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A Study of Conservation Status of Endemic Plants at Musonda Falls in Luapula Province, Zambia.

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ABSTRACT

This study was made to carry out an inventory of woody plants and determine the conservation status of endemic plants at Musonda Falls in Luapula Province, Zambia. Musonda Falls is 56 km north-west of Mansa and 8 km east of the Democratic Republic of Congo (DRC)-Zambia boarder. The waterfalls is located at 10° 42.856′ S and 028° 48.858′ E on Luongo River, a tributary of the Luapula River. The site lies at an altitude of 1,131 m above sea-level. The Musonda Falls area has been designated as a heritage conservation area whereas the hydroelectric power station has been built near the site where Luongo River descends sharply along the escarpment zone. Encroachment is slowly creeping through the pristine zone of Musonda Falls area. This situation raises a lot of concerns with regards to the safety of endemic plant species which were reported to exist at Musonda Falls. This study was to offset the extinction of the endemic species such as Aloe luapulana and Euphorbia luapulana at Musonda Falls area for which Zambia is obliged to conserve on behalf of the globe. A reconnaissance survey was employed in order to carry out an inventory of woody plants of the vegetation in which endemics occur. The point-centered quarter method was employed in order to quantitatively determine the density and frequency of trees in the woodland. The method employed to determine the density of endemic species involves the use of quadrats set-up along a series of transect lines. The trees in this variant of miombo woodland are dispersed by a mean distance of 9.46 m with a standard deviation of 6.20. Other growth forms, such as the shrubs, suffrutices and lianes occur as strict understorey species. The understorey taxa include the two endemic species, namely Aloe luapulana and Euphorbia luapulana. The population density of Aloe luapulana is 16 plants per 100 m^2 and Euphorbia luapulana is 11 per 100 m^2. According to IUCN Red List of categories, the conservation status of endemic species occurring at Musonda Falls conservation area is therefore that of a hybrid category best described a Rare/Vulnerable (R/V). The impact of threats on endemic species might give rise to ecosystem transformation and species stresses through indirect species effects such as competition. Ex-situ conservation methods can help in several ways to re-stock a species in the wild. The Heritage Conservation Commission is urged to collaborate with ZESCO to apply existing regulatory legislation to protect the natural vegetation surrounding the waterfalls area.

Key words: *Conservation status, endemic species, Ex-situ conservation, In-situ conservation*

CHAPTER 1: GENERAL INTRODUCTION

1.1 The Physical Environment.

The physical environment in this study area relates to location, topography, geology, soils and climate of the site.

1.1.1 Location

Musonda Falls is 56 km north-west of Mansa and 8 km east of the Democratic Republic of Congo (DRC)-Zambia boarder (Williamson, 1968). The waterfalls is located at 10° 42.856' S and 028° 48.858' E on Luongo River, a tributary of the Luapula River (Lawton, 1964; Allen, et al. 2005). The site lies at an altitude of 1,131 m above sea-level. The Musonda Falls area has been designated as a heritage conservation area whereas the hydroelectric power station has been built near the site where Luongo River descends sharply along the escarpment zone. The map on Figure 1.1 and the photo on Figure 1.2 show where Musonda Falls is located on the escarpment terrain.

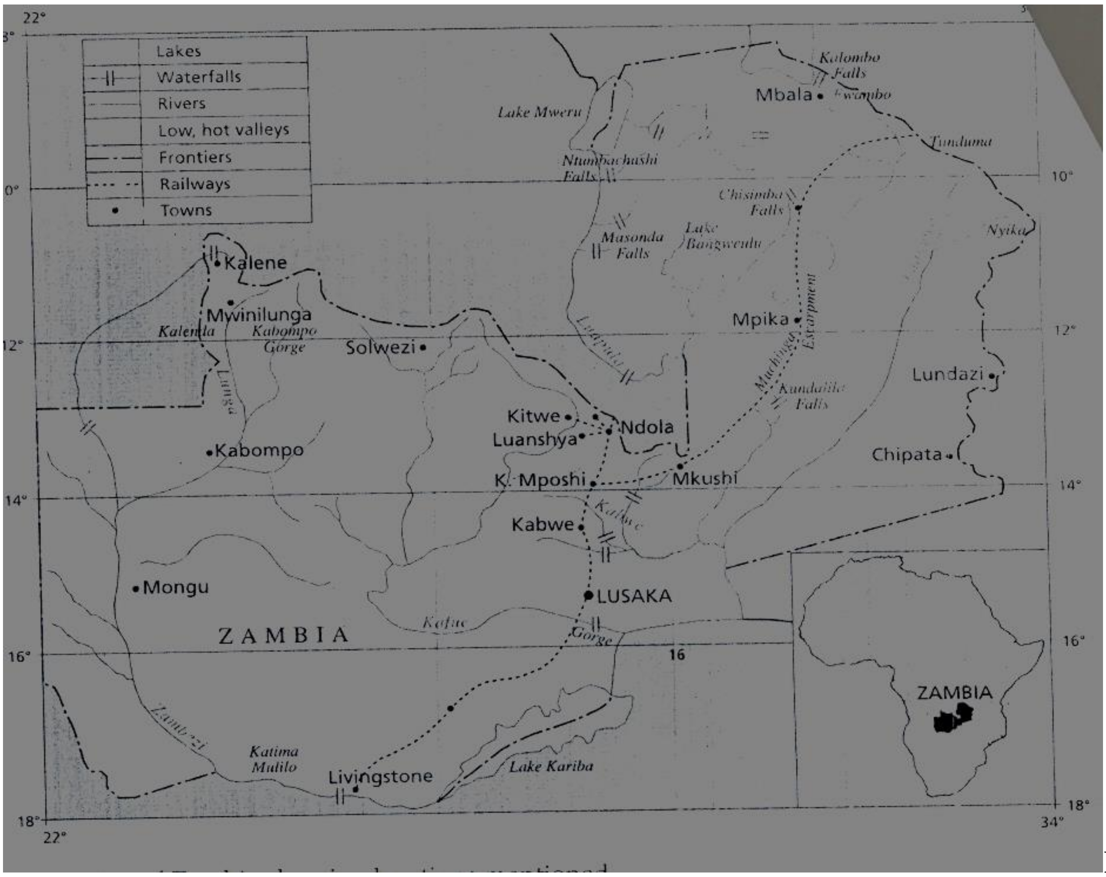

Figure 1.1(a) The map of Zambia showing locations for various falls, Musonda Falls inclusive (Williamson, 2001).

