountains offer a rich source due to their variety of vast natural landscapes. If taken into account that tourism employs more than 12 million people and that this number will increase in the coming decades, it is clear that mountains will take a decisive role in tourism, the worldôs largest industry (Price *et al.*, 1997).

In Africa, land-based tourism is a major economic activity every year generating millions of dollars in foreign exchange earnings (Emmerton & McCarter 1994). Sites such as the pyramids of Egypt, the Great Rift Valley of Eastern and Southern Africa as well as Africaôs major mountains such as the Table Mountain in South Africa, Mt. Kenya in Kenya and Mt. Kilimanjaro in Tanzania are some of the major tourist attraction features (Emmerton & McCarter 1994). Mt. Kenya, with its rugged glacier-clad summits, afro-alpine moorlands and diverse montane forests is one of the most impressive landscapes in Eastern Africa (Emmerton & McCarter 1994), although it is as yet undeveloped as a recreational and tourist destination attracts both domestic and international visitors. Between the years 1996 and 1997 there were a total of 14,000 visitors to Mount Kenya National Park, 30 per cent of who were international tourists (KWS, 1999). The mountain was declared a World Heritage Site in 1997 and gained international recognition as a Biosphere Reserve in 1978 under the UNESCOôs Man and Biosphere Programme, (Hemp et al., 2006).

1.5 Mountain forests are a wealth of biodiversity

Mountain forests are a wealth of biodiversity and may be the only areas left at the rate that forests around the world are being destroyed. Eastern Arc Mountains are among the 17 most threatened tropical eco-systems because of their biodiversity (Miltermeier *et al*., 2000) and are estimated to harbor between5 to 30 million species (Erwin, 1982). The world treeless alpine life zone alone accounts for 3% of the land surface area and hosts a vast biological richness, exceeding that of many low elevation biotas (Longmann *et al.,* 1974). The overall global plant species richness of the alpine life zone alone is estimated to be around 4% of the global number of higher plant species, (Körner, 2002). Tropical and sub-tropical mountains include major center of global biodiversity. It is documented that moist tropical forests cover only 7% of the earthĝs surface, yet they contain more than half of the worldĝs species (Langdale *et al.*, 1964). Kenyan mountain forests are endowed with a rich array of plant and animal life and some of the plant species such as *Lobelia* and *Senecio* species are endemic to the forest habitats, (Mazingira, 2008). These forests therefore remain refuges for a great wealth of endemic species, specialized ecosystems and remarkable landscapes (Longmann *et al.*, 1974).

Mt. Kenya, with a wide range in altitude, rainfall amount and eight different natural forest types, harbors a rich biological biodiversity (Lassau *et al*., 2005). Large mammals of international conservation interests in Mt. Kenya forests are; elephants, black rhinos, giant forest hogs, the bongo and black fronted duiker. Records on plants diversity show there are over 800 plant species belonging to 479 genera and 146 families that have been identified (Lassau *et al.,* 2005), excluding the bryophytes. Due to poor identification of the latter group they are inadvertently left out (Chuah, 2003).

Bryophytes are second in diversity after the flowering plants but difficulties in their identification, and lack of literature from tropical areas are a problem for their inclusion in biodiversity surveys (Pharo *et al*., 1997). Bryophytes occupy all types of mountain habitats and are ideal candidates for altitudinal gradient studies (Andrew *et al*., 2003). Several descriptive studies of Bryophytes and their altitudinal zonation have been done in Sierra Nevada de Santa Marta, Colombia (Van Reenen *et al*., 1984), Bolivia, Peru, and Columbia (Kessler, 2001), on Mt. Kinabalu in Malasya (Frahm, 1990), Mt. Kilimanjaro (Pócs, 1994) and La Reunion (Ah-Peng, 2005).

Species diversity and distribution are related to geographical parameters: latitudinal and altitudinal gradients (Lomolino, 2001), environmental variables (Whittaker *et al*., 2001) and microhabitats, (Lassau *et al*., 2005). Temperate and arboreal forests have been more surveyed and their biodiversity well documented. However, causes of high biodiversity in tropical areas remain unclear due to poor or limited research (Bates *et al*., 2008). With the aim of describing broad-scale tropical biodiversity patterns, recent studies have been conducted on the effect of altitude on mammals (McCain, 2010), birds (Kaboli ,2006), Insects (Axmacher *et al*., 2004), and Vascular plants (Senbeta *et al*., 2005).

Mt. Kenya like other tropical mountains of an old volcano flow (Ah-Peng, 2003) provides excellent natural conditions for studies on effect of gradual change in temperature, rainfall and vegetation. These climatic elements create distinct vegetation zonation (Hedberg, 1951). This current study on Mt Kenya therefore aims to provide data on plant diversity and describe the effect of various factors such as altitude, climate and human activities. The present study, conducted on Mt Kenyaôs Naro Moru track (NMT), aims at providing data on the effects of altitude, climate and human activities on the mountainsôs plant diversity and to relate the association of Bryophytes and Tracheophytes.

1.6 Environmental problems affecting mountain ecosystems

According to Myers (1988), the mountain forests are exposed to many forces of destruction, such as climate change, pollution, armed conflict, population growth, deforestation and exploitative agriculture, mining and tourism. These problems confronting the "water towers of the world" have prompted warnings that there is likelihood of disappearance of the forestôs unique biodiversity (FAO, 1993). The famous snowcap of Africa's highest peak Kilimanjaro is predicted to disappear by 2020 (Newmark, 2002). Ruwenzori's glaciers have declined from 2 Km^2 to less than 0.96 Km^2 (May, 1986). Snow on the famous Mt. Kenya peaks is also disappearing and has shrunk by 90% since the beginning of this century (Newmark, 2002).

Continued recession of the glaciers on the key mountains in Eastern Africa is expected to have a devastating effect on the unique alpine ecosystems of the mountains (Newmark, 2002), as well as the river catchment areas they serve. Deforestation is the major threat to water flow. Though studies indicate that the slopes of Mt. Kilimanjaro are experiencing abnormally high rainfall, it is poorly distributed and very intense where it occurs. According to (IHDPGEC, 2006) if the current trend towards a drier and warmer climate on Mount Kilimanjaro and Kenya continues, lower vegetation zones and savanna species will move upwards in higher altitude zones.
Deforestation on Mt. Kenya leads to decrease or loss of particular forest species like *Ocotea*

usambarensis, *Vitex keniensis* and *Podocarpus* species (Gathaara, 2000). People are living and farming within the reserves, the introduuction of the 'shamba' system of plantation management in 1993 resulted into opening up areas of forest in higher mountain zones (Gathaara, 2000). This allows poachers easy access to the altitude forests and to the moorland (WUA, 2006). Management problems have only intensified since re-designation as a National Reserve (Gathaara, 2000).

Problem animals, such as elephants (*Loxodonta africana*), account for the bulk of both crop damage and human injuries and deaths (EEIU, 2008). The elephants crave for the indigenous trees such as *Cinnamon camphora* which they debark, uproot and chew them up while buffaloes cause damage to the *Hagenia-Hypericum* vegetation during migration since their traditional corridors outside the mountain have been cut off (EEIU, 2008). Also threats from visitors who leave litter that cause a population boom of hyrax and rodents in the Teleki valley, cause damage to vegetation (KWS, 2010).

1.7 Problem statement

The importance of substrate type and structure in Bryophyte species diversity and composition in the functioning of tropical mountain ecosystems water catchment sources is well established (Pharo & Beattie, 2002), but effects of microhabitat and altitude in bryophyte distribution have received relatively little attention (Putz *et al*., 1986).

Research on bryophyte taxonomy and their relationship to the different species of tracheophytes in Mt. Kenya will provide knowledge on the ecological functioning of the mountain and the impact on conservation efforts needed to stem the mountain degradation.

1.8 Research aims and objectives

1.8.1 General aim

The aim of this study was to establish the taxonomic and ecological relationship between bryophytes and tracheophytes along western slope of Mt. Kenya.

1.8.2 Specific objectives

1. To determine the diversity and distribution of bryophytes and tracheophytes along Naru Moru tract (NMT) on the western slope of Mt. Kenya.
2. To establish the ecological relationships between bryophytes and tracheophytes.
3. To provide taxonomic information needed for the conservation of those plant groups on Mt. Kenya.

1.9 Research questions

1. How are bryophytes and tracheophytes distributed along Naro Moru track on Mt. Kenya?
2. How does rise in elevation influence the diversity and distribution of bryophytes and tracheophytes along the Naro Moru track?
3. How does microhabitat variation control bryophyte diversity?
4. How do bryophytes associate with tracheophytes along the altitudinal gradient?
5. How can the taxonomic information on bryophytes and tracheophytes be used to improve their conservation in Mt. Kenya?

CHAPTER TWO

LITERATURE REVIEW

2.1 Characteristics of tropical mountains

Understanding of the environment is a vital aspect for proper planning, utilization and management of natural resources, that is why habitat studies have become a focal point in ecology (Wardle, 1965).

Plants growing at high elevations in tropical mountains show a scleromorphic habit at the leaf and plant level. This tends to increase with increasing elevation, despite the fact that alpine landscapes are generally considered to be cool and humid environments (Wardle, 1965). High elevation plants generally have a reduced height, total leaf area and size, thicker leaves, epidermal cell walls, and cuticles compared to lowland plants. Also leaf pubescence is widespread among plants growing at very high elevations (Troll, 1968).

Pronounced changes in plant vegetation structure occur with increase in elevation in tropical mountains where tall, predominantly mesophyllous tree species are replaced by crooked, nanophyllous species (Grubb, 1979) and finally higher elevations of the tropical alpine belt, sclerophyllous shrubs, tussock grasses, cushion and giant rosette plants with marked scleromorphic features are the dominant life forms. In tropical latitudes, the elevation changes in plant physiognomy were commonly attributed to direct or indirect effects of altitudinal decrease in temperature, changing light levels, and low soil nutrient availability (Ohsawa, 1990).

Water in East Africa (Beck *et al.*, 1990) is an important limit to plant growth at high elevation. This perception is based on the abundance of fog and lichens in many tropical alpine ecosystems (Smith and young, 1987). Bogs are typical elements of several tropical high- elevation landscapes such as the Ramos of Northern South America, the highlands of New Guinea (Hope, 1980) and at the top of Mt. Kenya (Coe, 1967). Another property needed for perpetuation of the balance of biological biodiversity in a stable ecosystem depends on the ability of constituent species to coppice (Mazingira, 2008). In Mt. Kenya ecosystem, coppicing occurs in 80% of tree species in disturbed areas (Mazingira, 2008).

2.2 Geological and geographical factors influencing plant distribution

The number of vegetation zones in mountains depends on the height of a mountain and its geographical location in respect to latitude (Lomolino, 2001). In the tropics, climatic zones like geology, position in relation to sea and height of mountains are important factors that create the diversity of the vegetation types in different mountains (Kruckberg and Robson, 1986).

Biodiversity is distributed heterogeneously across the Earth and some areas team with biological variation (some moist tropical forests as on Mount Kenya and coral reefs), others are virtually devoid of life (some deserts and polar regions), but most fall somewhere in between, (Lomolino, 2001). Differences in plant morphology and anatomy can be ecologically conditioned by a plantôs location in a geologically heterogeneous landscape lined to form its function (Kruckberg and Robson, 1986). There also exists altitudinal, latitudinal and longitudinal gradients of variation in species diversity. The land area available for biota on the mountains declines with elevation, because the mountains do not have vertical walls but slopes (Kruckberg and Robson, 1986). Tropical forests begin to exhibit plant zonation from their foot base up to their peaks (Kruckberg and Robson, 1986). According to Mahaney (1987) and Speck (1986), soils of Mount Kenya show altitudinal zonation. Its long-extinct volcano has been much denuded, and the highest peaks consist of the crystalline nepheline-syenite which plugged the former vent. Around this core are gently dipping lavas, agglomerates, and tuffs. The land elevation determines the type of soil as a result of volcanic activities. Mount Kenyaộs vegetation succession is well developed where it emerges from the surrounding savanna. The montane forest extends upward from a lower limit of about 2,000m to 3,000m and includes giant trees; *Cinnammum camphora* and *Podocarpus* species.

2.3 Environmental factors influencing plant distribution and diversity

Various factors influence the growth of plants in a particular environment; moisture, soil physical and chemical properties (Munishi, 2004). Also the distribution may show large variations within a landscape as influenced by different environmental factors (Lovett et al., 2000). Two richness patterns have been identified along mountain slopes: 1) A trend of decreasing species richness with increasing land elevation and 2) a hump-shaped distribution of species richness at mid elevation areas (Rahbek, 1995). The hump-shaped distribution of species richness is the most typical pattern but its predominance in species-elevation studies depends strongly on spatial grain or micro-topography along the mountain and the length of the slope (Rahbek, 2005).

2.4 General distribution of vegetation on Mount Kenya

In Kenya forests, including the Mt. Kenya forest, cover only 1.7% of the country. The countryôs hydro-geography has been described by several authors and each has expressed the grave concern about the effects of changing climatic conditions on the tropical mountains (UNESCO, 1992; Decurtins, 1992). According to Decurtins (1985), the best areas with the highest amount of water are found on the moorland and upper forest zones of the mountain. This zone is also the area that has tremendously changed in Mt. Kenya as the numerous glacial moraine and small lakes have disappeared, leaving only eleven out of twenty that existed on the mountain in the 1930s (Hastenrath, 1984).

According to Hastenrath (1984) the natural vegetation on Mount Kenya can be divided into five main altitudinal zones:

1. Montane/savanna forest zone at altitude (2100-2400m),
2. Bamboo/foot zone at altitude (2400-2800m),
3. *Hagenia* and *Hypericum*/forest zone at altitude (2800-3000m),
4. Heath/alpine meadow moorland zone (3000-3500m) and
5. Mountain peak zone right up to the snowline at altitudes (3500-4800m)

The characteristics of those vegetation belts are primarily determined by altitude and rainfall but also by changes in temperature and soil depth. The forests begin at 1900m and trees gradually decrease in height as the land elevation increases (Figure 2.1).

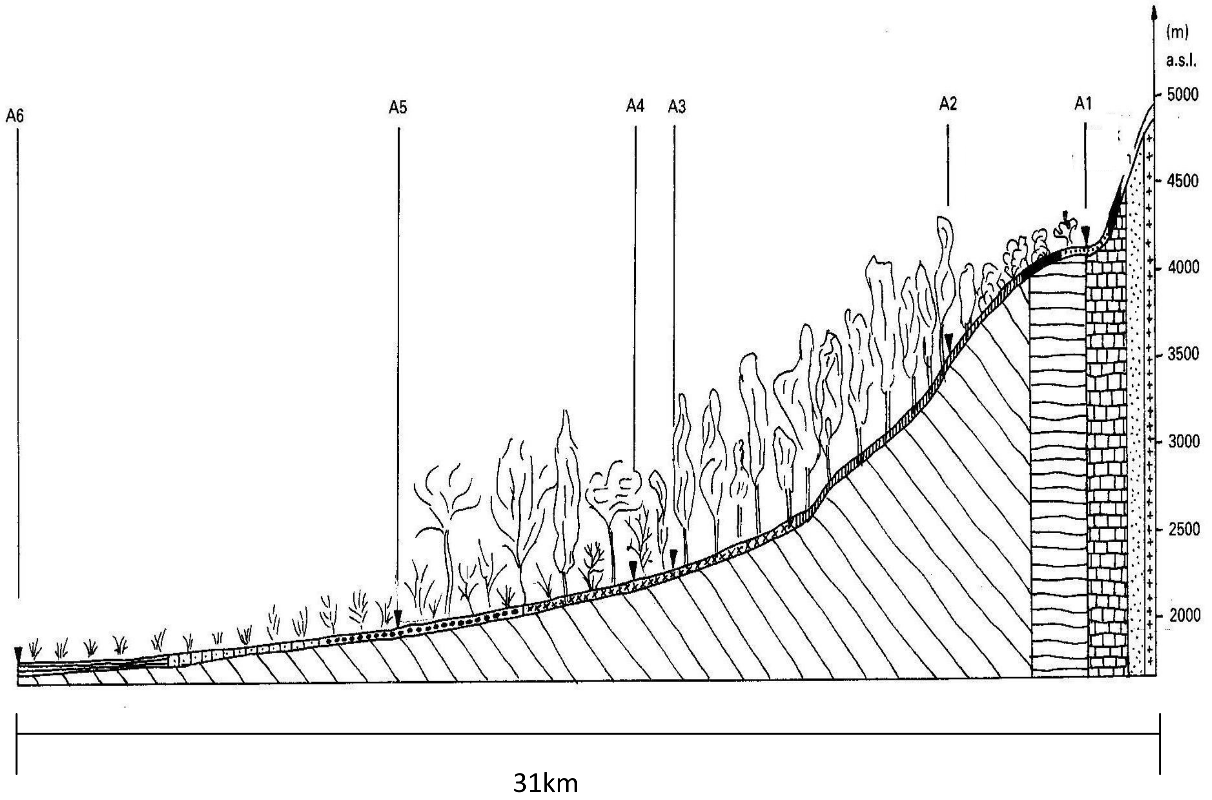


Figure 2.1 Altitudinal profile of natural vegetation along the Naro Moru Track (Source: Decurtins, 1992).