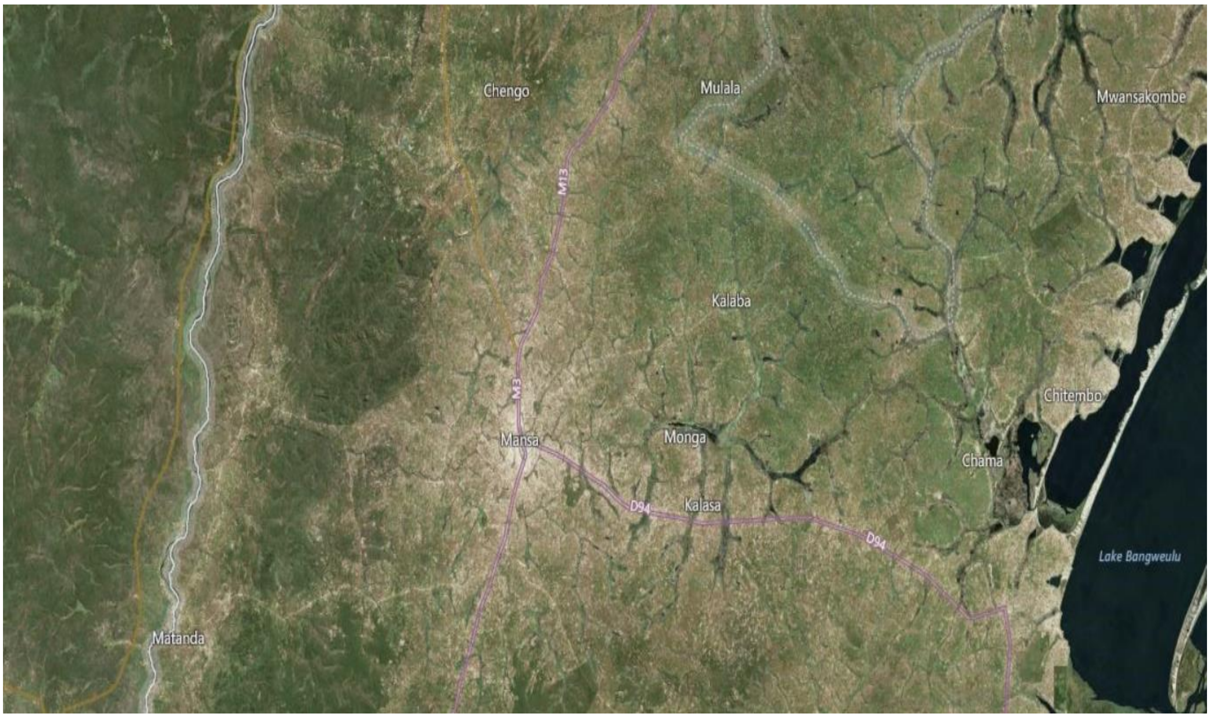

Figure 1.1(b) **Satellite google map showing Mansa and the surrounding areas**

Figure 1.2: The photo of Musonda Falls outlook (taken by the researcher on 25th December, 2013).

1.1.2 Topography, Geology and soils

The terrain of Musonda Falls area is situated on the escarpment zone overlooking the Luapula Valley. The plateau section of Luapula Province is part of the main Central African plateau which lies at the elevation in the range of 1,200 – 1,700 m above sea level. The study area is on the flanks of the western end of the East African Albertine Rift Valley System in which lakes Tanganyika and Mweru are situated. However, the Mweru depression embraces the Luapula Valley which stretches as far as Mambilima Falls (Mansfield et al, 1976).

Geology is one of the fundamental criteria used in defining a landscape. The geology of the landscape that encompasses the Musonda Falls area is referred to as the Kundalungu series. However, this is part of a much broader geological formation that is underlain by a strata of upper quartzites and sandstones in a form of rock types linked to the Katanga System, and this lithology is rich in cobalt, copper, lead, zinc and traces of gold (Mansfield et al, 1976; Thieme et al, 1981; Trapnell, 1996; Phiri; 2005,). Silicon is a mineral with a valency 4+. Its oxide, silica, is represented by SiO_2 and is well known as quartz. Silica is the most abundant of all oxides in nature (59.26%). Sandstone is made of second-hand materials of worn fragments derived from the disintegration of some older rock which contained some mineral. Sandstone is, perhaps the most familiar of all rocks, for it is easily quarried and it has been used more than any other kind of natural stone for building purposes. Siliceous sandstone in which most of the grains as well as the cement consist of quartz is often referred to as quartzite (Holmes, 1965).

Soil types are closely correlated to geological formations and geomorphological features. The main determinant factor linked to soil formation is the parent rock (Astle, 1968-69). The yellow-brown to brown-red loamy soils are found along the eastern flank of the Luapula River south of Lake Mweru. In this study area the soils are loamy sands with a low content of clay in deeper horizons. The soils are excessively drained, shallow to moderately shallow, stony gravelly and course to fine loamy soils (Astle, 1968-69; Ministry of Agriculture, 1991; Phiri, 2005). The map of Zambia on Figure 1.3 shows geological formation.

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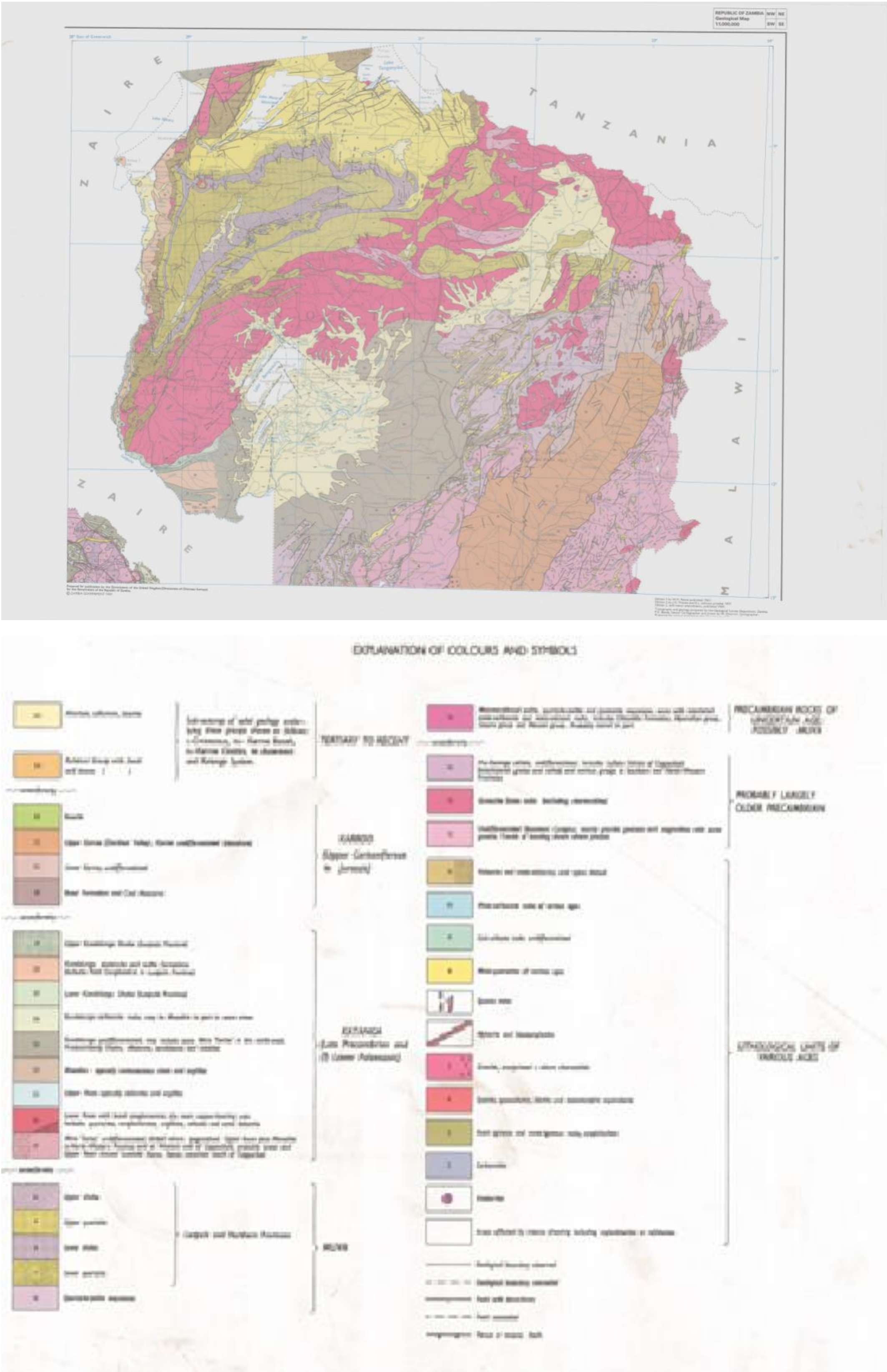

Figure 1.3 A map of geological formation in Northern and Luapula provinces of Zambia; from Geological Survey Department.

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1.1.3 Climate

The Musonda Falls area, which is close to Mansa, has three well-marked seasons.

The rainy season occurs from November to April. The rainfall pattern is more regular throughout the months of February, but the rains gradually diminish by March and end in April. The peak rainfall of 283 mm is registered in December and the total rainfall in the area is 1,213 mm per annum. The cold dry season occurs from May to July when the night mean minimum temperatures are as low as 8.8˚C. The hot dry season occurs from August to October which registers the mean maximum temperature of 30.9˚ C (Meteorological Department, 1970). The climatic data given in Table 1.1 that impacts on Musonda Falls is obtained from Mansa, which is about 56 km south-east of the study site. Rainfall and temperature records are graphically reflected in Fig. 1.2, Fig. 1.3 and Fig. 1.4 given below.