Hedberg (1951) published a comprehensive account of the vegetation zonation of East African high mountains. The high mountain vegetation was divided into three large belts according to altitude. These were Montane Forest, Ericaceous and the Alpine Belt. All these studies classified the vegetation based on vascular plants. Among the researchers who have worked on vegetation in Mt. Kenya, only Bussman (1992) mentioned bryophytes but he admitted that the bryophytes and lichens had not been considered during the study. Bussmanôs subsequent study in (1993) divided the Mt. Kenya forest vegetation into six zones: Cultivated land, Sub-montane, Montane, Sinnarundinaria zone, Sub alpine and Alpine.

White (1983) and Abraham (1980) classified Mount Kenya vegetation based on altitudinal sequence and physiognomic criteria from the bottom to the top of the mountain. Several authors used edaphic factors and partly species dominance: (Fries and Frries, 1948, Hedberg, 1951, Knapp, 1973, Lind and Morrison, 1974, White, 1983, Trapnell and Brunt, 1987, Beenjte, 1988 while Schmitt 1991 used floristic and ecological criteria.

Chuah (2003) who collected numerous specimens of bryophyte and documented their distribution in a wide range of habitat niches in Mt. Kenya and specimens deposited in the University of Nairobi Herbarium (NAI), where many remained unidentified. Chuah (2003) also generated a classification of known bryophytes without mentioning their association or relationship with tracheophytes in Mt. Kenya. Therefore, the plant diversity of the vegetation still remains unclear. This study sought to establish the altitudinal distribution, abundance and diversity of bryophytes and their association with tracheophytes along an altitudinal gradient (Naro Moru track) on the western slope of Mount Kenya.

2.4.1 State of knowledge of bryophytes

Bryophytes are one of the least studied groups of plants, yet they play a vital role in the dynamics of plant communities. Bryophytes can absorb atmospheric water, up to 600 times their dry weight, and retain water up to 13% of their own weight (Mwangi, 2008); and this is made available to the tracheophytes as water flows from the bryophytes as they subsequently released it slowly. Several plant inventories have been conducted in Mt. Kenya with no mention of the percentage or ratio of bryophytes to tracheophytes (Hedberg, 1951; Bussmann, 1994 and Pócs, 1980). In his third edition (Agnew, 2013) has written about grasses, sedges, ferns and flowers, stating that ñit is particularly useful for managers of rangelands and parks, giving a high chance of identifying any non-woody plant in upland Kenyaò, but he did not include bryophytes in this recommendation.

Characteristics of bryophytes include exhibition of alternating generations; poorly developed root support system and water transport tissues; lack of a cuticle or poorly developed ones, which allows them to absorb water quickly through the general surface and slowly release it to the surrounding environment; dependence on water for successful fertilization and a dominant gametophyte generation, (Hallingback and Hodgets*.,* 2000). Bryophytes reproduce both by sexual and asexual means. They also inhabit all types of ecosystems but more abundantly in moist humid cool climates. This is a characteristic of cloud forests especially in Africa where Bryophyte diversity is not evenly distributed (OôShea, 1999). The available information shows that the Sub-Saharan African moss flora is endemic to the region and the number of taxa increases with altitude up to a certain level. The level of endemism greatly depends on habitat diversity expressed by the number of vegetation belts (Chuah, 2003). On Mt. Kenya, the families *Grimmiaceae* and *Andreaeacae* appear at altitudes above 3400m.

Most centers of Bryophyte diversity in tropical Africa are on mountains (Hallingback and Hodgets*,* 2000), which are either of ancient crystalline or volcanic origin such as, Mountains of Virunga, Tanzania highlands, Ethiopian highlands, Mt. Rwenzori, Mt. Elgon and Mt. Kenya. Bryophytes are important plants in various ways: firstly they act as indicators of pollution and natural habitat quality. Some bryophyte species (*Antitrichia curtipendula, Hylocomium* *splendens, Hypnum cuppressiforme,Fontinalis antipyretica* are pollution sensitive to show indication of pollution in the air even at very low level (Chuah, 2003), water pollution (Grime , 1979) and monitoring of radioactive metals such as caesium; secondly, some bryophytes are used as medicine for instance *Marchantia polymorpha, Plagiochila appendicullata, Polytrichum species, Ricca species, Philonotis fontana* and *Hypnum cupressiforme; t*hirdly, bryophytes are a source of food for example *marchantia polymorpha, Plagiogasma appendiculata, Polytrichum* spp. *Ricca spp* and fourthly Bryophytes have cultural and aesthetic qualities; fourthly, bryophytes are cultivated as ornamental plants for cultivation in landscape trays (Hallingback and Hodgets, 2000). Fifthly bryophytes are employed in scientific research as experimental model organisms in biochemical experiments and genetic studies e.g *Polytrichum commune* and are excellent experimental specimens when introducing students on the use of microscope. Lastly, Bryophytes constitute a major portion of the biodiversity in moist forests and play a major role in ecological functions in wetland and mountain systems. They also contribute significantly to community structure forming mixed communities (Hallingback and Hodgets., 2000). Mosses and lichens are usually the first plants to colonize newly exposed land and frequently dominate in severely stressed environments. Bryophytes also encourage water infiltration into the soil (Ah-Peng, 2007).

2.4.2 Pteridophytes

This group of tracheophytes is poorly known in the scientific field; they are vascular plants with well differentiated plant body of shoot, stem and roots and well developed conducting tissues, the phloem and xylem. Pteridophytes are generally sporophyte-oriented. The sporophyte is a normal diploid plant while the gametophyte is haploid. The pteridophyte gametophyte is free living and this makes them different from the angiosperms whose free living is the sporophyte generation. Pteridophytes are found in almost all climatic regions of East Africa (Johns, 1982). They are mostly ramicolous, terricolous and humicolous.

Pteridphytes have several economic use 1) Food; *Asplenium ensforme, Ceratopteris thalictriodes, Diplozium esculentum, Nephrolepis biserraia* 2) Medicinal*; Actinopteris radiata, Adiantum aethiopium, Acrostichum aereum,* 3) Pesticides; *Dryopteris filixmas, Phymatosorus scolopendria* 4) Ornamentals; *Lycopodium volubile, Saleginella serpens, Pteris vittata and* on a smaller scale they are used as firewood. All these plants have been documented in the Plants of Mt. Kenya (Hedberg 1951).

2.4.3 Gymnosperms

These are Tracheophytes that bear naked seeds. They are not very many in Kenya hence not much has been done on them in terms of research. Of the three indigenous families occurring in Kenya, only three species are observed in Mt. Kenya; Juniperous *procera, Podocarpus falcatus* and *P. latifolius* (Beentje, 1994).

2.4.4 Angiosperms

The total number of vascular plants on Mt. Kenya according to the record shows that by 1994 were 882 species, 479 genera and 146 families without specifying them into angiosperms, pteridophytes or gymnosperms (Bussman, 1994). Angiosperms are vascular plants that are most dominant and diverse. They are the most highly evolved group of plants. They regularly undergo an alternation of generation of a complex, independent visible sporophyte and an inconspicuous and reduced gametophyte. Angiosperms are found almost everywhere in each possible type of habitat and climate (Judd *et al.,* 2002).

Angiosperms are vital in manõs life directly. Firstly, they provide 80% of the worldõs food. Secondly, they are used for the production of organic pesticides. The plant species used include, *Chrysanthemum cinerariifolium*, *Acokanthera spectabilis, Melia azedarach, Acacia arabica, Ageratum houstonianum and Annona montana*. Thirdly Angiosperms are used for in traditional medicines and as sources of conventional drugs; *Achyranthus aspera, Adansonia digitata, Albizia schimperi, Aloe secundifolia, Cassia didymobotrya, Catha edulis, Acokanthera* species among others. Others are used as spices for example, Ginger *(Zingiber officinale*), Parsely (*Petroselinum crispum*), Rosemary (*Rosemarinus vindicum*), Peppermint (*Mentha piperita*), Garlic (*Allium salivum*), Onion (*Allium cepa*) and Vanilla (*Vanilla planifolia*). All these plants have been documented to be present on Mt. Kenya (Hedberg 1951) though the author may not have encountered them all because of limitations in sampling procedures.

2.5 Conservation strategy of Mount Kenya

Since the discovery of the receding of the glaciers and subsequent disappearance of the forests, Kenya Wildlife Service launched a plan for the conservation of animals and vascular plants from 1993. In 1999 the vascular plants in the Mt. Kenya region was recommended for its conservation as this affected the natural diurnal rain pattern of the area. While the rainfall pattern is altered, human activities have also affected the plant biodiversity (Osborne, 2000). This contributes to the flooding of the river Ewaso Ngiro fed from the mountain. If the KWS (2010) strategy plan and other concerned conservation bodies adopt the ecological information that this study will provide, then the soils around and within the mountain will regain their vegetation cover by having all the plants conserved. This will in turn reduce the soil erosion from the mountain base and consequently help to curb the sedimentation in the river. As a result, the riverbed will clear off the sediments hence reducing flooding.

2.6 Social-Economic importance of Mt Kenya

Apart from being the main water catchment system to the Ewaso Nyiro River drainage systems which are essential for the water supply in Kenya and a source of most of the tributaries that feed river Tana, it also serves as a source of economic value for the country as one of the main tourist attractions of the country with high recreational value such as fishing, climbing, camping recreational sites and general agriculture at its foot zone. It was crowned as a World Heritage Site in 1997 and an international recognition as a Biosphere Reserve in 1978 (Hemp, et al., 2006).

CHAPTER THREE

METHODOLOGY

Study Area.

Location and structure of Mt Kenya

Mt. Kenya is Kenyaôs highest mountain, a nation icon, a climberôs Mecca, the nationôs namesake to the countryôs name, wildlife stronghold (KWS, 2004) and a UNESCO World Heritage site (UNESCO, 1992) and a wildlife stronghold situated 175 km North- East of Nairobi. Mt. Kenya can be approached through seven gates; the Naro Moru, the Chogoria, the Sirimon, the Kihari, the Kamweti, the Marania and the Ithangaini. This research concentrates on Naro Moru route herein referred to as Naro Moru Track (NMT) and which is the richest in the flora population as compared to others, (Chuah, 2000). This study was carried out along the Naro Moru track from the gate upto point Lenana which was a vertical distance of 38 km and an altitude height of 2400m.

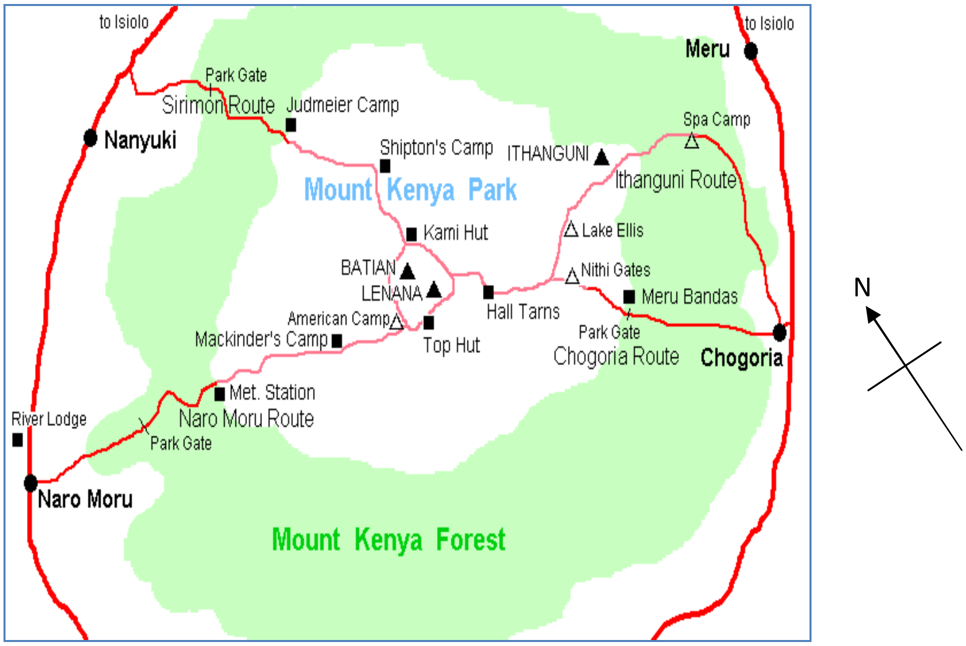


Figure 3.1. Map of Mt. Kenya Region showing some of the seven routes into Park, (KWS, 1999)

The hydro geography of the area has been described by several authors and each has shown grave concern of the changing climatic conditions of the mountains for instance the Conference on Environment and Development held by UNESCO was an occasion to draw the attention of policy makers to the increasingly grave problems besetting Mt. Kenya (UNESCO, 1992).

The National Park and the Reserve measure 715 Km^2 and 2,124 Km^2 respectively making the total area of the mountain region to be 2, 839 Km^2 and mountain base diameter of 120 km (Chuah, 1994). The National Park and the National Reserve were gazetted in December 1949 and July 2000 respectively (KWS 2010). The mountains whose peaks are usually covered with clouds; gives rise to many river sources that provides water for intensive farming at its foot (Chuah, 2003, Plate 2.1). The region has 20 glacial tarns of varying sizes whose water levels are declining (e.g Teleki Tarn one of the small lakes at the peak of the mountain (Author, 2009).

Mt. Kenya like Mt. Kilimanjaro was earlier described as being snow caped, now it is scattered with snow (Figure 3.1). The cause of the mountain losing snow at its peaks should be established and if possible curbed.

Figure3.2 Scattered snows on the peaks of Mount Kenya following Naro Moru route (Muigai 2008)

3.1.1 Location of study area

This study was carried out between August 2008 and August 2009 on Mt. Kenya within geographical GPS coordinates; {(S 00, 16965º, E 37, 15234º) at the gate of Mt. Kenya national park and (S 00, 16680º, E 37, 18770º) at point Lenana on Mt. Kenya. Mt. Kenya lies between altitudes 1600 and 5199m. The mountain has three summits; the Batian Batian 5199, Nelion 5188 and Lenana 4895m (Figure 1.1).