Table 1.1 Climatic data derived from Mansa rainfall based on 10 years record and temperatures based on 9 years. (Adapted from Meteorology Dept. 1970)

MONTH	RAINFALL TOTAL (mm)	MEAN MAXIMUM TEMPERATURE (˚C)	MEAN MINIMUM TEMPERATURE (˚C)
JANUARY	258	26.5	16.6
FEBRUARY	218	26.8	16.9
MARCH	189	26.7	16.4
APRIL	49	27.2	15.0
MAY	3	26.0	11.0
JUNE	0	25.3	8.9
JULY	0	25.0	8.8
AUGUST	0	26.8	10.9
SEPTEMBER	6	29.5	13.5
OCTOBER	39	30.9	16.3
NOVEMBER	168	28.1	17.1
DECEMBER	283	26.1	16.7
TOTAL/AVER.	**1,213**	**27.0**	**14.1**

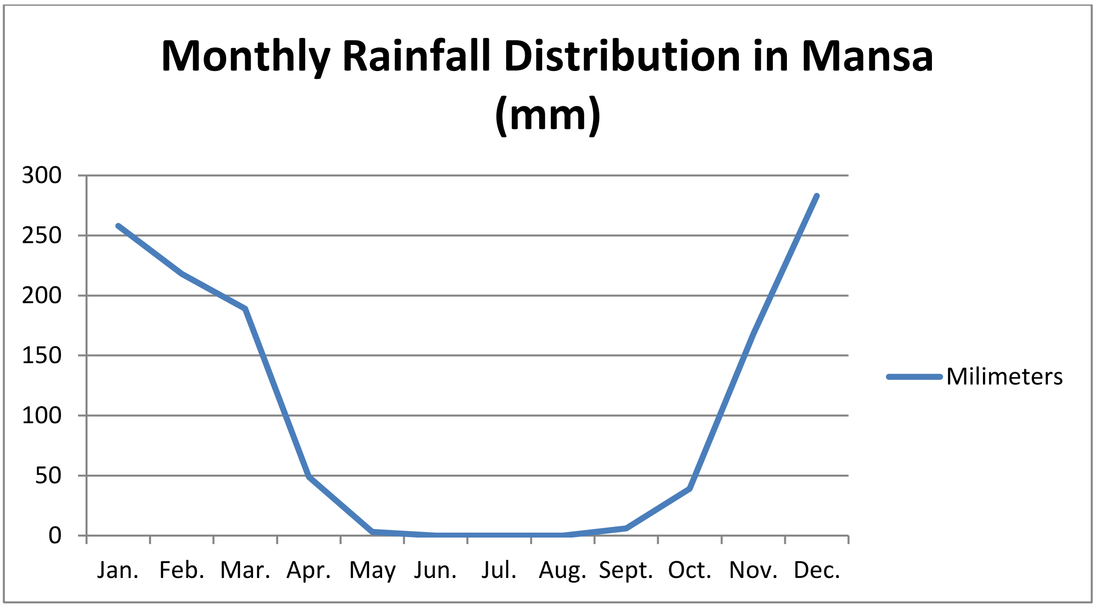

Figure1.4 A graph showing monthly rainfall distribution for Mansa

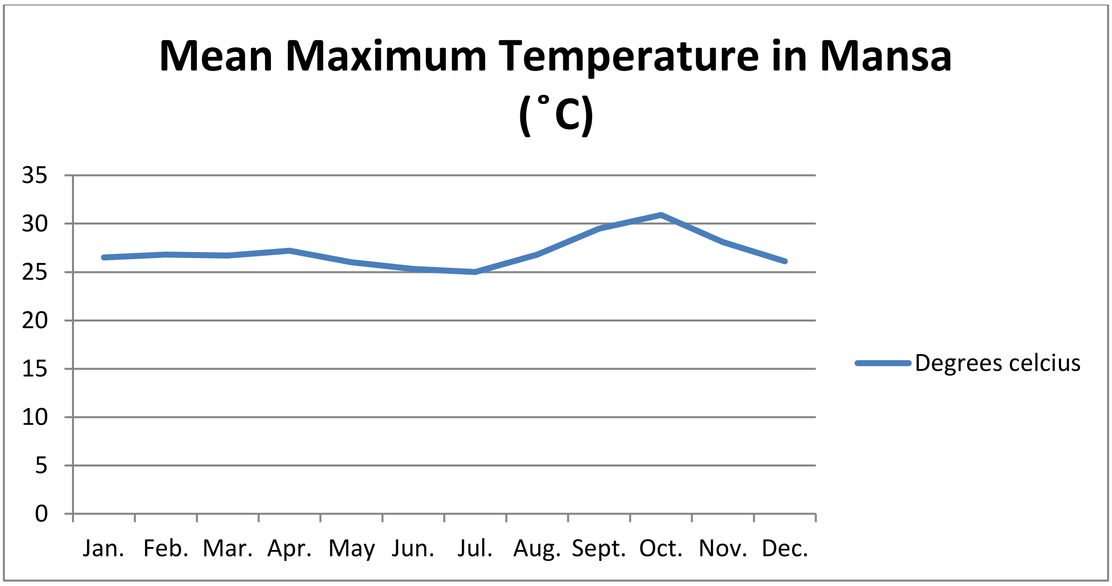

Figure 1.5 A graph showing monthly mean maximum temperature distribution in Mansa.

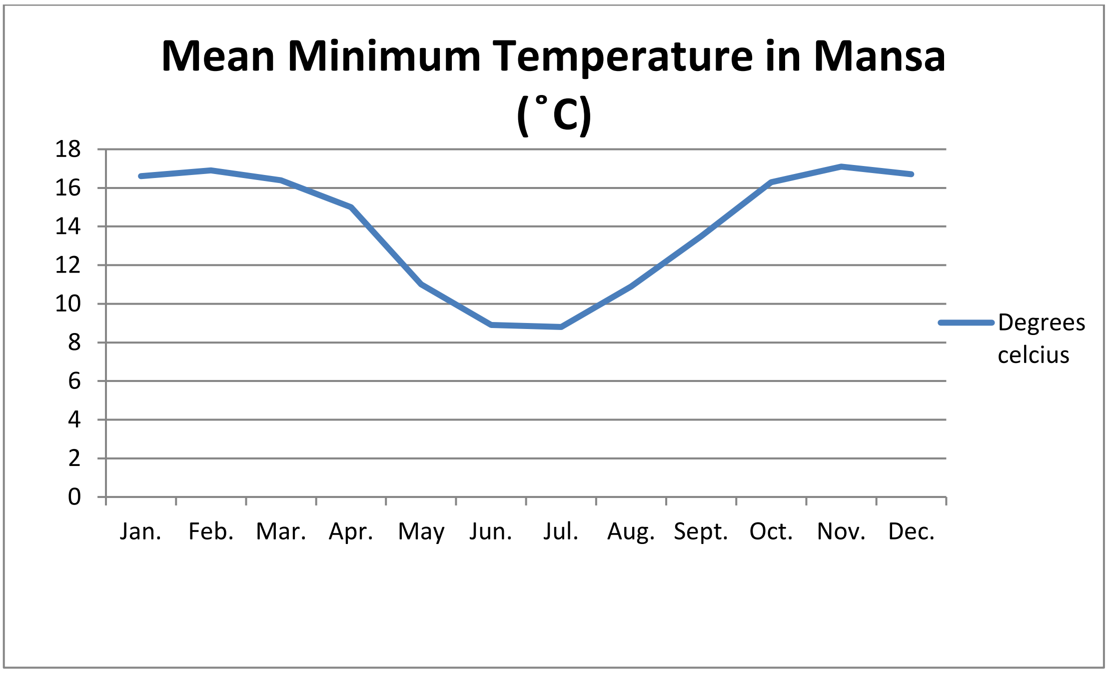

Figure 1.6: A graph showing monthly mean minimum temperature distribution in Mansa.