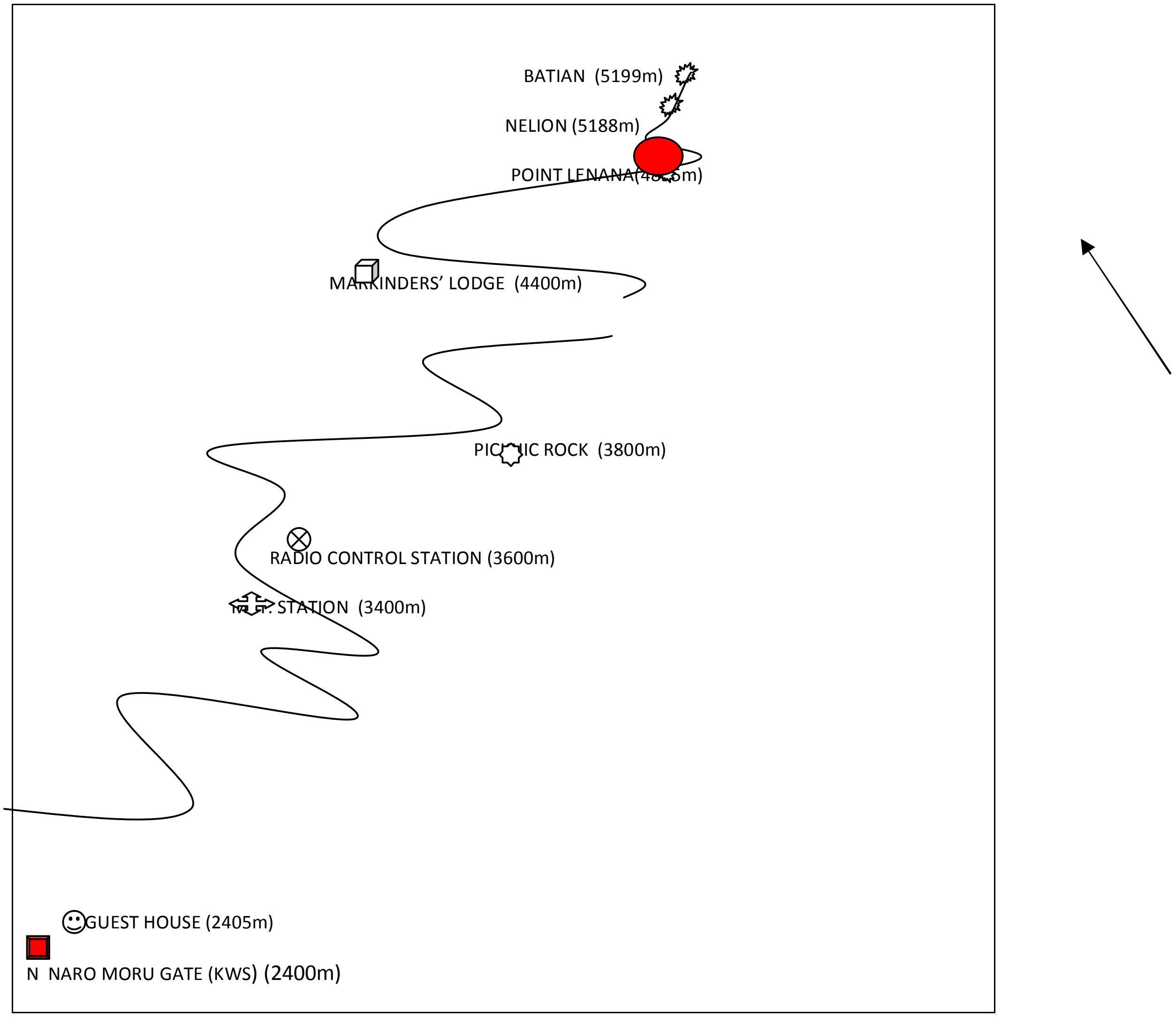


Figure 3.2 A sketch map of Naro Moru Track in Mt. Kenya with red boxes showing beginning and the end points of this study (by Author 2009).

3.1.2 Climate of Mt. Kenya

The climate of Mt. Kenya can be described as moist cold tropics with large diurnal temperature variations. Kenya is positioned on the equator 0 37° S (Decurtins, 1992) and because of this; it has equal day lengths throughout the year. The mountain has altitudinal zonation of decreasing temperature and two main rain seasons, the long wet period that occurs between March and June and the short wet period that occurs between December to February. This research was done within these periods.

Mt. Kenya derives its rainfall from the moisture bearing north and south-west monsoon winds. The air circulation is controlled by a sequence of low pressure areas which form the Inter-tropical Convergence Zone (ICZ) (Decurtins, 1992). It moves with the sun North and South of the equator twice a year. This makes the mountain area to experience seasonality of precipitation which makes the mountain to experience drier areas in its northwestern side and moist areas in the southeastern.

Rainfall increases with increase in elevation. The low rainfall ranges between 600-900 mm p.a. at the lower slopes while the maximum ranges from 1500-2000 mm p.a. from the height of 1500-3600 m (Decurtins, 1992). In this connection, plants are threatened. We can’t tackle the environmental challenges without a deep understanding of plant categories association. Human activities and their impact and our changing climate are each having an impact on the health of plant life on a global scale (Decurtins, 1992).

The total cover of forests in Kenya is up to 1.7%. This is because the human communities living around the forests engage in illegal logging, encroachment and denudation while wild animals graze destructively. This in turn results in soil erosion which leads to more forests disappearing (KWS, 1999).

The montane forests in this study lies between 2400m and 3600m which experiences abundant rainfall that contributes to the high humidity and cloud cover in the region. Regions above montane forests experience diurnal fluctuations in temperatures, intense solar radiation and relatively low and erratic rainfall (Decurtins 1992). The zones above the montane region sometimes experience rainfall with hailstones and even snow. These harsh conditions have and limited the survival of both the fauna and flora which occur mostly in the rocky areas. Solifluctions soil conditions between 3800 and 4400m support moss bryophytes than vascular plants.

3.1.3 Land elevation and zonation of the Naro Moru track

Three forest zones in the Naro Moru Track studied are shown in Table 3.1.

Table 3.1. Forest zones studied along the Naro Moru Track

Section	Position/ altitude range	Vegetation zones
1	Gate to Radio station 2400 ï 3600 asl	Montane zone
2	Radio station to Mackinderôs lodge 3600 ï 4200 m asl	Subalpine to Alpine zones
3	4200 ï 4800 m asl	Alpine to ï Nival zones

3.2 Study design

The composition of the plant communities, their structure, and density were determined. The diameter and height of the vascular plants which hosted the bryophytes were measured by using a tape measure, Vanier caliper as well as clinometers and range finder respectively.

3.2.1 Site selection

In each zone/stratum, systematic and random sampling techniques were employed to determine the species diversity and abundance. A 50m transect was made on either side of the track and along it four plots of 10 by 10m were established 5m from either side. These plots were used as major quadrants for vascular plant sampling; the major quadrants are the same in which three smaller quadrants of 2 by 2m were made for bryophyte sampling. In each, three bryophyte quadrants measuring 10 x5cm were randomly selected and specimens collected from all the existing microhabitats (Figure 3.3). This was repeated after every 200m elevation (figure 3.4). A survey was carried out to get a good understanding of the altitudinal bryophyte, pteridophyte, gymnosperm, and angiosperm diversity and distribution.

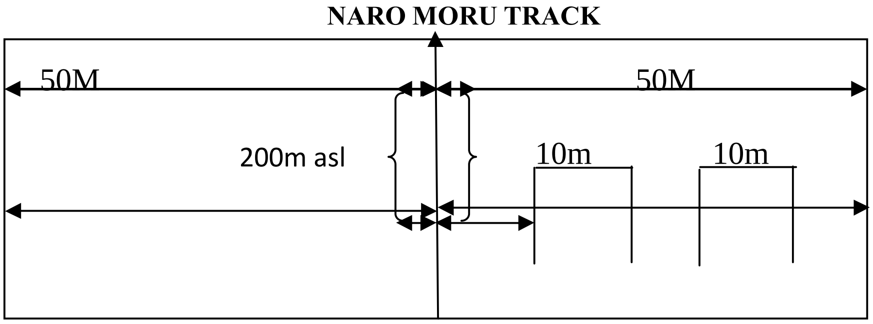


Figure.3.3a) Layout of 10x10m plots selected along NMT

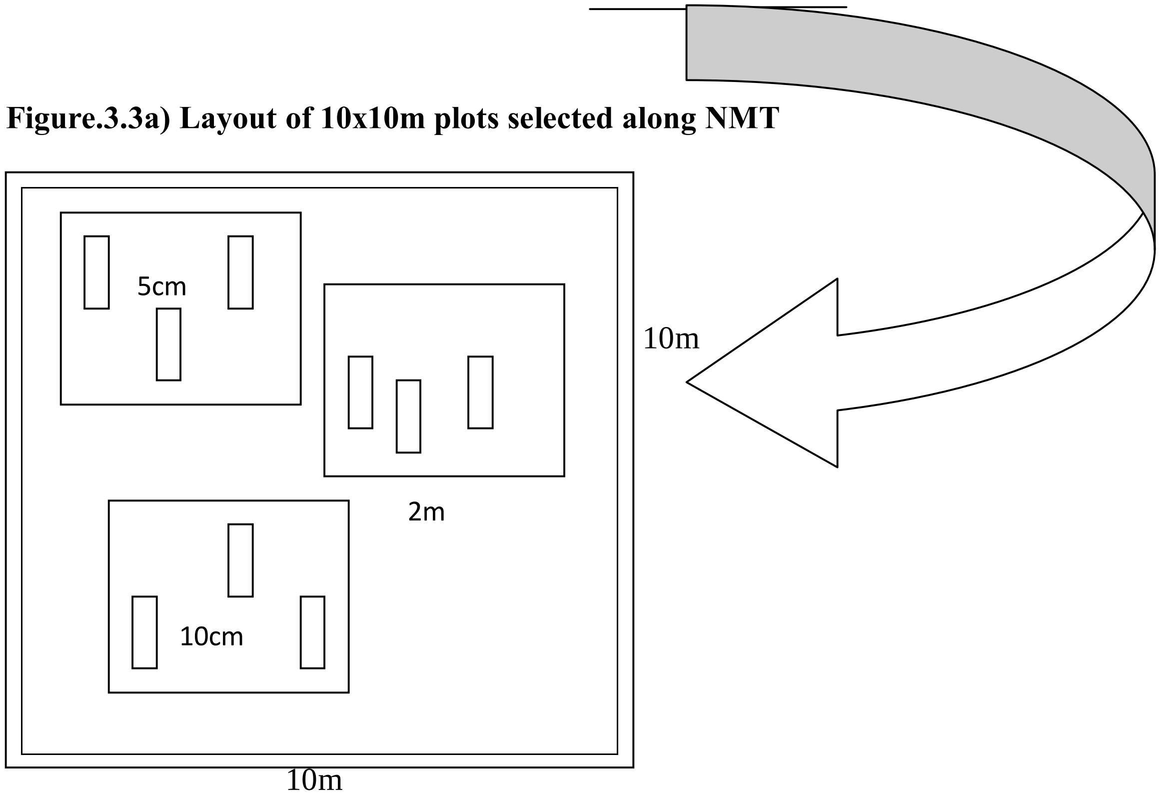


Figure.3.3b) Layout of subplots of 2mx2m and 5cmx10cm within 10x10m plots.

The GPS coordinates were used for selecting the sampling areas and for mapping out the distribution of plants based on the altitude.

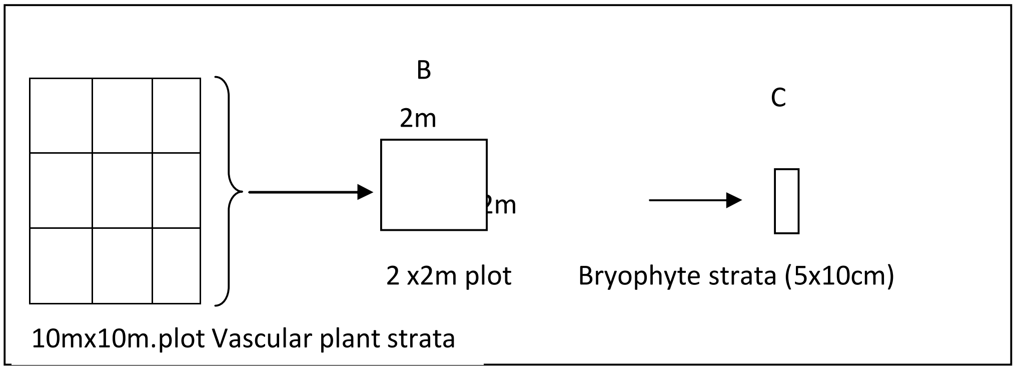


Figure.3.3.c) Layout of plots used in sampling tracheophytes and bryophytes

Vascular plants were sampled from 10 by 10m plot (Figure 3.4c (A)) while Bryophytes were from a 10cm by 5cm quadrant (Figure 3.4c (C)). The altitude was measured with an altimeter calibrated with a topographical map and the GSP instrument (1: 25,000).

3.2.2 Vegetation Sampling

3.2.2.1 Sampling of Angiosperms

Three plots of 2m by 2m were randomly set within a 10 by 10m area. The vascular plants were collected from the macro habitats (10 by 10m plots) noting the life forms, plant communities, structure, density and environmental parameters. Within each plot, the percentage cover for small phanerogams was estimated while trees and shrubs were counted individually. Leafy samples of branches with required characteristics were collected from trees and shrubs while small plants were taken in portions.

(a) Cutting a specimen from *Podocarpus latifolius*

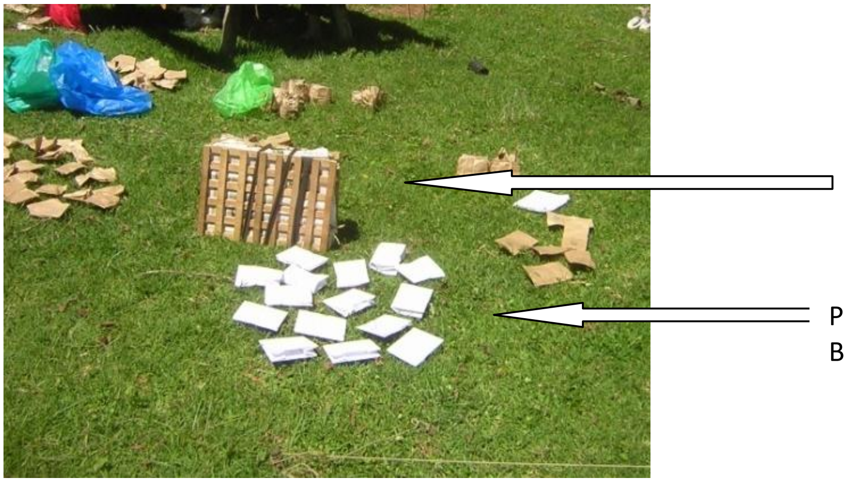
(b) Sampling of small vascular plants by uprooting a portion - (*Isolepis setacea*)

(c) Sampling of terricolous Pteridophyte- *Lycopodium saururus* by uprooting a portion)

Figure 3.2 (a-c) Sampling of some major plant groups

3.2.2.2 Sampling Bryophytes

Within each plot of 2 by 2m, nine micro plots of 10 by 5cm (here called relevés) were sampled. Bryophytes were collected from all observable microhabitats namely: those collected from dead decayed plant matter as Humicolous (Hu), decaying plant materials as Lignicolous (Li), rocks as Rupicolous/Saxicolous (Ru), ground as Terricolous (Te) and from live plants as Corticolous (Co). Those from tree trunks were collected at three levels: 0.0-0.5, 0.5-1 and Ó 1m above the ground, rachises and leaves in this text referred to as Cort1, 2 and 3 respectively though during sampling collection they were referred to as TC1, TC2 and TC3.



Plant press for drying
Trcheophyte plants

Paper pockets for drying
Bryophyte plant samples

Figure 3.3 Curating the specimens (Author)

3.3 Data Analysis

Plant communities were recorded in the field while the analysis of the relevés and the data analysis were based on the procedures of Braun-Blanquet. Plants collected were analyzed by hand sorting, while high cover abundance was weighted because the Bruan-Blaquet method which was used puts emphasis on the dominant species. The regular occurrence of species with small cover in vegetation was also regarded as important for classification.

After relevés analysis, the species were rearranged to point out differential species. The constancy of each species within a relevé group was calculated with the programme `TABô (PEPPER 1988)/SPSS VER 15.0 (Norman *et al*., 2007) in classes of percentage.

3.3.1 Vegetation data analysis

a. Species abundance

Species abundance is the number of species sampled and their total numbers. The species were samples, listed and their numbers noted. The species abundance was also used to conduct analysis of variance between the altitudinal levels and microhabitats of bryophytes.

b. Sample similarity

Similarity index was calculated using species abundances to compare the species collected at different altitudes and microhabitats. Comparison was necessary because in plant ecology this is expected to be representative of communities (Kruskal, 1964).

c. Species density

It is important in determining how many individuals of each species are present to all of them in a particular study; calculated by dividing the number of individuals by the total area sampled thus;

Density = Total number of species ÷ Total area sampled

Where area for different plant groups is,

For Tracheophytes is 10 x 10m = 100 m^2

For Bryophytes is 5cm x 10 cm = 50 cm^2

d. Frequency

This is the probability in percentages of encountering an individual. These values are used to determine whether the species was encountered or not. Relative frequency reveals how many times a species is appeared relative to all other species;

Frequency = number of sampling levels in which species A appeared divided by
number of all the levels sampled

Where number of sampling levels were for:

Tracheophytes is 13 levels x4sampling quardrats x2 because it is on both sides of the NMT =104.

Bryophytes is 13 levels x3 quardrats of two by two x 3 quardrats where bryophytes were sampled from=468.

e. Species diversity and richness of all plants sampled

Species diversity and richness were calculated using, the Shannon - Weiner diversity index, H´ from the Information Theory (Zar, 1996). The index formular:

$$H' = -\overset{\overset{i=1}{s}}{\times}\ p\acute{\imath} \log p\alpha$$

Where,

H´ = the Shannon Diversity index

$p\acute{\imath}$ = the proportion of plants of the dth species over all plants of all species

s = the number of species

The indices were then compared for differences amongst forest proximity category using Kruskal-Wallis K test for medians (Fowler *et al*., 1989/1990; Zar, 1996). Correlation was used to find the relation of bryophyte cover to altitude and this was compared with the vascular plant cover and according to the altitude.

f. Analysis of species diversity of Bryophytes

Using presence and absence of species, bryophyte species richness was compared at each altitude. The effects of altitude and microhabitat on bryophyte diversity were tested with a non-parametric one-way Kruskal-Wallis test (Zar, 1996). Variation between species assemblages and microhabitats were determined using a Correspondence Ordination Analysis (COA). Only species with the frequency of Ó5 were analysed. Field and laboratory observations and results from the COA were summarized. The analyses were performed by SPSS software package.