1.2 Rationale

Most waterfalls sites in Zambia, if not all, are naturally rich in botanical diversity. Musonda Falls of Mwense District is not an exceptional as it is reported to be endowed with some endemic plant species. A visit which was undertaken in July, 2013 revealed that Musonda Falls area had expanded in terms of human settlement. Encroachment is slowly creeping through the pristine zone of Musonda Falls area. This situation raises a lot of concerns with regards to the safety of endemic plant species which were reported to exist at Musonda Falls (Williamson, 2001). The loss of one plant species, more especially the endemic species, in this area would bring about the imbalance in the ecosystem both at local and a global loss of the endemic species. This is then the right time to record all plant species at Musonda Falls area and establish the conservation status of the endemic species so that in future it becomes the basis for monitoring and planning conservation interventions. Leaving the situation as it is currently, endemic species may go into extinction. The knowledge of conservation status is very important in order to help safeguard all the plant species in the area. It also helps to know which plant species and how many plants have been lost or sustained. The Convention of Biological Diversity (CBD), Article 1, stipulates that '*states are responsible for conserving their biological diversity and for using their biological resources in a sustainable manner*'. In other words, the

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CBD Article 1 affirms that the conservation of biological diversity is a common concern of human kind.

Plants are distributed in three broad types and these have been recognised as: cosmopolitan distribution, disjunct distribution and endemic distribution. Cosmopolitan distribution simply means that a species is located widely all over the world. Disjunct distribution is a condition when a species distribution has its populations widely separated; and an endemic distribution is a condition where a species is restricted to one geographical area of the world (Van Wyk, 2001),

Two species *Aloe luapulana* L. C. Leach (family: Aloaceae) and *Euphobia luapulana* L. C. Leach (family: Euphorbiaceae) have been recorded as endemic species to Zambia occurring at Musonda Falls area (Williamson, 2001). These two species are endemic, meaning that they are not found anywhere else in the world apart from the Musonda Falls area. It has been noted that earlier researchers did not take the inventory of all plant species at Musonda Falls area neither did they determine the species conservation status. Conservation and sustainable use of plant resources at Musonda Falls area could only be appreciated if a study to establish conservation status was undertaken. Today, Musonda Falls area is developing into an urban settlement. The construction of the hydroelectric power station to supply electricity to Luapula province has been undertaken. The development of the hydroelectric power station has generated a diversity of developments such as human settlements and other social infrastructures in form of a health centre and secondary school. With such developments and population growth evolving around at Musonda Falls, a lot of plant species would be lost if not properly and closely checked.

In this regard, Musonda Falls area has a flora that needs to be conserved. In other words conservation is meaningless without taking into account the inventory of all the vital plant species in the area. In addition, the extent of botanical diversity is very important so as to appreciate the conservation status of the two endemic species. In other words, it is justifiable to undertake this study since Musonda Falls has unique specialized habitats that have given rise to the evolution of the endemic species. Therefore, the floristic knowledge is vital in the programme of sustainable forest resources. This research tries to offset the extinction of the endemic species such as *Aloe luapulana* and *Euphorbia luapulana* for which Zambia is obliged to conserve on behalf of the globe. This investigation also tries to conserve the genetic pool to

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support the provision of genetic resource so as to uphold a pristine ecosystem in the area and the surrounding places.

1.3 Hypothesis

The theme for this study is hinged on the hypothesis that the onset of human settlement around at the Musonda Falls area will tend to endanger the existence of endemic species in their natural habitat.

1.4 Objectives

1.4.1 Main Research Objective

1.4.1.1 To carry out an inventory of woody plants and determine the conservation status of endemic plants at Musonda Falls.

1.4.2 Specific Research Objectives

1.4.2.1 To carry out an inventory of woody plants and succulent species.

1.4.2.2 To determine the density and frequency of trees in the woodland of Musonda falls conservation area.

1.4.2.3 To determine the conservation status of succulent endemic species.

1.5 Research Questions.

The research questions are as follows:

1.5.1 What woody plants and succulent species are found at Musonda Falls area?

1.5.2 (a) To what extent are the trees dispersed in the woodland?

(b) What is the frequency occurrence of tree species in the woodland?

1.5.3 (a) What is the population density of the endemic species?

(b) What kind of threats endanger the existence of the endemic species at Musonda Falls?

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CHAPTER 2: INVENTORY OF VEGETATION.

2.1 Introduction

Earlier researchers have contributed to a better understanding of the vegetation of Zambia through the preliminary studies they carried in the country (Fanshawe, 1971; Lawton, 1964 and1978; Trapnell, 1959). A classification of the vegetation of Zambia based on sound ecological principles and a map showing the territorial distribution of the vegetation and vegetation types has been documented. The vegetation types in Northern Zambia were identified as chipya, dambo, miombo, and mutemwa (Trapnell, 1959). A number of local descriptive terms have been used because indigenous people are familiar to foresters, agriculturists and others working with the vegetation in their area. The map in Figure 2.1 given below shows vegetation types recorded in Zambia.

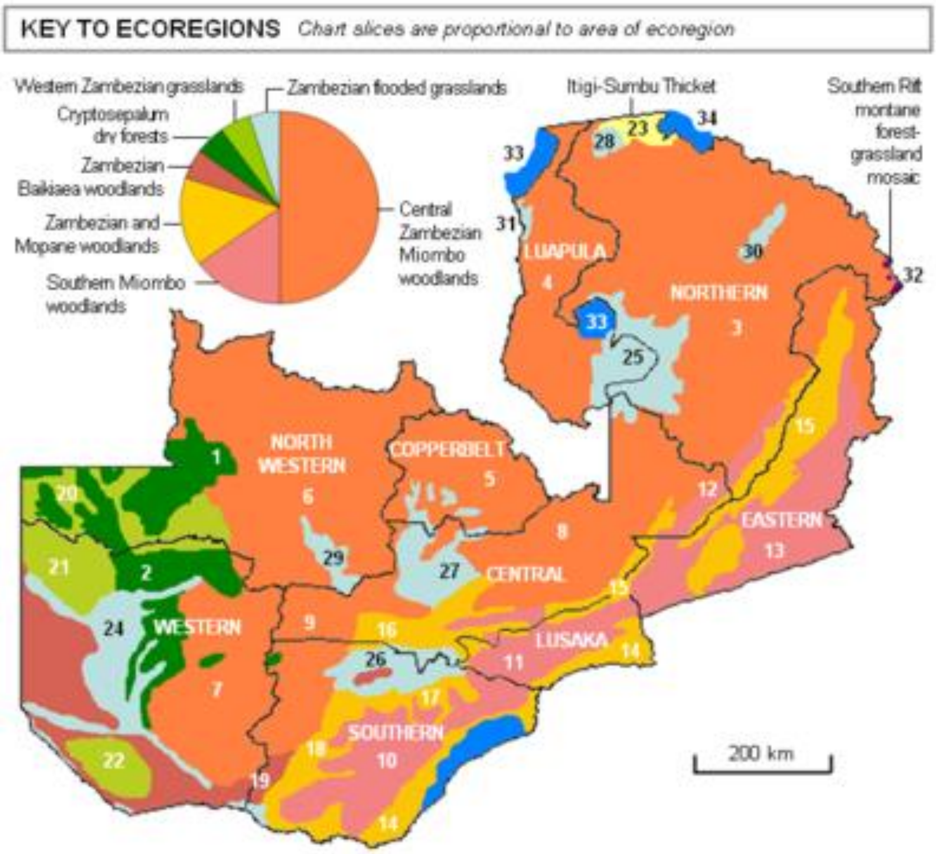

Figure 2.1 The terrestrial ecoregions of Zambia. (Adopted from Ecological Department, Zambia)

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Chipya is a woodland with high grass in which fierce fires occur annually. Chipya woodland arises from original miombo vegetation due to late fires. 'Chipya' woody species are fire-hardy species of *Combretum, Erythrophleum, Pterocarpus* and *Terminalia*. In the absence of fire, chipya will later revert to the process of regenerating into dry evergreen forest or the *Brachystegia – Julbernardia* (miombo) woodland (Lawton, 1978)

The most relevant vegetation formations prevalent in Luapula Province are the dambos and miombos. The dambo is an edaphic grassland found in shallow drainage channels. The miombo is a woodland type which is dominated by species of *Brachystegia*, *Isoberlinia* and/ or *Julbernardia* (Trapnell, 1959; Werger and Coetzee, 1978). Werger and Coetzee, (1978) have defined the miombo woodland as 'a stratified plant community with an open tree layer with crown less than one crown diameter apart or touching but predominantly not overlapping'. Scattered shrubs may be present and with the undergrowth of grasses and forbs although usually not very dense. Epiphytes and climbers are present in the wet miombo. Central African woodlands are mostly deciduous, but the evergreen elements are usually prominent among the understorey shrubs.

Biodiversity is the variety of life forms and refers collectively to variation at all levels of biological organization (Heywood, 1993). Biodiversity refers to all forms of life such as plants, animals, fungi, bacteria and protozoa. It consists of a diversity of plants, vertebrates and invertebrate animals and fungi. Botanical diversity refers to plant life forms, zoology refers to animal life forms and mycology deals with fungal life forms. The value of botanical diversity is associated with four aspects of human interests: aesthetic values, practical uses, life sustaining and ethical values. Aesthetic means highly attractive for tourism and recreation. Practical use means the provision of a wide range of useful biological resources, food and drugs. Life sustaining means maintaining environmental conditions composed of the atmosphere, soil, temperature regulation, precipitation and biological processes like recycling carbon, oxygen and other gases. Ethical values mean to know that a particular plant or animal species exists elsewhere in the world may not be enough to accord it status, however, if that plant or animal species is rare and may have attributes important for human survival, there is a global responsibility to protect and to preserve it for future generations.

With the increasing human population, expansion of agriculture into marginal areas, destruction of natural habitats and increased exploitation of the resource base in general, biodiversity is on decline throughout the world. An estimated 27 000 tropical species are disappearing each year (Wilson, 1992) and the extinction process seems certain to continue as human impact on the environment becomes ever more pervasive. A wealth of biodiversity resources is therefore being lost without any formal recognition of its existence or assessment of its potential. Botanical diversity requires taking the inventory of plants in a research area. Inventories give a snap shot of the state of botanical diversity and identify key variables and bio-indicators. Inventories also provide baseline information for the assessment of change and they apply to all ecosystems from fully natural to intensively managed. Inventory also entails the surveying, sorting and cataloguing, quantifying and mapping of entities such as genes, individuals, population, species, habitats, ecosystems and landscapes or their components and the synthesis of the resulting information for the analysis of processes (Heywood, 1993). No inventory is ever complete as there will always be the addition of new entities and new variations through immigration, birth, mutation, disappearances of entities through emigrants, death and extinction as well as change in abundance. Inventories are more than simply lists of names and numbers. They also involve the extensive application of systematics, ecology, biogeography and management (Heywood, 1993).

2.2 Methods.

The methods employed were based on taking stock of woody plants and succulent plant species, determining the extent to which trees in the woodland are dispersed and the frequency occurrence of tree species in the woodland at Musonda Falls study site. After locating the study site two methods were employed: Reconnaissance survey of woody plants and the Point-Centered Quarter Method. Reconnaissance Survey was employed in order to carry out an inventory of woody plants of the vegetation at Musonda Falls area. The point-centered quarter method was employed with a purpose to quantitatively determine the density and frequency of trees in the woodland in the study area. The point-centered quarter method dates back to 150 years and provides a quick way of making quantitative estimates of plant densities and species frequencies.

2.2.1 Reconnaissance survey of woody plants.

Reconnaissance survey means a preliminary investigation involving an exploratory exercise. The method involved the identification of plants species by species whereby all the woody and succulent plant species in the research site were recorded using local names and botanical names. This exercise involved two elderly men, residents of Musonda Falls area, who helped to provide the local names of plants in Bemba. The woody plant species were listed and some herbarium specimens of \any new interesting plants were also collected for subsequent identification processes using the Floras. A species list of the overall plant inventory is given under Appendix 1. However, photos in

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Figures 2.2 and 2.3 illustrated below show the residents of Musonda Falls area who assisted in providing the local plant names.

Figure: 2.2 Folklore botanists Mr Patrice Mbulwe a resident of Musonda Falls.

Figure: 2.3 Folklore botanists Mr Prince Mupeta a resident of Musonda Falls.

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2.2.2 Point-Centered Quarter Method

The second method employed was the Point-Centered Quarter Method for quantitative analysis. It is a plot-less method which is comparatively faster, as it requires less equipment, and may require fewer workers.

The Point-centered quarter method was conducted along two transects. Each transect was 200 m long and both laid down parallel to the Luongo river but sited between water channel and ZESCO compound to eliminate bias. The number of sampling points along transects was arrived at by picking random numbers between 3 and 8. Thus 4 sampling points 50 m apart were selected along each transect using a measuring tape as shown on Figure 2.4 below.

Transect

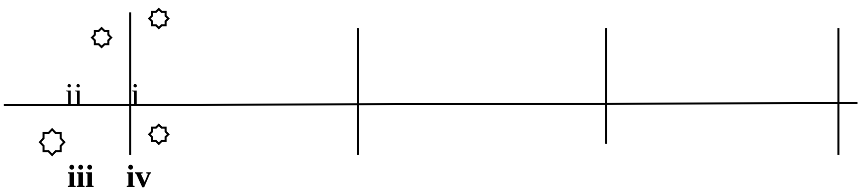

Figure 2.4 Sample points along a transect with the nearest trees in each quarter indicated by i, ii, iii, and iv.

At each sampling point along the transect line four sectors were selected, hence the technique being described as "point-centered quarter method" (see Figure 2.4). In each of the 4 quarter, the tree nearest to the sampling point was located. For each sampling point the following information was collected: the quarter number (i, ii, iii or iv), the distance from the sampling point to the base of the tree, the species name of the tree and the circumference at breast height (CBH) to the nearest cm. A measuring tape was used to measure distances and circumferences of tree trunks. The photo of a measuring tape is shown on Appendix 2 (b).

2.2.3 Determination of heights of common trees

For the determination of heights of common trees, the Abney level 37 and trigonometry software were employed. The Abney level is an instrument which was used to determine the slope around research site. It was also used to determine the height of trees. 50 m distance between each common tree and observer was considered when taking the measurements for heights and the observer's height was 1.68 m. The photo of the Abney level is shown in Appendix 2 (c). At this point, trigonometry method was employed and the Carbide Depot Trigonometry software was

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downloaded from internet to compute automatic calculations. Carbide Depot Trigonometry software is a trigonometry calculator for Right Triangles. At least two known variables were entered into the text boxes sides a, b and c; angles A and B. To enter a value, click inside one of the text boxes. Then click on the "Calculate" button to solve for all unknown variables. Appendix 3 shows Carbide Depot Trigonometry software.

2.3 Results and Discussion.

The methods employed generated the overall inventory of woody plants and succulent species, the density, frequency, dominance of woody plants and the heights of common trees. The resultant data facilitated reasonable interpretations of the vegetation type occurring at Musonda Falls.

2.3.1. Overall inventory

The overall inventory of woody plants and succulent species list appears on Appendix1. However, the summary of overall inventory is on Table 2.1 and a pie-chart showing composition of plant growth forms is given on Figure 2.5 below.

Table 2.1 Summary of overall plant inventory depicting composition of growth forms.

Plant Growth form	Number	Percentage composition (%)
Trees	36	74
Shrubs	10	20
Suffrutices	02	04
Liane	01	02
Total	**49**	**100**

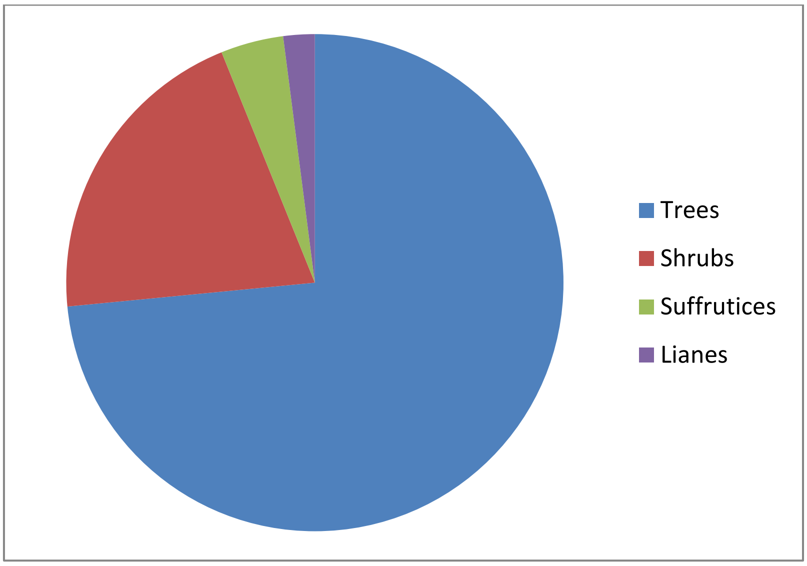

Figure 2.5 A pie-chart showing the composition of plant growth forms.