CHAPTER FOUR

RESULTS

4.1 Species diversity of all the plants in Naro Moru track

The study identified a total of seventy seven (77) families, one hundred and eleven (111) genera and one hundred and sixty four (164) species and these were shared among different plant groups as shown in table 4.1

Table 4.1Taxonomic plant diversity along Naru Moru Tract, Mt. Kenya

Plant category	Family	Genera	Species
Bryophytes	39 (50.6%)	56 (50.5%)	81 (49.4%)
Angiosperms	31 (40.3%)	48 (43.2%)	68 (41.5%)
Pteridophytes	6 (7.8%)	6 (5.4%)	13 (7.9%)
Gymnosperms	1 (1.3%)	1(0.9%)	2 (1.2%)
Total	77 (100%)	111 (100%)	164 (100%)

4.2 Tracheophyte species richness and distribution

4.2.1 Tracheophyte species richness by altitude

Tracheophyes also refered to as vascular plants, were spread over all the altitudes except one, 4800m. They decreased with increase in altitude until 4600m where it was only one species; *Senecio purtschelleri* recorded. The frequency of the species varied but at 2400m and 2600m *Achyranthus aspera* dominated with a frequency of 9.9% and 10.6% respectively. In altitude 2800m, the plant species that occurred most was *Sinnarundinaria alpina* with a frequency of 8.8% while at 3000, 3200 and 3400 m it was *Alchemilla argyrophylla* with a frequency of 7.7%, 13% and 8.4% respectively.

At 3600m and 3800m, the dominant species was *Erica arborea* with the frequency of 13.6% and 18.3% in that order, at 4000 and 4200 *Lobelia teleki* with 37.5% and 50% respectively. At 4400 and 4600m was *Senecio purtschelleri* dominated with 50% and 100% in that order. The altitude where most plant species were found was 3000m with the total frequency species occurring standing at 364 (Figure 4.1).

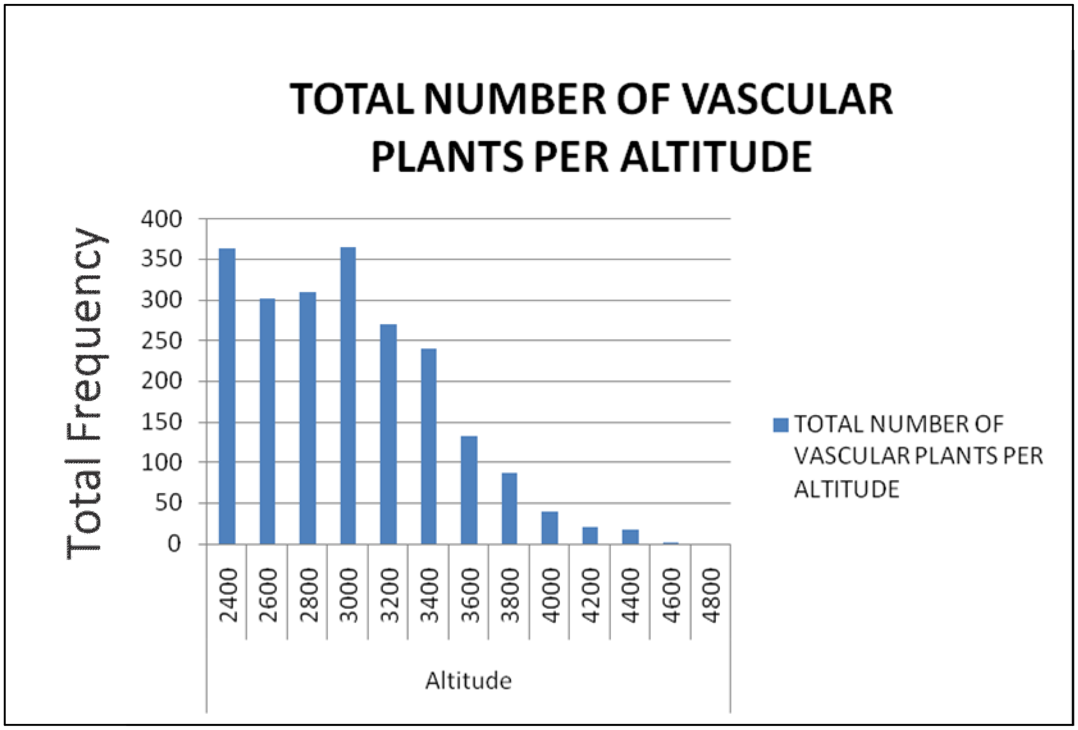


Figure 4.1 Total frequencies of Vascular plants by altitude

4.2.3 Tracheophyte species distribution

Three categories of tracheophte plants were identified; pteridophytes, gymnosperms and angiosperms. The study noted a higher distribution and richer diversity of tracheophytes in the lower and mid altitudes 2400-3800m, than in the higher altitudes, 4000-4800m (Figure 4.2).

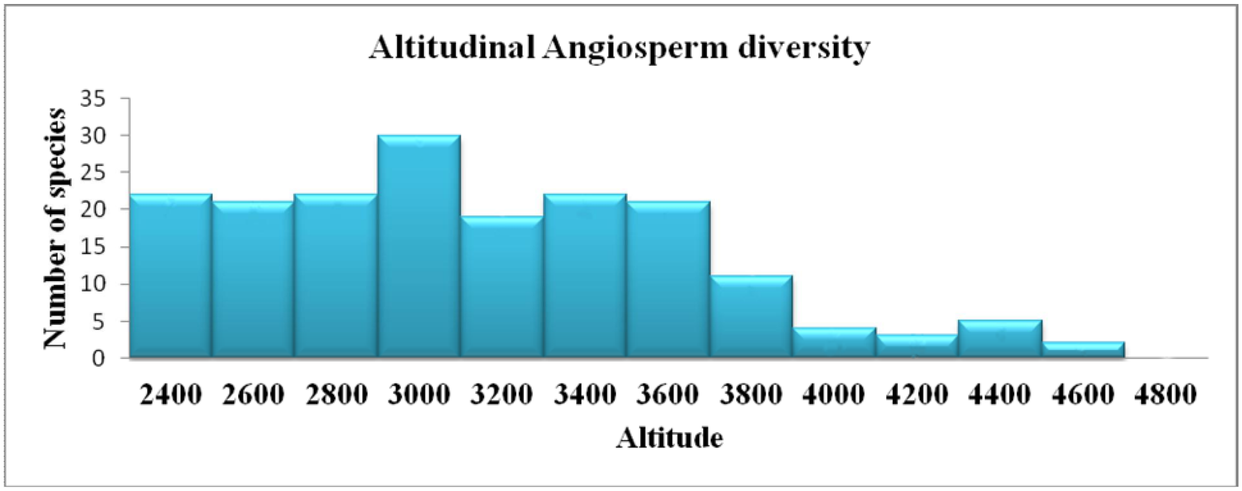


Figure 4.2 Numbers of Angiosperm species per altitudinal level (at ±95% CL).

4.2.4 Tracheophyte density

The Tracheophyte plant density varied greatly across the altitudinal transcend on NMT, Mt. Kenya, where the highest density was at 2400m and the lowest was at 4600 (Figure 4.3).

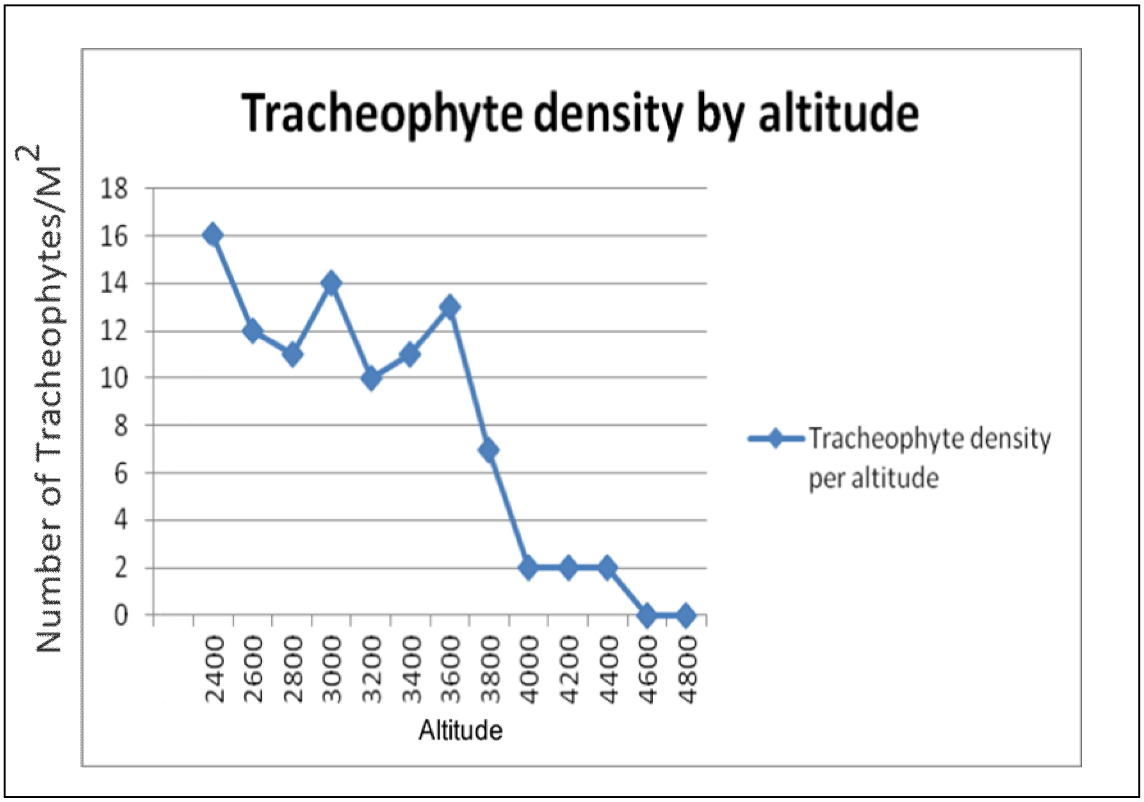


Figure 4.3 Tracheophyte species density

4.3 Diversity of Angiosperm

Sixty eight species of Angiosperms were identified across 13 altitudinal levels in the study site. Species richness varied across the altitudes. The study also noted a higher evenness of species in the lower and mid altitudes (2400-3800m.) than higher altitudes 4000-4800m.

Angiosperm species richness was highest at 3000m. (H´=1.099) and lowest at 4600m (H´=0.013).

The species were more equitably distributed at 2400m (E_H=0.339) and 3000m. (E_H=0.323) than the rest of the ecosystem. Diversity of species at 2800m was higher compared to 2600m.

(H´=0.902) but were more equitably distributed at 2600 (E_H=0.293) than 2800m (E_H =0.292, Table 4.2).

Table 4.2 Diversity and species richness of Angiosperm

ALTITUDE	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800
Shannon Weiner diversity index (H´)	1.047	0.893	0.902	1.099	0.82	0.801	0.534	0.348	0.086	0.062	0.086	0.013	0
Evenness (*E_H*)	0.339	0.293	0.292	0.323	0.28	0.259	0.175	0.145	0.062	0.056	0.054	0.019	0
Number of Species	22	21	22	30	19	22	21	11	4	3	5	2	0

The study noted that *Achyranthes aspera* (Amaranthaceae) was the most commonly occurring angiosperm species at 2400m and at 2600, accounting for 10% of all species found in the altitudes. It was followed closely by *Conyza newii* accounting for 9% of all species found in these altitudes. *Commelina latifolia* (Commelinaceae) accounting for 11 and 10% of species in the altitude respectively. *Plantago palmata* and *Cyphostemma bambusetii* were the least occurring species accounting for 2% of species in this altitude. The most common species across the lower and mid altitudes was *Erica arborea* occurring in eight (2400m to 3800m) out of thirteen altitudes whereas *Senecio purtschelleri* was the most common species in the higher altitudes occurring between 3800 and 4600m. The species accounted for 50% of plants at 4600m and 36% of plants at 4400m respectively. Angiosperm species assemblage was highest at2400-

3400m. Altitudes 2800m and 3000m shared the highest number of angiosperm species accounting for 28.2% of all angiosperm species identified in the study. The Percentage Similarity matrix among angiosperm species assemblages at the thirteen altitude levels is shown in Table 4.3. No angiosperm species were observed at 4800m.

Table 4.3 Percentage Similarity matrix among Angiosperm species assemblages at the thirteen altitude levels

	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4600	4800
2400	23.9	24.6	26.8	12.7	19.7	11.3	2.8	0.0	4.2	4.2	1.4	0.0
2600	-	22.4	26.8	11.3	11.3	4.2	1.4	0.0	0.0	0.0	0.0	0.0
2800	-	-	28.2	12.7	12.7	5.6	1.4	0.0	0.0	0.0	0.0	0.0
3000	-	-	-	19.7	19.7	7.0	2.8	0.0	0.0	0.0	0.0	0.0
3200	-	-	-	-	23.9	11.3	2.8	0.0	0.0	0.0	0.0	0.0
3400	-	-	-	-	-	11.3	2.8	0.0	0.0	0.0	0.0	0.0
3600	-	-	-	-	-	-	2.8	0.0	0.0	0.0	0.0	0.0
3800	-	-	-	-	-	-	-	5.6	4.2	4.2	1.4	0.0
4000	-	-	-	-	-	-	-	-	4.2	4.2	1.4	0.0
4200	-	-	-	-	-	-	-	-	-	4.2	1.4	0.0
4400	-	-	-	-	-	-	-	-	-	-	2.8	0.0
4600	-	-	-	-	-	-	-	-	-	-	-	0.0
4800	-	-	-	-	-	-	-	-	-	-	-	0.0

4.4 Pteridophyte species richness, distribution and evenness

The study identified six families, six genera and thirteen species of Pteridophytes across the NMT transect. The most common Pteridophyte species in the entire NMT was *Lycopodium clavatum* which occurred in seven out of the thirteen altitudes (Table 4.4). *Selaginella kraussiana* was the most commonly frequent pteridophyte species in the lower altitude (2400-3200m.a.s.l) accounting for over 90% of all pteridophyte species in these altitudes whereas *Lycopodium clavatum* was commonest in the higher altitudes (3600-4400m).

The highest species diversity pteridophyte was observed in 2400 and 2600m (H'=0.357 and 0.396 respectively). Species were more equitably distributed at 2600m (E_H=0.246) followed closely by 2400m. (E_H=0.222) and 3800m. (E_H=0.21). Species assemblages were higher in the lower altitudes (2400-3200m.) than the higher altitudes (3600-4800m.). At altitudes 2600 and 2800m.most number of pteridophyte species was shared 30.8% while 2800 and 3000m shared 23.1% (Table 4.4).

Table 4.4 Altitudinal Pteridophyte species diversity

ALTITUDE	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800
1.*Selaginella kraussiana*	0.93	0.92	0.95	0.94	0.93	-	-	-	-	-	-	-	-
2.*Pteridium aquilium*	0.02	0.02	0.02	-	-	-	-	-	-	-	-	-	-
3.*Lycopodium clavatum*	-	-	0.01	0.01	-	-	1.00	0.88	0.63	1.00	1.00	-	-
4.*Spinium*	0.01	0.02	-	0.01	0.01	-	-	-	-	-	-	-	-
5..*Pteridium aquilium*	-	-	-	-	0.02	-	-	-	-	-	-	-	-
6. *Bazzaminae-abundant*	-	-	-	-	0.02	-	-	-	-	-	-	-	-
7.*Commelina latifolia*	0.02	0.02	0.02	0.02	-	-	-	-	-	-	-	-	-
8.*Lycopodium saururus*	-	-	-	-	-	-	-	0.13	0.38	-	-	-	-
9.*Lycopodium cernuum*	-	-	-	0.02	-	-	-	-	-	-	-	-	-
10.*Cheilanthes farinosa*	0.02	-	-	-	-	-	-	-	-	-	-	-	-
11..*Cheilanthes afromontane*	-	-	-	-	0.02	-	-	-	-	-	-	-	-
12. *Dryopteriskirkii*	-	-	-	-	-	1.00	-	-	-	-	-	-	-
13. *Aspleniumelliotte*	-	0.02	-	-	-	-	-	-	-	-	-	-	-
Number of species	5	5	4	5	5	1	1	2	2	1	1	0	0
Shannon Weiner diversity index (H´)	0.357	0.396	0.26	0.2	0.2	0	0	0.07	0.14	0	0	0	0
Evenness (E_H)	0.222	0.246	0.19	0.1	0.1	0	0	0.11	0.21	0	0	0	0

4.5 Gymnosperm diversity and distribution by altitude

Only ttree species of Gymnosperms were identified in the study, namely *Podocarpus latifolius and Podocarpus falcatus. Podocarpus latifolius* was most abundant at 3400m accounting for 75% of all plants within the altitude whereas *Podocarpus falcatus* was abundant at 3000m accounting for 57% of all plants in the altitude. The species were more equitably distributed at 3000m. (E_H =0.2) and 3200m. (E_H =0.2) respectively. Species diversity and evenness were as shown in table 4.9. Species assemblage was highest in the lower altitudes (2400-3400m.) whereas no Podocarpiacae species were observed above 3400m.