2.3.2 Density, Frequency and Dominance.

The common woody plants recorded from sampling points and their distances from sampling points are given on Table 2.2 and Table 2.3.

Table 2.2 Data derived from Transect A generated by a point-centered quarter method.

Sampling points (50 m apart)	**Quarter**	**Plant species**	**Dist. from SP (m)**
1	i	*Pterocarpus angolensis*	08.80
	ii	*Erythrophleum africanum*	27.90
	iii	*Baphia bequaertii*	25.50
	iv	*Pseudolachnostylis maprouneifolia*	10.37
		Sub-total distance	**72.57**
2	i	*Brachystegia spiciformis*	05.90
	ii	*Diplorhynchus condylocarpon*	02.93
	iii	*Baphia bequaertii*	12.60
	iv	*Maranthes floribunda*	05.00
		Sub-total distance	**26.43**
3	i	*Oldfieldia dactylophylla*	09.70
	ii	*Oxytenanthera abyssinica*	05.19

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	iii	*Pseudolachnostylis maprouneifolia*	06.72
	iv	*Oldfieldia dactylophylla*	04.30
		Sub-total distance	**25.91**
4	i	*Brachystegia spiciformis*	10.82
	ii	*Erythrophleum africanum*	04.23
	iii	*Brachystegia spiciformis*	21.60
	iv	*Pterocarpus angolensis*	10.73
		Sub-total distance	**47.38**

Table 2.3 Data derived from Transect B generated by a point-centered quarter method.

1	i	*Parinari curatellifolia*	09.80
	ii	*Annona senegalensis*	03.80
	iii	*Pseudolachnostylis maprouneifolia*	18.10
	iv	*Combretum sp.*	12.53
		Sub-total distance	**44.23**
2	i	*Kigelia africana*	01.60
	ii	*Albizia antunesiana*	05.72
	iii	*Pterocarpus angolensis*	03.78
	iv	*Erythrophleum africanum*	10.67
		Sub-total distance	**21.77**
3	i	*Albizia antunesiana*	09.66
	ii	*Pterocarpus angolensis*	13.15
	iii	*Maranthes floribunda*	09.25
	iv	*Brachystegia spiciformis*	03.80
		Sub-total distance	**35.86**
4	i	*Baphia bequaertii*	09.00
	ii	*Julbernardia globiflora*	05.85
	iii	*Anisophyllea boehmii*	10.34
	iv	*Albizia antunesiana*	03.50
		Sub-total distance	**28.69**
		Grand Total Distance	**302.84**

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Table 2.4 Computation of Variance and Standard Deviation

Quarters from SP	PLANT SPECIES	x	$x - \bar{x}$	$(x - \bar{x})^2$
i	*Pterocarpus angolensis*	8.8	-0.66	0.44
ii	*Erythrophleum africanum*	27.9	18.44	339.90
iii	*Baphia bequaertii*	25.5	16.04	257.16
iv	*Pseudolachnostylis maprouneifolia*	10.37	0.91	0.82
i	*Brachystegia spiciformis*	5.9	-3.56	12.70
ii	*Diplorhynchus condylocarpon*	2.93	-6.53	42.69
iii	*Baphia bequaertii*	12.6	3.14	9.84
iv	*Maranthes floribunda*	5	-4.46	19.93
i	*Oldfieldia dactylophylla*	9.7	0.24	0.06
ii	*Oxytenanthera abyssinica*	5.19	-4.27	18.26
iii	*Pseudolachnostylis maprouneifolia*	6.72	-2.74	7.53
iv	*Oldfieldia dactylophylla*	4.3	-5.16	26.66
i	*Brachystegia spiciformis*	10.82	1.36	1.84
ii	*Erythrophleum africanum*	4.23	-5.23	27.39
iii	*Brachystegia spiciformis*	21.6	12.14	147.29
iv	*Pterocarpus angolensis*	10.73	1.27	1.60
i	*Parinari curatellifolia*	9.8	0.34	0.11
ii	*Annona senegalensis*	3.8	-5.66	32.08
iii	*Pseudolachnostylis maprouneifolia*	18.1	8.64	74.58
iv	*Combretum sp.*	12.53	3.07	9.40
i	*Kigelia africana*	1.6	-7.86	61.84
ii	*Albizia antunesiana*	5.72	-3.74	14.02
iii	*Pterocarpus angolensis*	3.78	-5.68	32.31
iv	*Erythrophleum africanum*	10.67	1.21	1.46
i	*Albizia antunesiana*	9.66	0.20	0.04
ii	*Pterocarpus angolensis*	13.15	3.69	13.59
iii	*Maranthes floribunda*	9.25	-0.21	0.05
iv	*Brachystegia spiciformis*	3.8	-5.66	32.08
i	*Baphia bequaertii*	9	-0.46	0.22
ii	*Julbernardia globiflora*	5.85	-3.61	13.06
iii	*Anisophyllea boehmii*	10.34	0.88	0.77
iv	*Albizia antunesiana*	3.5	-5.96	35.57
	Total	**302.8**		**1224.29**

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Computations:

Population = N

Total number of individual trees sampled from transects = n = 32

Distance of each sampled tree from sampling points = x

Average distance (sample mean) of trees from sampling points) = $\bar{x}$ = x/n = 302.84/32 = **9.46**

Deviation of each individual sampled tree (departure from the sample mean) = x - $\bar{x}$

The square difference departure from the mean of each sampled tree = $(x - \bar{x})^2$

Sum of squares of deviation from the sample mean = $\sum (x - \bar{x})^2$ = 1224.29

Degree of freedom = n - 1

Variance (the mean of departure) = $d^2 = \frac{\sum (x - \bar{x})2}{n-1}$ = 1224.29/31 = **39.49**

Standard deviation = d = $\sqrt{\frac{\sum (x - \bar{x})2}{n-1}} = \sqrt{39.49}$ = **6.19**

Table 2.5 Summary data from Tables 2.2 and 2.3

Transect	Sampling Points	Total distance
A	1	72.57
	2	26.43
	3	25.91
	4	47.38
		172.29
B	1	44.23
	2	21.77
	3	35.86
	4	28.69
		130.55
	Grand total distance	**302.84**

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Mean distance = Total distance/ Number of quarters

= 302.84/ 32

= **9.46** m with a standard deviation of 6.19

Area of each tree = $(9.46)^2$ = **89.50 m^2**

Number of trees per hectare = 10000 m^2/ 89.50 m^2 = **111.70**

Density = 111.70 trees per hectare.

Table 2.6 Frequency of common trees at Musonda Falls area.

Species	**Occurrence**	**Frequency**	**Frequency (%)**
Albizia antunesiana	3	3/32	09
Anisophyllea boehmii	1	1/32	03
Annona senegalensis	1	1/32	03
Baphia bequaertii	3	3/32	09
Brachystegia spiciformis	4	4/32	13
Combretum sp.	1	1/32	03
Diplorhynchus condylocarpon	1	1/32	03
Erythrophleum africanum	2	2/32	06
Julbernardia globiflora	1	1/32	03
Kigelia africana	1	1/32	03
Maranthes floribunda	2	2/32	06
Oldfieldia dactylophylla	2	2/32	06
Oxytenanthera abyssinica	1	1/32	03
Parinari curatellifolia	2	2/32	06
Pseudolachnostylis maprouneifolia	3	3/32	09
Pterocarpus angolensis	4	4/32	13
Totals	**32**	**32/32**	**100**

Frequency is the number of occurrence each species reflects in a given vegetation type. The data in Table 2.6 shows the frequencies scored by each species. In this regard *Brachystegia spiciformis*, being the tallest tree (21 m high), and having registered the highest frequency is the dominant species in this miombo woodland. *Pseudolachnostylis maprouneifolia* (3/32), *Pterocarpus angolensis* (4/32) and *Baphia bequaertii* (3/32) are genetically understorey small trees wherever the miombo occurs.

2.3.3 Heights for Common Trees.

Table 2.7 Data showing determination heights for common trees at Musonda Falls.

Species	Abney level readings	Height of tree (m)	Average heights of a tree
Pterocarpus angolensis	11˚20'	09.90 + 1.68 = 11.58	**13.76**
	17˚30'	15.57 + 1.68 = 17.25	
	12˚20'	10.81 + 1.68 = 12.46	
Erythrophleum africanum	13˚31'	11.83 + 1.68 = 13.81	**17.43**
	17˚15'	15.43 + 1.68 = 17.11	
	21˚50'	19.70 + 1.68 = 21.38	
Baphia bequaertii	05˚20'	04.55 + 1.68 = 06.23	**08.02**
	09˚15'	08.05 + 1.68 = o9.73	
	07˚30'	06.41 + 1.68 = 08.09	
Brachystegia spiciformis	23˚40'	21.64 + 1.68 = 23.32	**21.36**
	17˚50'	15.76 + 1.68 = 17.44	
	23˚40'	21.64 + 1.68 = 23.32	
Maranthes floribunda	09˚15'	08.05 + 1.68 = 09.73	**12.60**
	16˚20'	14.53 + 1.68 = 16.21	
	11˚50'	10.17 + 1.68 = 11.85	
Oldfieldia dactylophylla	15˚00'	13.40 + 1.68 = 15.08	**13.41**
	11˚28'	09.97 + 1.68 = 11.65	
	13˚30'	11.82 + 1.68 = 13.50	
Pseudolachnostylis maprouneifolia	10˚30'	09.09 + 1.68 = 10.77	**11.66**
	11˚15'	09.85 + 1.68 = 11.53	
	12˚40'	10.99 + 1.68 = 12.67	
Albizia antunesiana	12˚40'	10.99 + 1.68 = 12.67	**12.68**
	10˚40'	09.18 + 1.68 = 10.86	
	14˚40'	12.84 + 1.68 = 14.52	

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Note that distance between a common tree and observer was 50 m and the height of the observer was 1.68 m.

2.3.3 Description of Musonda Falls Vegetation.

Data obtained from Point-centered quarter method relative to analysis of species frequencies and measurements of tree heights, suggest that *Brachystegia spiciformis* with a frequency of 4/32 and height of 21 m tall is the most dominant species in this variant of miombo woodland. *Albizia antunesiana, Baphia bequaertii, Pseudolachnostylis maprouneifolia* and *Pterocarpus angolensis* are relatively small trees forming the understorey stratum. *Brachystegia spiciformis* is thus the tallest tree attaining height of 21.36 m and registering a frequency of 13% in this area. The woody taxa commonly associated with miombo woodland at Musonda Falls are: *Albizia antunesiana, Baphia bequaertii*, *Erythrophleum africanum, Maranthes floribunda*, *Oldfieldia dactylophylla, Parinari curatellifolia* and *Pseudolachnostylis maprouneifolia.*

The trees in this variant of miombo woodland are dispersed by a mean distance of 9.46 m with a standard deviation of 6.20. Other growth forms, such as the shrubs, suffrutices and lianes occur as strict understorey species. The understorey taxa include the two endemic species, namely *Aloe luapulana* and *Euphorbia luapulana.*

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CHAPTER 3: STATUS OF ENDEMIC PLANTS.

3.1 Introduction

The endemic species found at Musonda Falls can be categorized as succulents. The term 'succulent' refers to a group of plants which possess fleshy leaves, stems and roots as an adaptation to dry environments. Such plants have water storage tissues consisting of large parenchyma cells with thin cell walls capable of expanding and shrinking depending on the state of water availability. Many succulents occur in arid regions, but some species do also occur in areas under high rainfall regions, growing in habitats which dry rapidly, such as in shallow soil over rock slabs, or on cliff surfaces where run-off is rapid (van Jaarveld, *et al*., 2000).

In Southern Africa succulents are grouped into eight families, namely: Apocynaceae (*Adenium* spp., *Fockea* spp.), Asphodelaceae (*Aloe* spp., *Gasteria* spp.), Crassulaceae (*Cotyledon* spp., *Crassula* spp., *Kalanchoe* spp.), Euphorbiaceae (*Euphorbia* spp.), Geraniaceae (*Geranium* spp.), Mesembryanthemaceae (the mesems under genus *Mesembryanthemum*), Passifloraceae (*Adenia* spp.) and Portulacaceae (*Portlaca* spp.). The family Euphorbiaceae is comprised of over 300 genera and over 5000 species world-wide. In Africa the family is represented by 50 genera and 480 species; whereas in Zambia this family is represented by 43 genera and 262 species (Koekmoer, *et al*. 2013; Carter and Leach, 2001; Leistner, 2000; Phiri, 2005).

The genus *Euphorbia* L. is comprised of herbs, suffrutices, shrubs and trees. Most species are succulent, often spiny and contain milky latex. Apparently, the latex is toxic, causes intense irritation and blistering of the skin and mucous membranes. The medicinal value of latex is that when taken in small amounts, it is a purgative and also a remedy to treat bronchitis. The irritant compounds of the milky latex are known as the phorbol esters. In Angola and Namibia the latex of *Euphorbia virosa* Wild is an ingredient of arrow poisons (van Wyk *et al*, 2002; Wink and van Wyk, 2008). Out of 60 species of *Euphorbia* recorded in Zambia, *Euphorbia luapulana* L. C. Leach is a shrub which is endemic at Musonda Falls.

Euphobia luapulana L.C. Leach is a spiny succulent shrub up to 1 m high. The stems are quadrangular (4-angled), up to 10 mm in diameter, tapering toward the base; the spines are paired, 5-8 mm long. The leaves which are 1 mm long and 1.25 mm wide are deltate. The cyanthia which are 2.5 mm long and 2.5–4 mm broad and funnel-shaped, bear 10-15 male flowers and female flower. The capsules are 2.75 mm long and 3.5 mm broad, turning bright red at maturity, with a pedicel of up to mm long. The plants grow on rock outcrops near the waterfalls and rapids in

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association with *Aloe luapulana* and the orchid known as *Summerhaysia zambesiaca* (Williamson, 2001)

Figure 3.1 *Euphorbia luapulana* growing in rock crevices at Musonda Falls**.**

Aloe L. (Family: Aloaceae) is essentially an African genus which has spread into the Arabian Peninsula, Socotra and Madagascar. The genus is comprised of about 500 species of which only 19 have been documented in Zambia. *Aloe luapulana* L. C. Leach is a short –stemmed succulent species which is endemic at Musonda Falls in Luapula Province of Zambia (Leistner, 2000; Carter, 2001). All species of the genus *Aloe* are of medicinal value. The leaves have a sap that contains several active compounds, such as aloesin which is an anti-inflammatory compound; has purgative principles called aloin and anthrone; and also contain the glycoproteins which are the wound-healing components of the aloe gel (Schmelzer and Gurib-Fakim, 2008; van Wyk *et al*., 2009).

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Figure 3.2 Close-up of *Aloe luapulana* on rock outcrops at Musonda Falls (photograph by the researcher)

Figure 3.3 *Aloe luapulana* in flower (adopted from Williamson, 2001).

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Both *Euphobia luapulana* and *Aloe luapulana* so far are known to be endemic to the escarpment area above the Luapula valley at Musonda Falls. The plants were cultivated in Harare and later described as new species by Leach (Williamson, 2001). Endemism is an ecological state of being unique to a defined single geographic location, such as an island, nation or other defined zone. Organisms that are indigenous to a place are not endemic to it if they are also found elsewhere. The extreme opposite of endemism is the phenomenon of cosmopolitan distribution.

Physical, climatic, and biological factors can contribute to endemism. There are two subcategories of endemism – paleoendemism and neoendemism. Paleoendemism refers to a species that was formerly widespread but is now restricted to a smaller area. Neoendemism refers to a species that has recently evolved such as a species that has diverged and become reproductively isolated or one that has formed as a result of hybridization and is now classified as a separate species. This is a common process in plants, especially those that exhibit polyploidy (van Wyk, 2001).