Table 4.5 Gymnosperm diversity by Altitude

Gymnosperms \ Altitude	2400	2600	2800	3000	3200	3400	3600-4800
Podocarpus latifolius	0.583	0.571	0.5	0.43	0.57	0.75	-
Podocarpus falcatus	0.417	0.429	0.5	0.57	0.43	0.25	-
Number of species	2	2	2	2	2	2	-
Shannon Weiner diversity index (H´)	0.05	0.043	0	0.04	0.04	0.13	-
Evenness (E_H)	0.063	0.073	0	0.2	0.2	0.19	-

4.6 Bryophyte species distribution and richness on NMT, Mt. Kenya

4.6.1 Bryophyte species distribution

Bryophytes had the richest species diversity accounting for 49% of all plant species identified in the study area (Appendix II). They also occurred in all the altitudes in the Naru Moru track (Figure 4.4).

The species that occurred in the largest number of altitude ranges were *Grimmia* and *Andreaea*, the two species occurred most in high altitudes where no other species were found.

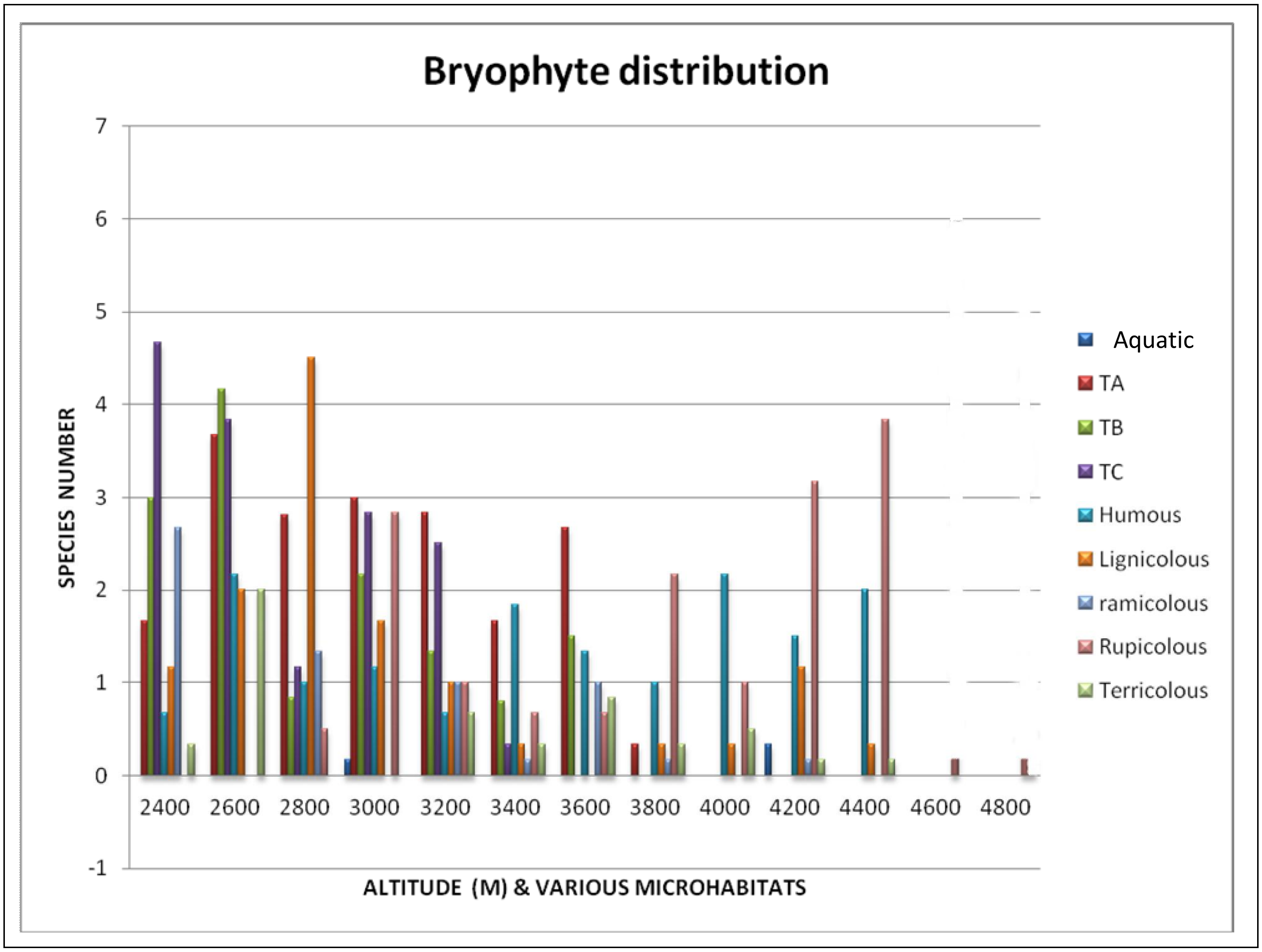


Figure 4.4 Bryophyte distribution by altitude and microhabitat

Legend : -bryophytes growing on height of tree from

-tree base of 0.0 to Ò0.5m as (TA),

-tree base of 0.5 to Ò1m as (TB)

-tree base of Ó1m as (TC).

4.6.2 Bryophyte species richness

The diversity and equitability of bryophyte species varied significantly along the NMT ecosystem. Species richness was highest at 2400m and lowest at 4600 and 4800m. At 2400m there were 28 species of bryophytes and at 4600 and 4800m there were only two species (Figure 4.5).

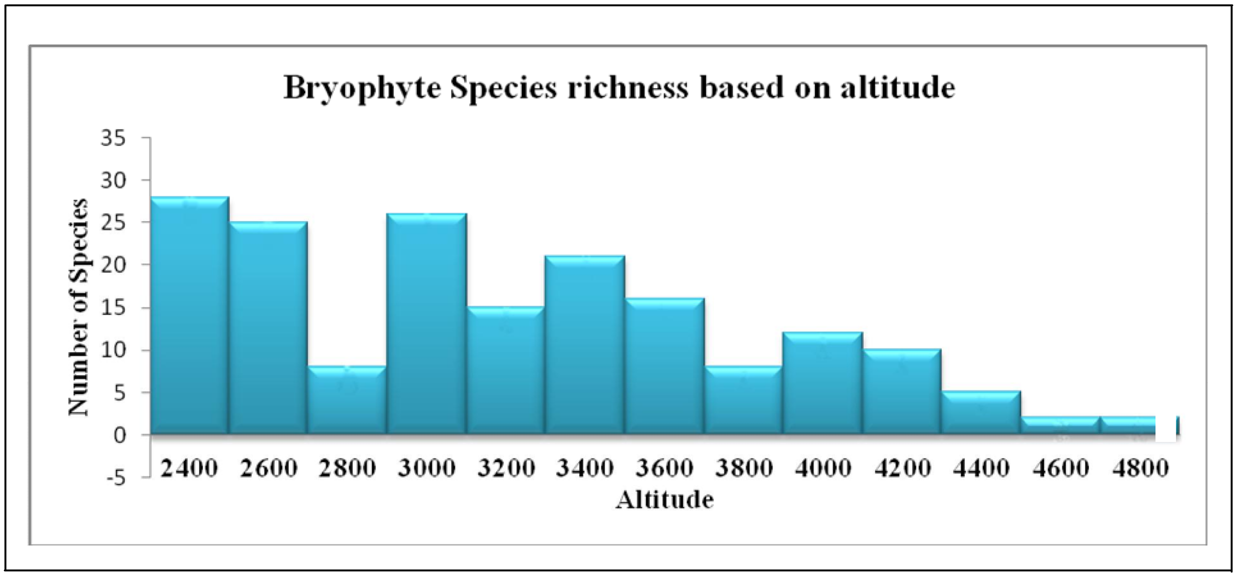


Figure 4.5 Bryophyte species richness at different Altitudes

4.6.3 Bryophyte species abundance

There were 81 bryophyte species identified on NMT, Mt. Kenya. Of these species 28 were found to be growing at altitude 2400m. The diversity and equitability of bryophyte species varied significantly along the NMT, (PÒ0.002) (Table 4.6). Species richness was highest at 2400m and lowest at 4600 and 4800m respectively.

Table 4.6 Bryophyte species abundance by Altitude

	Altitude													
Species	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	Total
Number of species	28	22	9	26	15	21	18	8	12	10	5	2	2	81
Shannon weiner (H´)	2.64	1.59	0.78	2.57	1.49	2.04	1.78	2.59	2.36	2.71	1.66	0.0	0.13	
Evenness (E_H)	0.431	0.52	0.81	0.63	0.55	0.54	0.62	1.25	0.9	0.98	0.95	0.00	0.19	

Grimmia longirostris was the most common species occurring at eight (8) different altitudes between 3400-4800m. and accounting for 9.6% of all bryophytes identified on NMT. It was followed closely by *Andreaea mildbraedii* which occurred at seven (7) altitudes, accounting for 8.4% of all species observed (Table 4.6). Abundance of the two species relative to each other was similar in the higher altitudes (4400m-4800m.) while these two species were the only ones identified at altitudes between 4600m and 4800m. At lower altitudes (2400-3200m), *Neckera spp* were the most abundant accounting for 5.2% of all bryophyte species identified.

4.6.4 Bryophyte distribution by altitude and microhabitat

The study identified nine bryophyte microhabitats along NMT: Those growing alongside water streams as Aquatic (Aq), on Humicolous (Hu), on lignified stems that have not started rotting as Lignicolous (Li), on branches or twigs of trees as Ramicolous (Ra), on rock surfaces or crevices as Rupicolous (Ru), on the ground as Terricolous (Te), on height of tree from tree base Ò0.5m as (TA), on of tree height from tree base 0.5 Ò1m as (TB) and on of tree height from Ó1m as (TC). There was a notable influence of altitude on bryophyte diversity and distribution. There were also significant variation (PÒ0.05) in altitudes and microhabitats; Hu and Ru microhabitats hosted more bryophytes in the higher altitudes (3800 to 4800m). Li and Corticolous hosted more bryophytes in the lower altitudes (2400-3400m). No bryophytes were identified in Aquatic microhabitat except at 4200m (Table 4.8). At 2400m, TC hosted a higher number of bryophytes compared to other microhabitats whereas none were observed in Aquatic and Rupicolous habitats.

Bryophyte distribution at altitude 2600 in microhabitats TA, TB and TC was comparable (21%) as well as in Te, Li and Hu (11%) but with no significant difference between microhabitats (PÒ0.099), (Table 4.7). At 2800m, Lignicolous had the highest bryophyte distribution (39%) followed by (height from tree base Ò0.5m) TA, (20%) and TB (13%) while no bryophytes were identified in Aquatic and Te microhabitats but with significant variation (P’ 0.00, Table 4.8). At 3000m, rupicolous hosted 24% of all bryophytes whereas TA and TB hosted 21 and 20% respectively. The distribution varied significantly
(PÒ0.19, Table 4.7).

Table 4.7 % Bryophytes distribution by altitude and microhabitat

	% of bryophytes encountered per Microhabitat							
Altitude m.a.s.l	Aq	Hu	Li	Ra	Ru	TA	TB	TC	Te
2400	0	5	8	18	0	13	21	33	2
2600	0	11	11	2	0	21	22	21	11
2800	0	9	39	6	4	20	13	9	0
3000	0	8	11	0	24	21	20	16	0
3200	0	5	11	11	5	27	13	22	6
3400	0	29	3	3	12	29	12	6	6
3600	0	2	8	0	17	47	26	0	0
3800	0	21	7	3	52	7	0	3	7
4000	0	43	7	0	40	0	0	0	10
4200	6	26	21	3	41	0	0	0	3
4400	0	37	0	0	61	0	0	0	3
4600	0	0	0	0	100	0	0	0	0
4800	0	0	0	0	100	0	0	0	0

Bryophytes growing alongside water streams as Aquatic (Aq), on Humicolous (Hu), on lignified stems that have not started rotting as Lignicolous (Li), on branches or twigs of trees as Ramicolous (Ra), on rock surfaces or crevices as Rupicolous (Ru), on the ground as Terricolous (Te), on height of tree from tree base Ò0.5m as (TA), on of tree height from tree base 0.5 Ò1m as (TB) and on of tree height from Ó1m as (TC). At 3200m., there was a significant variation in the distribution of bryophytes between the habitats (PÒ0.042) with TA recording the highest number of bryophytes (27%, Table 4.8). Humicolous (bryophytes growing on humus) and TA (bryophytes growing on tree trunks up to a heght of Ò0.5m) had comparable numbers of bryophyte densities at 3400m each contributing 29% of all bryophytes in the altitude. Li, (bryophytes growing on decaying matter) TC (bryophytes growing on tree trunks Ó 1m), Te (bryophytes growing on the ground) and Ra (bryophytes growing on tree branches twigs) had lower bryophyte densities compared to Hu and TA. There was a statistical significant variation in the distribution of bryophytes at 3600m.a.s.l with 47% of Bryophytes being hosted by TA while 53% hosted by the other microhabitats (PÒ0.02). No bryophytes were identified in Aquatic (Aq.) microhabitat except at 4200m (Table 4.7).

At 2400, TC hosted a higher number of bryophytes 62%, compared to other microhabitats whereas none were observed in Aquatic and Rupicolous. Bryophyte diversity between the nine microhabitats at this altitude was however statistically significant, PÒ0.039.

Also another observation made during this study was that, vascular plants are important as hosts of bryophytes while alive (Corticolous) as well as when they are dead (Lignicolous). It was found out that 50% of the bryophytes on NMT are Lignicolous, 30% corticolous bryophytes and others microhabitats host only 30% (Figure 4.6).

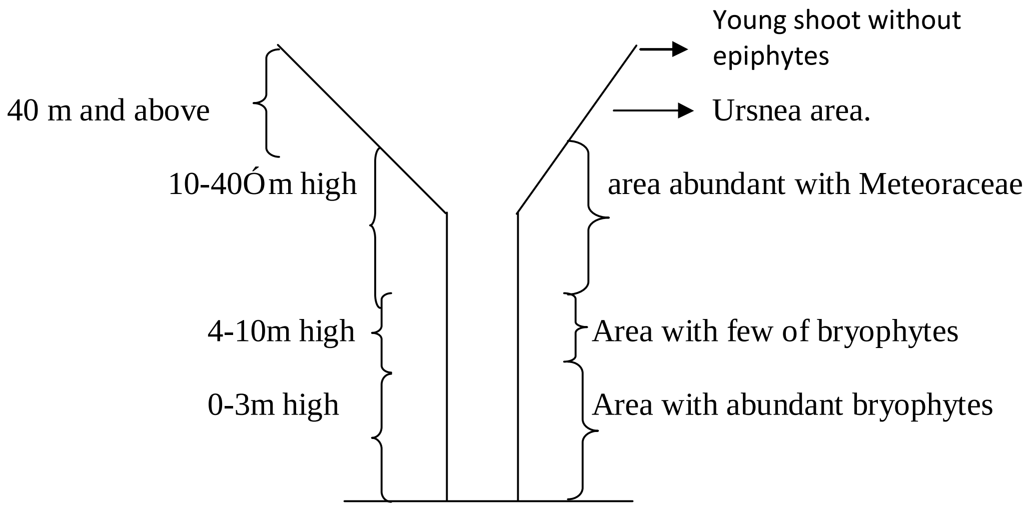


Figure 4.6 (a)

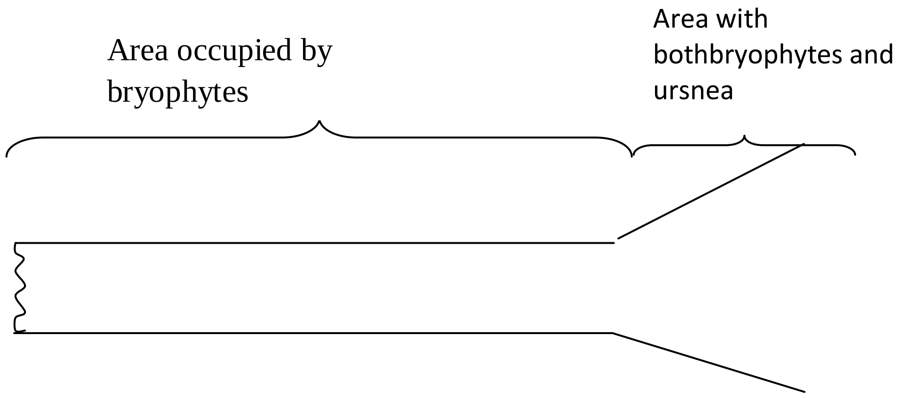


Figure 4.6 (b)

Figure 4.5 (a) and (b) Distribution of Bryophytes on fallen dead decaying (lignilcolous) vascular Plants

4.6.5 Diversity of bryophyte species for the nine microhabitats.

There was a significant contribution of microhabitat to bryophyte species distribution in the NMT, Mt. Kenya. TA (height from tree base Ò0.5m) microhabitat hosted the highest diversity of bryophyte species (H') =3.1106) whereas Aq. hosted the least (H' = 0) Table 4.9. Species were more equitably distributed at TB microhabitat (E_H=0.896) compared to other microhabitats. The most common species in TB (height from tree base 0.5Ò 1m) microhabitat was *Orthotrichum arborescens* which accounted for 12.8% of all species. The number of species at TB and TC was comparable 39.5% and 40.7% respectively. Twenty three bryophyte species were identified in the NMT for Humicolous microhabitat.

Table 4.8 Total Bryophyte species encountered in each of the nine microhabitats in each altitude

ALTITUDE	**Aquatic**	**TA ≤0.5m**	**TB 0.5-1m**	**TC ≥1m**	**Hu**	**Li**	**Ra**	**Ru**	**Te**	**ALTITUDINAL TOTAL**
2400	0	39	13	7	4	4	17	0	0	84
2600	0	34	13	14	9	41	1	0	10	122
2800	0	12	10	8	7	27	4	2	0	70
3000	0	16	16	16	6	11	0	21	2	88
3200	0	21	7	11	2	5	7	3	4	60
3400	0	11	4	1	9	1	0	2	2	30
3600	0	18	14	6	4	14	0	3	2	61
3800	0	1	0	0	5	1	0	16	2	25
4000	0	0	0	0	12	2	0	10	3	27
4200	2	0	0	0	9	7	0	16	1	35
4400	0	0	0	0	13	2	0	20	0	55
4600	0	0	0	0	0	0	0	36	0	36
4800	0	0	0	0	0	0	0	36	0	36
TOTAL	2	152	77	63	80	115	29	11	26	

Table 4.9 Distribution and evenness of Bryophyte species between microhabitats

Microhabitats	Aq	Hu	Li	Ra	Ru	TA	TB	TC	Te
Number of species	1	23	25	14	21	36	32	33	8
Shanon Weiner diversity index(H´)	0.000	2.399	2.623	2.107	2.354	3.111	3.017	3.018	1.434
Evenness	0.000	0.765	0.815	0.799	0.707	0.868	0.890	0.863	0.690

Lepodontium pungens was the most abundant species in this microhabitat accounting for 18.8% of all species followed closely by *Aulacomnium turgidum* accounting for 14.1%, species were more equitably distributed (E_H=0.765). The most shared species were *Orthotrichella cuspidata, Neckera* spp. and *Porotrichum usagarum*. There were 25 species in lignicolous with a diversity index of (H´=2.623). Species diversity varied notably across the microhabitats while equitability of the species was fairly even across them.

4.6.6 Species assemblage relationship at microhabitats

TA and TB were the most closely related microhabitats in the NMT ecosystem sharing 28.4% of all bryophyte species identified. TC and TA are the second most related sharing 23.5% of all bryophyte while TB and TC share 23.3% of all bryophyte species identified in the study. The microhabitats that shared the least number of species are Aquatic and Humicolous, Aquatic and Rupicolous, Aquatic and TC, Rupicolous, and Ramicolous and Terricolous Table 4.9.

Table 4.10. Percentage similarity matrix among bryophyte species assemblages at the nine Microhabitats.

	Aquatic	Humicolous	Lignicolous	Ra	Ru	TA	TB	TC	Te
Aquatic	1.2	-	-	-	-	-	-	-	-
Humicolous	-	-	8.6	8.6	8.6	7.4	7.4	8.6	7.4
Lignicolous	-	-	-	7.4	4.9	14.8	17.3	14.8	6.2
Ra	-	-	-	-	6.2	9.9	9.9	9.9	1.2
Ru	-	-	-	-	-	6.2	8.6	11.1	3.7
TA	-	-	-	-	-	-	28.4	23.5	2.5
TB	-	-	-	-	-	-	-	23.3	2.5
TC	-	-	-	-	-	-	-	-	3.7

Legend

Bryophytes growing: Near or in water- Aquatic (Aq), on Humicolous (Hu), on lignified stems that have not started rotting as Lignicolous (Li), on branches or twigs of trees as Ramicolous (Ra),

on rock surfaces or crevices as Rupicolous (Ru), on the ground as Terricolous (Te),

on height of tree from tree base Ò0.5m as (TA), on of tree height from tree base 0.5 Ò1m as (TB) and on of tree height from Ó1m as (TC).

4.6.7 Bryophyte species density and evenness

Bryophytes had densities varying in all altitudes from 0.4 to 14 as shown in Figure 4.9.

At altitudes 2600m, 4600m and 4800m the density was highest and same while at 4000m it was lowest. On the overall, the altitudes that had the most number of bryophytes observed were 2400 and 3000m asl where each recorded 350 numbers of specimens.

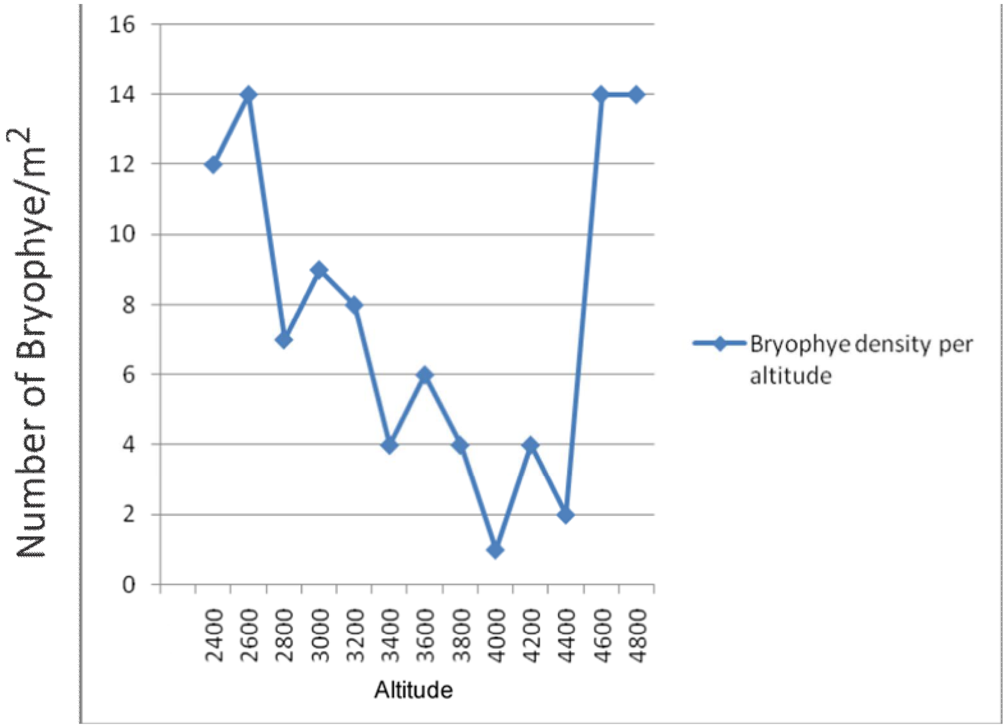


Figure 4.7 Bryophyte density variations by altitude

Overall plant distribution along NMT, Mt. Kenya.

There were four major categories of plants found on Naro Moru Track of Mt. Kenya. Representatives of each category are shown in Figure 6 (a-d);

(a)Bryophyta (*Marchantia porllymophia*) **(b) Pteridophyta (*Lycopodium saururus* JPG)**

(By auther) **(http// commons.wikimedia.org)**

(c) Gymnospermae (*Podocarpus latifolius*) **(d) Angiospermae (*Isolepis setacea*)**

(By auther) **(By auther)**

Figure 10 (a-d) Diversity of plant categories and their classification as observed on Naro Moru Track, Mt. Kenya.

4.7 Scientific classification and key differentiating characaters of representative members of bryophytes and tracheophytes

Machantia pollymophia		*Lycopodium saururus*	
Kingdom	Plantae	Kingdom	Plantae
Division	Machantiapsida	Division	Lycopodiophyta
Class	Jungermanniopsida	Class	Locopodiapiatae

Order	Machantiales
Family	Polysporangiates
Genus	*Machantia*
Species	*Machantia pollymophia*

The thallus is the sexual generation, Lacks stomata in its sporophyte generation. Most universally recognized Liverwort. Used in liver treatment.

It also reduces erosion at the stembank.

Order	Locopodiales
Family	Locopodiaceae
Genus	*Locopodium*
Species	*Locopodium saururus*

Reproduces by use of rhizomes.

Alkaloids used in chemical classification

Podocarpus latifolius

Kingdom	Plantae
Division	Tracheophyta
Class	Coniferopsida
Order	Coniferales
Family	Podocarpaceae
Genus	*Podocarpus*
Species	*Podocarpus latifolius*

Podocarpus latifolius grows in an upright, weeping habit to 30-40 m tall in its native habitat. Hosts *Neckera species*

Isolepis setacea

Kingdom	Plantae
Division	Angiospermae
Class	Monocots
Subclass	Commlinids
Order	Poales
Family	Cyperaceae
Genus	*Isolepis*
Species	*Isolepis setacea*

Because of its fibrous root system, it binds the soil together reducing soil erosion. It is also medicinal for stomach ailments.

In summary, the overall plant distribution can be represented on the graph as shown in Figure 4.8 which shows that tracheophytes and bryophytes do exist in almost equal numbers on Naro Moru track and also their trend in abundance is similar. The trend between 2400m and 3200m asl, shows that, at the beginning they both start in large numbers and decrease at 2800m, then shoot up at 3000m.Then tracheophytes stable off between 3200 and 3400 but bryophytes keep a sharp decreasing trend after 3600m asl to the end with little increase at 4400m asl. Tracheophytes shoot up abit at 4000m asl then stagnates at 4600 and disappears completely at 4800m asl.

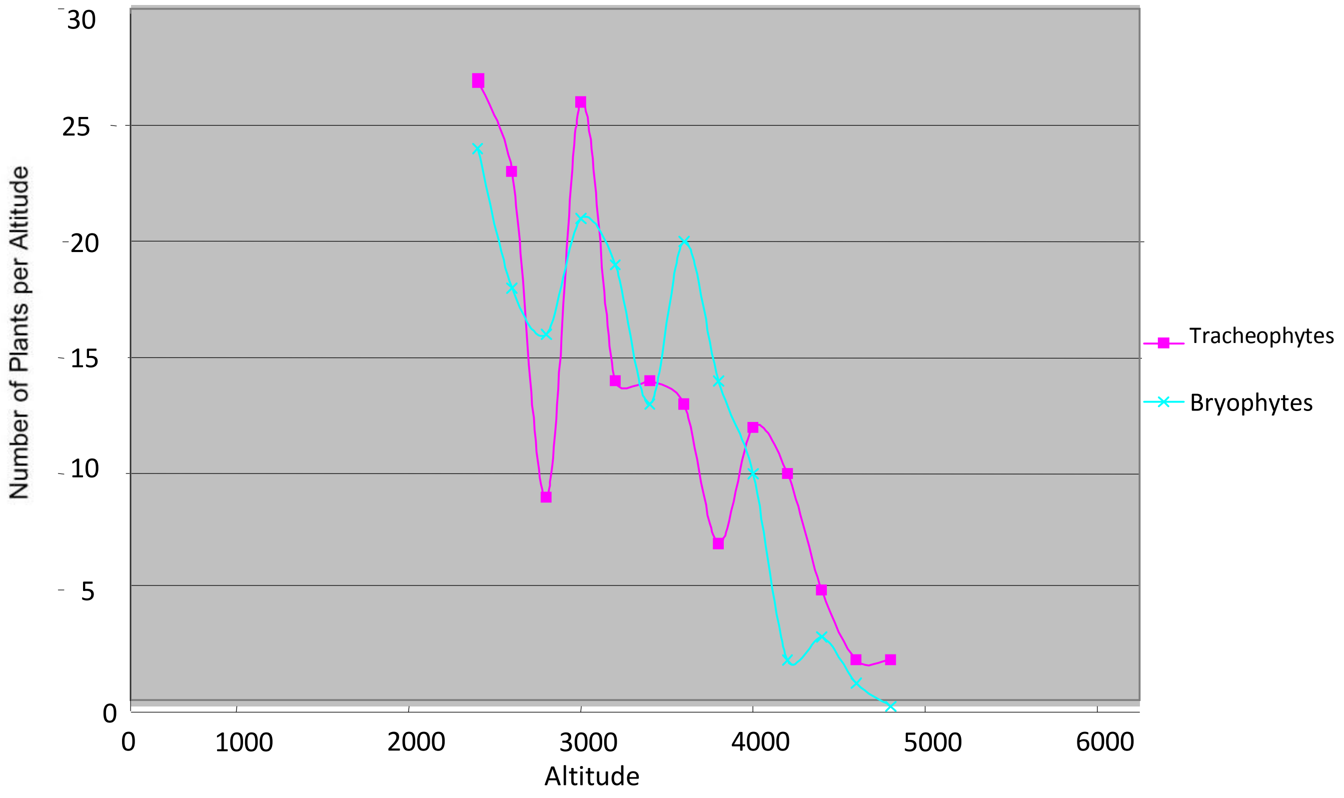


Figure 4.8 Summary of distribution of Tracheophytes and Bryophytes on NMT, Mt. Kenya.

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction and purpose of the study

This study found out that tracheophytes and bryophytes do exist almost in equal numbers on Naro Moru track as they are 83 and 81 species respectively. Tracheophytes acted as a home for bryophytes whereas bryophytes supplied water to them (Mwangi, 2008). (Those growing alongside water streams as Aquatic (Aq), on Humicolous (Hu), on lignified stems that have not started rotting as Lignicolous (Li), on branches or twigs of trees as Ramicolous (Ra), on rock surfaces or crevices as Rupicolous (Ru), on the ground as Terricolous (Te), on height of tree from tree base Ò0.5m as (TA), on tree height from tree base 0.5 Ò1m as (TB) and on tree height from Ó1m as (TC), these TA, TB, TC and Ra are collectively refered to as corticolous). In total Corticolous bryophytes ranked highest in number, followed by Lignicolous and Humicolous. The percentage of the species that thrived on tracheophytes whether alive or dead, and their related materials was 70%; this implies that out of the 81 species identified on NMT, about 57 of them were hosted by tracheophytes or its related materials like humicolous and lignicolous bryophytes (Tables 8 and 9). This agreed with Mwangi (2008) where he stated that pendant bryophytes species in Mt. Marsabit constituted 50% of all the bryophytes he identified. Some bryophyte species that existed on their own known as Terricolous were; *Warnstorfia sarmentosa, Syntichia cavallii* and as Aquatic; *Philonotis fontana.*

From these findings broadly, it can be believed that trees form the major structural and functional basis of Mt. Kenya tropical forest ecosystems. This could serve as robust indicators of changes and stressors at the landscape scale. In this study the spatial heterogeneity of diversity, could have been the result of some underlying pattern or process such as biotic control, and abiotic/biotic coupling process with spatial patterns of species richness. And this could be extensively used to identify Mt. Kenya as a biodiversity hotspot. Therefore the assumption was that managing an area of high species richness as was observed on Mt. Kenya, could be equated to improved conservation outcomes. The plant richness on Mt. Kenya was a positive predictor of a place of conservation value as indicated in this results which can be defined as a place where species of interest are abundant. Therefore this project provides an understanding of species diversity and distribution patterns that is important for helping managers to evaluate the complexity and resources of Mt. Kenya forests.

5.2 Distribution of Bryophytes and Tracheophytes along NMT, Mt. Kenya.

Bryophytes were the most dominant plant group (Table 4.1and Figure 4.5), and were distributed into organized micro-habitats. Vertically from 2400 to 4800m, the bryophyte species richness decreased with altitude. This was attributed to the fact that the bryophyte microhabitats also decreased on the same basis as the species composition is distinct among the microhabitats investigated (Table 4.8). In the study of the Rumoka Volcano in the Democratic Republic of Congo, it was reported that the mosses were neglected by samplers despite the vegetation group being dominant in number and abundance (Skottsberge, 1927). In this study, mosses comprised about 36% out of the 73 families identified on the track.

Bryophyte species richness, just as that of tracheophytess species, decreased with increase in altitude (Table 4.7). At 2400m, both plant groups were at optimum diversity numbers with bryophytes having 28 species (Figures 4.2 and 4.3) while tracheophyte plants had 24 species. Actual species of tracheophytes have been documented in Appendix II. Diversity decreased until there were only two bryophyte species (*Grimmia longirostris* and *Andreaea mildbraedii*) and one vascular plant (*Senecio purtschelleri*) species at 4600m. However, the decrease in bryophyte numbers between 2400 and 2800 in this region may be attributed to the distruction by large wild animals like *Loxondonta africana* that graze a lot and scratch themselves against the trees and logs which are the main hosts of bryophytes in the process the bryophytes are destroyed. These results were consistent with those Frahn, (1990c) who noted changes in species composition as floristic discontinuities. In this study, 2400 and 4800m were the altitudes at which maximum number of species had their upper most and lower most occurrences respectively; they were regarded as the altitudes with the highest degree of floristic change. This study also agreed with Poc´s (1994) on the altitudinal distribution of bryophytes on Mt. Kilimanjaro in which most bryophyte species were found between comparatively similar altitudes of 2400 and 5050 m). The findings also agreed with Ah-Peng (2005) in which it was observed that altitudes above 750m on the East African continent could be compared well with those between 250m and 850m on the lava flows of La Reunion. These results were also consistent with those by Grytnes *et al.,* (2006) who stated that altitude influenced the biodiversity of Mt. Kenya. Similarly, these results also agree with those of (Grytnes *et al.,* 2006) on Mount Kinabalu who noted that plant richness was influenced by elevation.

5.3 Influence of altitude on diversity and distribution of Bryophytes and Tracheophytes

The overall plant richness on the NMT varied significantly (PÒ0.000) between plant categories because of the altitudinal variance that accompanied the mountain ascend. Bryophytes recorded the highest average richness (13.69) while gymnosperms recorded the least (0.92) (Table 4.2).

Species richness was highest at 3000m and lowest at 4800m with averages of 15.75 and 0.5 respectively. This may be accorded to the favorable climatic conditions that prevail at lower altitudes and the unfavorable at higher altitudes. Species richness was similar at 3200m (10.25) and 3600m (10.00) because this seems to be the transitional zones between Montane and Subalpine zones. The tracheophytes are reducing due to the changing precipitation and soils; (Mahaney, 1987 and Speck, 1986) found out that soils of Mt. Kenya show altitudinal zonation and the land elevation determines the type of soil as a result of volcanic activities.

The number of shared species between altitudes was highest between 2400 and 3600m but gradually decreasing with rise in altitude. This is because most of the bryophytes are hosted by tracheophytes or tracheophyte related materials; (Bryophytes growing , on Humicolous (Hu), on lignified stems that are not completely decomposed as Lignicolous (Li), on branches or twigs of trees as Ramicolous (Ra), on height of tree from tree base Ò0.5m as (TA), on tree height from tree base 0.5 Ò1m as (TB) and on of tree height from Ó1m as (TC).)Ra, TA, TB and TC (collectively referred to as corticolous) or Hu and Li. The tracheophyes that hosted bryophytes most were; *Sinnarundinaria alpina, Podocarpus latifolius, Podocarpus falcatus* and *Ericaceae spp.* This also proved a point whereby out of 13 microhabitats for bryophytes, six were tracheophye related. Between 2800m and 3200m, 80% of all the species of tracheophytes identified in the ecosystem were observed implying that also most of the tracheophytes occured here; (Table 4.3).

The bryophyte population increased again at 3600m and dropped at 3800m because at this altitude, the Bog/moorland area starts and Ericaceaous spp. hosts almost all the bryophyte spp. as TA, TB, TC and Ramicolous, Rupicolous are few. However the bryophytes remained relatively constant between 3800 and 4400m which may be attributed to the presence of montane to subalpine region and the tracheophytes dominating have little lignin in their stems (eg Grasses, *Alchemillas*, Giant *Senecio* and *Lobelia* spp.) hence hardly able to provide a home for bryophytes; the only microhabitats in this region for bryophytes were Rupicolous and to the least Aquatic. The type of rain experienced in this region is in form of hailstones or snow; this also has made it almost impossible for the survival of tracheophytes hence their low lifeforms.

5.4 Variation of bryophyte diversity by microhabitat

In the higher altitudes (4400m to 4800m) stones were frequent in most of the sampled areas and only two species *Grimmia longirostris* and *Andreaea mildbraedii* were the ones observed to be adapted to rocky/stone life. These also were the most common species on the NMT ecosystem occurring in 8 and 7 altitudinal levels respectively. *Nekera* spp. was the most abundant in the lower altitudes (2400-3200m.a.s.l) accounting for 5.2% of all bryophyte species identified because this was found to be growing on the tree species of (corticolous) both the *Podocarpus* and *Sinnarundinaria alpina* occupying the first three metres of the over forty metre tall trees.

Bryophytes growing alongside water streams as Aquatic (Aq), on Humicolous (Hu), on lignified stems that have not started rotting as Lignicolous (Li), on branches or twigs of trees as Ramicolous (Ra), on rock surfaces or crevices as Rupicolous (Ru), on the ground as Terricolous (Te), on height of tree from tree base Ò0.5m as (TA), on of tree height from tree base 0.5 Ò1m as (TB) and on of tree height from Ó1m as (TC). At 3800m asl, hosted the most bryophytes because in this region there is a lot of decomposing humus from the *Hyperemia* grass covering the ground, while Ru microhabitats hosted more bryophytes in the higher altitudes (4600 and 4800m) as they are the only habitats, whereas Li and Corticolous hosted more bryophytes in the lower altitudes (2400-3400m) because most of the bryophytes here are pendant. Aquatic microhabitat was sited only once at 4200m.

At 2400m, TA hosted a higher number of bryophytes because this is the first 1m height on the trees where there is least wild animal disturbance and conducive moisture content for survival. Bryophyte diversity between the nine microhabitats at this altitude was however statistically significant (PÒ0.039) (Table 4.3).

Between 3200m and 3400m, there was a significant increase in the distribution of bryophytes due to the presence of *Sinnarundinaria alpina* which is host to most corticolous bryophytes. The bamboo is host the humicolous hence these two habitats to have similar bryophyte densities. Li, TC, Te and Ra had lower bryophyte densities compared to Hu and TA because this is an area where many wild animals graze and also a camping site. The game animals use the trees to scratch their backs thus destroying the bryophytes that occupy this height and at the same time, at this ascend is where the camp people collect wood to burn for heating the house (Banda) at the campsite where along with the wood; the small plants carried on are also burnt.

Microhabitats for bryophytes at 3600m were only five namely; (Bryophytes growing on Humicolous (Hu), on lignified stems that have not completely decomposed as Lignicolous (Li), on branches or twigs of trees as Ramicolous (Ra), on rock surfaces or crevices as Rupicolous (Ru), on height of tree from tree base Ò0.5m as (TA), on of tree height from tree base 0.5 Ò1m as (TB) and on of tree height from Ó1m (TC).) here referred to as corticolous bryophytes were most at 73% because this is a transition area between montane and sub-montane and the stony ground is just at introductory stage, rupicolous plants are not much thus hosting only 17% as compared to the upper altitudes; while humus and decaying wood were 2% and 8% respectively. The temperatures at these higher altitudes were also unfavorable for decomposition process since temperatures are decreasing to lower values. It is also observed that most of the game animals graze upto here the reason why TC hosts zero. *Sphagnum spp* were the only terricolous bryophytes, here seems to have been trampled on by the game until it was not observed in the samples hence its percentage occurrence here was zero.

At 3800m, 52% of bryophytes were mainly rupicolous because there were very few angiosperms which did not offer habitation to bryophytes that is Ericaceae family. The rest of the microhabitats; humicolous hosted 20% while Li, TA, TB and Te were equal each contributing 7% of all bryophytes implying that the rocky area has completely set in and only Rupicolous bryophytes can survive in this area successfully. Rupicolous and humicolous hosted over 80% of all bryophytes identified at 4000, 4200 and 4400m.whereas all bryophytes identified between

4600 and 4800 m were rupicolous because this is entirely an alpine region with soil type as very dark stony loams with high content of organic matter and low bulky density (Lithosols & Regosols) not much is expected for the angiosperms; angiosperms do not have adaptive features like bryophytes. Bryophyte densities varied significantly (PÒ0.05) between microhabitats in these altitudes as shown in Table 4.6.

There was a significant contribution of microhabitat to bryophyte species distribution in the NMT ecosystem. TA microhabitat hosted the highest diversity of species (H=3.1106) whereas Aq hosted the least (H=0) on the overall, this signifies that tracheophytes are the main hosts for the bryophytes regardless of their life statuses. Soil contributes to the habitation of bryophytes as second last to the Aquatic microhabitat. *Orthotrichum arborescens* which accounted for 12.8% of all species being hosted by angiosperms at the height of 0.0 Ó1 (TA &TB) on their stems suggests that if these angiosperms are destroyed, this species will also decline in existence. The number of species at TB and TC was comparable 39.5% and 40.7% respectively because these are areas above the ground and not so much moisture from the ground reach this area, cryptogams here make use of their retained water reservoirs. This is a cutting edge for bryophytes over the other plants. Twenty three bryophyte species were identified in the NMT from humicolous (Table 4.7*). Leptodontium pungens* being the most abundant species accounted for 18.8% of all species followed by *Aulacomnium turgidum* which accounted for 14.1%, species hence equitably distributed (E_H=0.7651), this shows how important is the angiosperms as a home for the Bryophytes which in turn are as important in the water cycles of Mount Kenya. The most shared species were *Orthotrichella cuspidata, Neckera sp* and *Porotrichum usagarum.* All were hosted by angiosperms and gymnosperms. In all, 74.2% of all the species of bryophytes identified in the study were hosted by angiosperms and gymnosperms; the more reason why the higher plants should not be destroyed anyhow.

5.5 Vascular Plants

Of the three categories of vascular plants identified under the study, gymnosperms and angiosperms play a major role in hosting cryptogams while pteridophytes do not host the plants at all. However, pteridophytes were also hosted by angiosperms such as *Lycopodium clavatum* which was hosted by *Dombeya torrida* at 3600m. The study also noted a wider distribution, richer diversity and a higher evenness of species of tracheophyte plants in the lower and mid altitudes (2400-3800m.) just as was with the bryophytes than higher altitudes (4000 -4800m.) and this proves how the two plant categories closely associate with each other; therefore in conservation of the higher plants; the small ones should be our core concern too.

5.6 Conclusion and Recommendations

5.6.1 Conclusion

The aim of this study was to establish the taxonomic and ecological relationship between bryophytes and tracheophytes along western slope of Mt. Kenya and this has been determined whereby the study revealed that NMT of Mount Kenya harbors a high diversity of bryophytes and tracheophytes 81 and 83 in percentage it is 50 and 49 respectively, which contribute significantly to the overall biodiversity of the ecosystem. The hygroscopic capacity of bryophytes is 13% (Mwangi 2008) and their high water interception capacity which they release at intervals to maintain the tracheophytes in dry spells is of great importance in maintaining the forest moisture index. The study has also demonstrated that the diversity and distribution of bryophytes and the tracheophytes is influenced firstly by altitude and secondly by the microhabitats provided by natural features such as bogs, rocks and the tracheophytes themselves. Bryophytes tend to be host specific and hence tracheophytes are host to specific bryophytes. The conservation of the two is therefore inter-twined and crucial for the ecological functioning of the mountain forests ecosystems. Therefore, the taxonomic and ecological information as provided in this study may be vital in laying down of the strategies to conserve Mt. Kenya.

Loss of woody vegetation cover, especially of tracheophytes in Mt Kenya forest will result in microclimate modification and the loss of substrates and habitats required for the survival of the bryophytes since 80% of the bryophytes are hosted by the tracheophytes/tracheophyte related materials. Water from Mt. Kenya is currently required to feed springs, rivers, marshes and other wetlands downstream. Therefore, the taxonomic information of the less studied and less appreciated groups is essential in laying down the strategies to conserve Mt. Kenya.

5.6.2 Recommendations

1 This was the first comprehensive study of bryophytes and their relationship with altitude, and distribution of tracheophytes in Mt Kenya. However, in order to determine the overall Mt. Kenya forest health, more statistical correlations are required along the track and along other routes to the peaks of Mt. Kenya. It is therefore recommended that such studies be carried out on other routes to Mt. Kenya so as to have a better understanding of the contribution of bryophytes to the mountains forest biodiversity as well as its ecological and hydrological functions.

2 Monitoring of the mountainôs biodiversity is recommended at reasonable intervals to establish the fluctuations of the two plant groups. This may be of importance in establishing the rainfall patterns on the mountain and to explain, such phenomena as erratic flooding of the rivers downstream, drought and other climate related changes. This information will be useful in the selection of appropriate conservation strategies, including enrichment of tree species. Monitoring epiphyllous bryophytes in particular will help to understand effects of forest degradation and climate change.

3 Results from this project should be incorporated into the Agro-forestry programs and County forest policy framework in Mt. Kenya region; to involve local people on the need to conserve and sustainably utilize the forest resources. This is because, the demand for wood, timber and medicinal forest products as well as burning of charcoal and growing of *Cannabis sativa* are serious threats to the forest reserve. Cultivation of the indigenous trees such as *Olea europea* ssp. *africana* will mitigate against habitat destruction and hence maintain natural substrates for bryophytes and give the forest a chance to recover its ecological health and eventually maintain the forest as water tower for the generations to come.

4 Bryophytes are closely linked to their habitats. It is essential to consider the pattern of these habitats on a broader scale. Maintenance of these microhabitats will mitigate against disappearance of their affiliated biodiversity on the mountains in totality.

5 Harvesting of Bryophytes in state forests should be strictly monitored and harvesting regulated.

6 Since bryophytes can be used to control soil erosion, this would be considered in future to control erosion at the river banks to curb adverse erosions experienced there.

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APPENDICES

APPENDIX I TRACHEOPHYTE DISTRIBUTION ON NMT, MT. KENYA

ALTITUDE	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800
1.*Sinnarundinaria alpine*	0.06	0.08	0.09	0.07	0.07	0.06	-	-	-	-	-	-	-
2.*Dracaena afromontana*	0.01	0.02	0.03	0.01	-	-	-	-	-	-	-	-	-
3.*Rubus steudneri*	0.06	0.07	0.05	0.03	-	-	-	-	-	-	-	-	-
4.*Stephania abyssinica*	0.08	0.07	0.05	0.01	-	-	-	-	-	-	-	-	-
5.*Drognetia iners*	0.01	0.02	0.02	0.01	-	-	-	-	-	-	-	-	-
6.*Plantago palmate*	0.01	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
7.*Cyphostemma bambuseti*	0.01	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
8.*Cyperusrotundus*	0.04	-	-	-	-	-	-	-	-	-	-	-	-
9 .*Cyperusnigricans*	-	0.03	-	-	-	-	-	-	-	-	-	-	-

10. *Digitariascalarum*	0.06	-	0.03	-	-	-	-	-	-	-	-	-	-
11.*Rhus natalensis*	-	0.01	-	-	-	-	-	-	-	-	-	-	-
12.*Commelina latifolia*	0.08	-	0.03	-	-	-	-	-	-	-	-	-	-
13.*Carduuskeniensisvaraberdaricus*	-	-	-	0.04	0.06	0.05	0.10	0.06	-	-	-	-	-
14. *Carduusmillefolius*	0.04	-	-	-	-	-	-	-	-	-	-	-	-
15. *Carduusnyasanus*	0.06	-	-	-	-	-	-	-	-	-	-	-	-
16.*Conyza floribunda*	0.07	0.07	0.06	0.03	0.04	0.02	-	-	-	-	-	-	-
17.*Conyza newii*	0.09	0.08	0.06	0.05	-	-	-	-	-	-	-	-	-
18.*Cotula abyssinica*	0.03	0.03	0.04	0.03	0.02	0.02	-	-	-	-	-	-	-
19. *Anagallisserpens ssp. Meyeri-johannis*	0.03	0.05	0.05	0.04	0.04	0.04	-	-	-	-	-	-	-
20.*Erica arborea*	0.01	0.02	0.03	0.03	0.04	0.04	0.06	0.01	-	-	-	-	-
21.*Senecio syringrifolius*	0.01	0.04	0.04	0.04	0.05	0.04	0.03	-	-	-	-	-	-

22.*Senecio keniensis*	0.02	0.04	0.05	0.02	-	-	-	-	-	-	-	-	-
23.*Urtica masaica*	0.04	0.06	0.06	0.07	0.07	0.06	0.04	-	-	-	-	-	-
24.*Hypoetes forskahlii*	-	0.05	0.06	0.01	-	-	-	-	-	-	-	-	-
25.*Peperomia abyssinica*	-	-	-	0.01	0.05	0.03	-	-	-	-	-	-	-
26.*Hibiscus vitifolius*	-	-	-	0.03	-	-	-	-	-	-	-	-	-
27.*Leptotrichilia volkensii*	-	0.04	0.06	0.04	0.04	0.03	-	-	-	-	-	-	-
28.*Dichrocephala chrysanthemifolia*	-	-	-	-	-	-	-	0.17	0.30	0.44	0.23	-	-
29.*Alchemilla johnstonii*	-	-	-	0.08	0.13	0.08	-	-	-	-	-	-	-
30.*Alchemilla argyrophylla*	-	-	-	0.05	0.13	0.07	-	-	-	-	-	-	-
31.*Alchemilla argyrophylla*	-	-	-	0.06	0.12	0.08	-	-	-	-	-	-	-
32.*Senecio battiscombei*	-	-	-	-	-	0.06	-	-	-	-	-	-	-
33.*Senecio keniodendron*	-	-	-	-	-	-	-	0.11	-	-	-	-	-

34. *Seneciopurtschelleri*	-	-	-	-	-	-	-	-	-	-	0.09	0.50	-
35. *Seneciomoorei*	-	-	-	0.01	-	-	-	-	-	-	-	-	-
36. *Sabucusafricana*	-	-	-	0.05	-	-	-	-	-	-	-	-	-
37. *Nuxiacongesta*	-	-	-	0.04	-	-	-	-	-	-	-	-	-
38. *Cassopoureamolesta*	-	-	-	0.04	-	-	-	-	-	-	-	-	-
39.*Lobelia thomsonii*	-	-	-	-	0.04	0.06	0.04	-	-	-	-	-	-
40. *Lobelia minutulta*	-	-	-	-	-	-	0.03	-	-	-	-	-	-
41.*Lobelia telekii*	-	-	-	-	-	-	-	0.18	0.38	0.44	0.23	-	-
42.*Lobelia deckenii*	-	-	-	-	-	-	-	0.02	0.18	-	-	-	-
43. *Bazzaminae-abundant*	-	-	-	-	0.01	-	-	-	-	-	-	-	-
44.*Erica excels*	-	-	-	-	-	-	0.04	-	-	-	-	-	-
45.*Hagenia abyssinica*	-	-	-	-	0.01	-	-	-	-	-	-	-	-
46. *Peucedanumkerstenii*	-	-	-	-	0.02	0.03	0.04	-	-	-	-	-	-

47.*Euphobia schemperiana*	-	-	-	-	0.02	0.05	0.05	-	-	-	-	-	-
48. *Ekebergiacapensis*	-	-	-	-	-	-	0.07	-	-	-	-	-	-
49.*Crassocephylum montuosum*	-	-	-	-	-	0.03	-	-	-	-	-	-	-
50.*Dombeya terrida*	-	-	-	-	-	0.02	-	-	-	-	-	-	-
51.*Kalaud densiflora*	-	-	-	-	-	0.03	-	-	-	-	-	-	-
52.*Festiuca piligii*	-	-	-	-	-	0.05	-	-	-	-	-	-	-
53.*Cinereria deltoidea*	-	-	-	-	-	-	0.01	-	-	-	-	-	-
54.*Sambucusa Africana*	-	-	-	-	-	-	0.05	-	-	-	-	-	-
55.*Bothriocline fusca*	-	-	-	-	-	-	0.03	-	-	-	-	-	-
56.*Phytolacca dodecandra*	-	-	-	-	-	-	0.06	-	-	-	-	-	-
57.*Erharta erecta*	-	-	-	-	-	-	0.02	-	-	-	-	-	-
58.*Cynoglosum coeruleum*	-	-	-	-	-	-	0.06	-	-	-	-	-	-
59. *Dichrocephala integrifolia*	-	-	-	-	-	-	0.03	-	-	-	-	-	-

60.*Heptocarpha rupelii*	-	-	-	-	-	-	-	0.05	-	-	-	-	-
61. *Senecio roseiflorus*	-	-	-	-	-	-	-	0.08	0.15	0.12	0.36	0.50	-
62.*Helicrisomia sereria*	-	-	-	-	-	-	-	-	-	-	0.09	-	-
63. *Carex monostachya*	-	-	-	-	-	-	0.09	-	-	-	-	-	-
64.*Dombeya goetzii*	-	-	-	-	-	-	-	0.11	-	-	-	-	-
65.*Typha latifolia*	-	-	-	-	-	-	-	0.13	-	-	-	-	-
66.*Achyranthes aspera*	0.10	0.11	0.06	0.04	-	-	-	-	-	-	-	-	-
67.*Commelina latifolia*	0.08	0.10	0.06	0.03	-	-	-	-	-	-	-	-	-
68.*Sonhus oleraceus*	-	-	-	-	-	-	0.12	-	-	-	-	-	-
69.*Erica whyteana*	-	-	0.02	0.03	0.03	0.03	0.05	-	-	-	-	-	-
70.*Isolepis setacea*	-	-	-	-	-	-	-	0.07	-	-	-	-	-
71.*Eleocharis marginulata*	-	-	-	-	-	-	0.04	-	-	-	-	-	-
Shannon Weiner diversity index	1.047	0.893	0.902	1.099	0.82	0.801	0.534	0.348	0.086	0.062	0.086	0.013	0

(H)													
Evenness (E_H)	0.339	0.293	0.292	0.323	0.28	0.259	0.175	0.145	0.062	0.056	0.054	0.019	0
Number of Species	24	21	22	20	19	22	21	11	4	3	5	2	0

APPENDIX II

Classification of Trcheophyte plants on the Naro Moru Track

In biology, modern classification can be done either by an identification key that is a printed or computer-aided device that aids the identification of biological entities, such as plants, animals, fossils, microorganisms and pollen grains. Identification keys are also used in many other scientific and technical fields to identify various kinds of entities, such as diseases, soil types, minerals, or archaeological and anthropological artifacts.

Traditionally identification keys have most commonly taken the form of single access keys. These work by offering a fixed sequence of identification steps, each with multiple alternatives, the choice of which determines the next step. If each step has only two alternatives, the key is said to be dichotomous, else it is polytomous. Modern multi-access or interactive keys allow the user to freely choose the identification steps and their order.

At each step, the user must answer a question about one or more features (characters) of the entity to be identified. In a botanical key one may ask about the color of flowers, or the disposition of the leaves along the stems. In this identification, the user has simply referred the readers to refer to the classification that already exists done by Agnew and Agnew 1994 for vascular plants while Po cs and O'Shea 1999 for bryophytes and. Pteridophytes are classified according to Johns 1991. The only addition is in reference to hodsting bryophytes by Tracheophytes.

All the plant species sampled and collected on the Naro Moru Track were 168, and of these, only two species of the family Podocarpiaceae (*Podocarpus latifolius* (Thumb.) Mirb. and *Podocarpus falcatus* Mirb.) belonged to the Gymnosperms between altitudes 2400 and 3400m, 85 angiosperms and 79 bryophytes that were spread along the whole length of altitudinal gradient sampled (2400-4800m.) and . The two *Podocarpus* species are rich as a home for many bryophytes particularly of the family Radulaceae. They are the only gymnosperm species represented on this track within the releves on Mount Kenya.

The 85 vascular plants belong to 31 families and 48 genera while the bryophytes belong to 39 families and 56 genera. On the track there were also lichens that occured quite often in the genus ussunia between 3600 and 4200m.

KEY TO THE PLANTS ON NARO MORU TRACK

1a. Vascular Plantsé é é é é é é é é é é é é ..é .2

1b. Non vascular plants é é é é é é é é é é é é é .4

2a. Seed plants é é é é é é é é é é é é é é é é é 3

2b. Non seed plantsé é é é é é é é é é é é é é é Pteridphytes

3a. Non flowering é é é é é é é é é é é é é é é é Gymnosperms

3b. Flowering plantsé é é é é é é é é é é é é é .Angiosperms

4a. Leaves bristle tipped with nerveé é é é é é é é é Mosses (Bryopsida/Musci)

4a. Leaves lobed without a nerveé é é é é é é é é .Liverworts (Hepaticopsida) and

Hornworts (Anthocerotopsida)

APPENDIX III

Bryophyte species on Naro Moru Track

On anlysis, the total number of species collected on Mount Kenya on Naro Moru Track were 71 while the families and Genera of both Musci and Hepatics are as shown below:

Musci

Family	Species
Amblystegiaceae	*Sanionia uncinata*
Andreaeaceae	*Andreaea mildbraedii*
Aulacomniaceae	*Aulacomnium turgidum*
	Warnstorfia sarmentosa
Bartramiaceae	*Brautelia muhavurensis*
	Philonotis fontana
Brachytheciaceae	*Palamocladium leskoides*
	Brachythecium plumosum
Bryaceae	*Bryum huillense*
	Bryum laevigatum
	Bryum pseudotriguetrum
Calymperaceae	*Syrrhopodon usagarum*

	Syrrhopodon usambarensis
Cryphaeaceae	*Cryphaea robusta*
Dicranaceae	*Campylopus hildebrandtii*
	Campylopus jamesonii
	Campylopus nivalis
	Campylopus savannarum
Entodontaceae	*Entodon macropodus*
Geocalycaceae	*Lophocolea bicuspidata*
	Leptoscyphus hedbergii
Grimmiaceae	*Racomiturm subsecundum*
	Grimmia longirostris
Hedwigiaceae	*Braunia camptoclada*
	Braunia secunda
Hylocomiaceae	*Hylocomium splendens*
Hypnaceae	*Hypnum cupressiforme var.cupressiforme*
Lembophyllaceae	*Cyclodictyon borbonicum*
Leucodontaceae	*Pterogonium gracile*

	Antitrichia kilimanscharica
Meteoriaceae)	*Squamidium brasiliense*
	Aerobryidium subpiligerum
	Papillaria africana
Neckeraceae	*Neckera spp*
	Leptodon smithii
	Porotrichum usagarum
	Porothamnium wariifoliodes
	Porothamnium stipitatum
Orthotrichaceae	*Orthotrichella cuspidata*
	Orthotrichum affine var affine
	Orthotrichum .arborescens
	Orthotrichum rupestre
	Macrocoma abyssinica
Polytrichaceae	*Pogonatum gracilifolium*
	Hedwigia stellata
Pottiaceae)	*Syntrichia cavallii*
	Leptodontium pungens

Pterobryaceae	*Calyptothecium hoehnelii*
Sematophyllaceae	*Sematophyllum sub brachytheciiforme*
Hepaticeae	
Allisoniaceae	*Calycularia crispula*
Frullaniaceae	*Frullania depressa*
	Frullania obscurifolia
	Frullania schimperi
Lejeuneaceae	*Lejeunea flava*
	Cheulolejeunea cordistipula
	Leucolejeunea xanthocarpa
	Microlejeunea africana
Lophoziaceae	*Anastrophyllum auritum*
Metzgeriaceae	*Metzgeria agnewii*
Plagiochilaceae	*Plagiochila abyssinica*
	Plagiochila barteri
	Plagiochila colorans

	Plagiochila effusa
	Plagiochila exigua
	Plagiochila haumannii
Porellaceae	*Porella abyssinica var. hoehnelii*
Radulaceae	*Radula voluta*
	Radula ankefinensis
	Radula quadrata
	Radula stipatiflora
	Radula boryana

APPENDIX IV

All vascular plants on Naro Moru Track, Mt. Kenya

Family	Species
Acanthaceae	*Hypoetes forskahlii*
Adianthaceae	*Cheilanthes tecta*
Adoxaceae	*Sambucus africana*
Amaranthaceae	*Achyranthes aspera*
Anacardiaceae	*Rhus natalensis*
Apiaceae	*Peucedanum kerstenii*
Apocynaceae	*Rauvolfia densiflora*
Asparagaceae	*Chlorophytum viridescens*
Asparagaceae	*Dracaena afromontana*
Asparagaceae	*Droguetia iners*
Asteraceae/Compositae	*Artemisia afra*
Asteraceae/Compositae	*Bothriocline fusca*
Asteraceae/Compositae	*Carduus keniensis*
Asteraceae/Compositae	*Carduus millefolius*

Asteraceae/Compositae	*Carduus nyassanus*
Asteraceae/Compositae	*Carduus platyplyllus*
Asteraceae/Compositae	*Cinereria deltoidea*
Asteraceae/Compositae	*Conyza floribunda*
Asteraceae/Compositae	*Conyza newii*
Asteraceae/Compositae	*Cotula abyssinica*
Asteraceae/Compositae	*Crassocephylum montuosum*
Asteraceae/Compositae	*Dendrosenecio brassica*
Asteraceae/Compositae	*Dendrosenecio keniensis*
Asteraceae/Compositae	*Dendrosenecio keniodendron*
Asteraceae/Compositae	*Dichrocephala chrysanthemifolia*
Asteraceae/Compositae	*Dichrocephala integrifolia*
Asteraceae/Compositae	*Helichrysum* spp
Asteraceae/Compositae	*Senecio battiscombei.*
Asteraceae/Compositae	*Senecio kiniensis*
Asteraceae/Compositae	*Senecio keniodendron*
Asteraceae/Compositae	*Senecio keniophytum*

Asteraceae/Compositae	*Sonchus oleraceus*
Boraginaceae	*Cynoglosum coeruleum*
Brassicaceae	*Arabis alpina*
Campanulaceae	*Lobelia deckenii*
Campanulaceae	*Lobelia telekii*
Campanulaceae	*Lobelia thomsonii*
Commelinaceae	*Commelina latifolia*
Cyperaceae	*Carex monostachya*
Cyperaceae	*Cyperus nigricans*
Dennstaedtiaceae	*Pteridium aquilium*
Dicranaceae	*Leptotrichellia volkensii*
Ericaceae	*Erica arborea*
Ericaceae	*Philippia trimera*
Euphobiaceae	*Euphobia schemperiana*
Euphobiaceae	*Euphorbia tirucalli*
Gentianaceae	*Swertia multicaulis*
Iridaceae	*Gladiolus thomsonii*

Lycopodiaceae	*Lycopodium clavatum*
Lycopodiaceae	*Lycopodium saururus*
Malvaceae	*Dombeya goetzii*
Malvaceae	*Dombeya torrida*
Malvaceae	*Hibiscus vitifolius*
Meliaceae	*Ekebergia capensis*
Piperaceae	*Peperomia abyssinica*
Plantaginaceae	*Plantago palmata*
Podocarpiaceae	*Podocarpus falcatus*
Podocarpiaceae	*Podocarpus latifolius*
Phytolaccaceae	*Phytolacca dodecandra*
Poaceae	*Agrostis trachyphylla*
Poaceae	*Ehrharta erecta*
Poaceae	*Sinnarundinaria alpine/Yushania alpina*
Poaceae	*Festuca piligii*
Proteaceae	*Protea kilimanjaro*
Pteridaceae	*Pteris dentata*

Rosaceae	*Alchemilla argyrophylla*
Rosaceae	*Alchemilla cyclophylla*
Rosaceae	*Alchemilla johnstonii.*
Rosaceae	*Hagenia abyssinica*
Rosaceae	*Pyrus ussuriensis*
Rosaceae	*Rubus steudneri*
Rosaceae	*Stephania abyssinica*
Ranunculaceae	*Ranunculus orephytes*
Selaginellaceae	*Selaginella kraussiana.*
Typhaceae	*Typha latifolia*
Urticaceae	*Urtica massaica*
Vitaceae	*Cyphostemma bambuseti*
Verbenaceae	*Lantana camara*
Xanthorrhoeaceae	*Kniphofia thomsonii*