Endemics can easily become endangered or extinct if their restricted habitat changes, particularly but not only due to human actions, including the introduction of new organisms.

3.2 Methods Applied

3.2.1 Quadrat along Transect Method

The method employed was the use of quadrats set-up along a series of transect lines.

Quadrats set up along a transect were employed to determine the density of the succulent endemic species (*Aloe luapulana* and *Euphorbia luapulana*) at Musonda Falls area.

Endemic species are located in an area that is in the range of 2500 m^2 (0.25 hectare) to 5000 m^2 (0.5 hectare). The method applied to sample endemic species included the use of quadrats set up along transects.

A quadrat is one of the most used tools in the field of ecology. A quadrat is thus a square sample plot applied for detailed analysis of the vegetation. This method was devised by Clements in 1898. The size of the quadrat depends on the nature of vegetation under study. In ecological studies quadrats are used in measuring such parameters as presence and the number of species and their frequency of occurence.

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Density is a parameter that involves the count of the number of individual plants within a specified area. Density is also interpreted as the numerical strength of the species in relation to a definite unit space. This measure refers to the number of the individuals species per unit area. This parameter involves the counting of the number of the individual species within systematically distributed quadrats located along line transects at regular intervals of 5 m apart. Line transects were set up along an environmental gradient. Then the mean number of individual species was computed relative to the size of the quadrat derived from several sample sites. The algorithm applied will indicate the extent to which the density of an organism relates to the area available as a living space. Such a parameter is referred to as the ecological density.

There were three transects set-up, 5 m apart and each transect had 5 quadrats, therein. The arrangement of quadrats was based on stratified sampling. Quadrats were spaced 5 m apart and each quadrat was 5m × 5m (or $25m^2$) in size.

Considerations for setting-up line transects were time efficient, in that the method was most suitable for plants and disturbance to the environment can be minimized. The limitation is that species occurring in low abundance may be missed.

3.2.2 Measure of Light Intensity

The Brannan Light meter was used to record how much light is available for endemic species in the open and shady places. These measures were conducted on 26/12/2013 at 12.00 hrs.

3.3 Results and Discussion.

The data sets generated from the ecological technique applied in the field are tabulated in Tables 3.1 to 3.4. The graphical presentation is given in Figures 3.4, 3.5, 3.6 and 3.7.

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Table 3.1 Density measures of Endemic species (*Aloe luapulana and Euphorbia luapulana*) along Transect 1

Quadrat (25 m^2)	Distance (m).from water channel	No. of ***Aloe luapulana*** plants	No. of ***Euphorbia luapulana*** plants
1	07.50	0	0
2	17.50	0	1
3	27.50	0	0
4	37.50	7	0
5	47.50	0	0

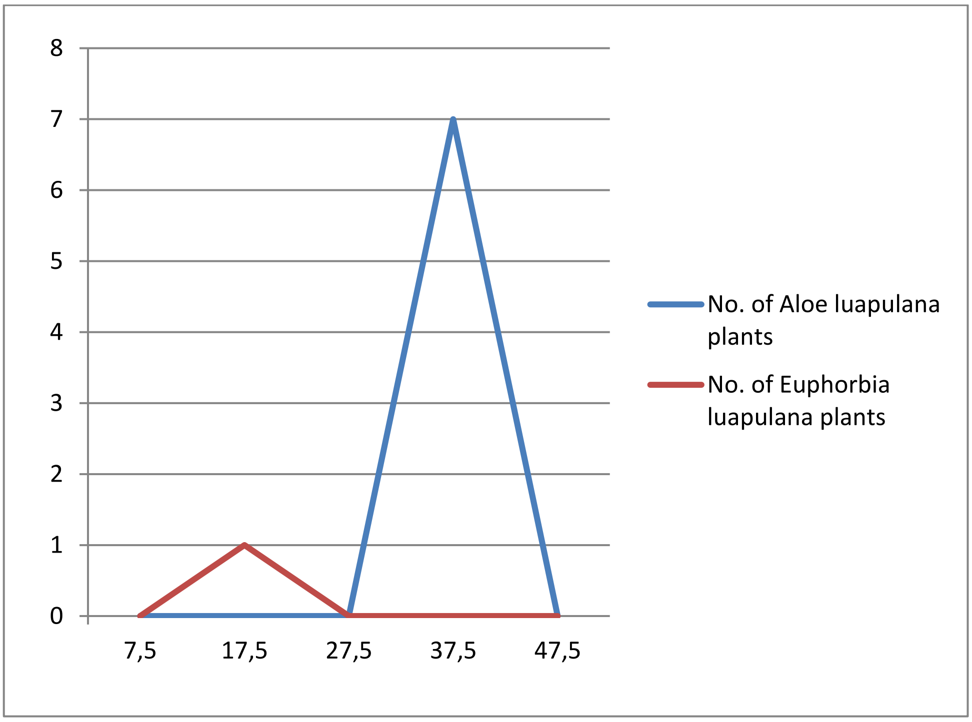

Figure 3.4 Graphical representation of number of endemic plant species along Transect1.

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Table 3.2 Density measures of Endemic species (*Aloe luapulana and Euphorbia luapulana*) along transect 2

Quadrat (25 m^2)	Distance (m).from water channel	No. of ***Aloe luapulana*** plants	No. of ***Euphorbia luapulana*** plants
1	07.50	5	0
2	17.50	4	1
3	27.50	10	0
4	37.50	10	19
5	47.50	0	2

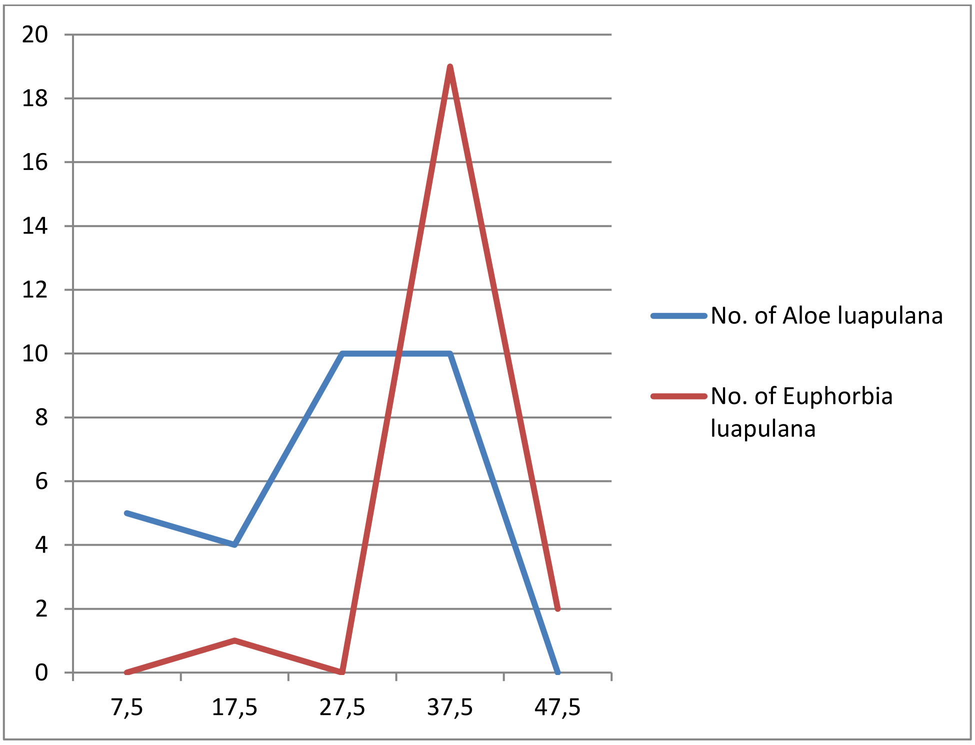

Figure 3.5 Graph of the number of endemic plant species along Transect 2.

Table 3.3 Density measures of Endemic species (*Aloe luapulana and Euphorbia luapulana*) along Transect 3.

Quadrat ($25\ m^2$)	Distance (m).from water channel	No. of ***Aloe luapulana*** plants	No. of ***Euphorbia luapulana*** plants
1	07.50	8	0
2	17.50	2	2
3	27.50	0	2
4	37.50	9	5
5	47.50	7	8

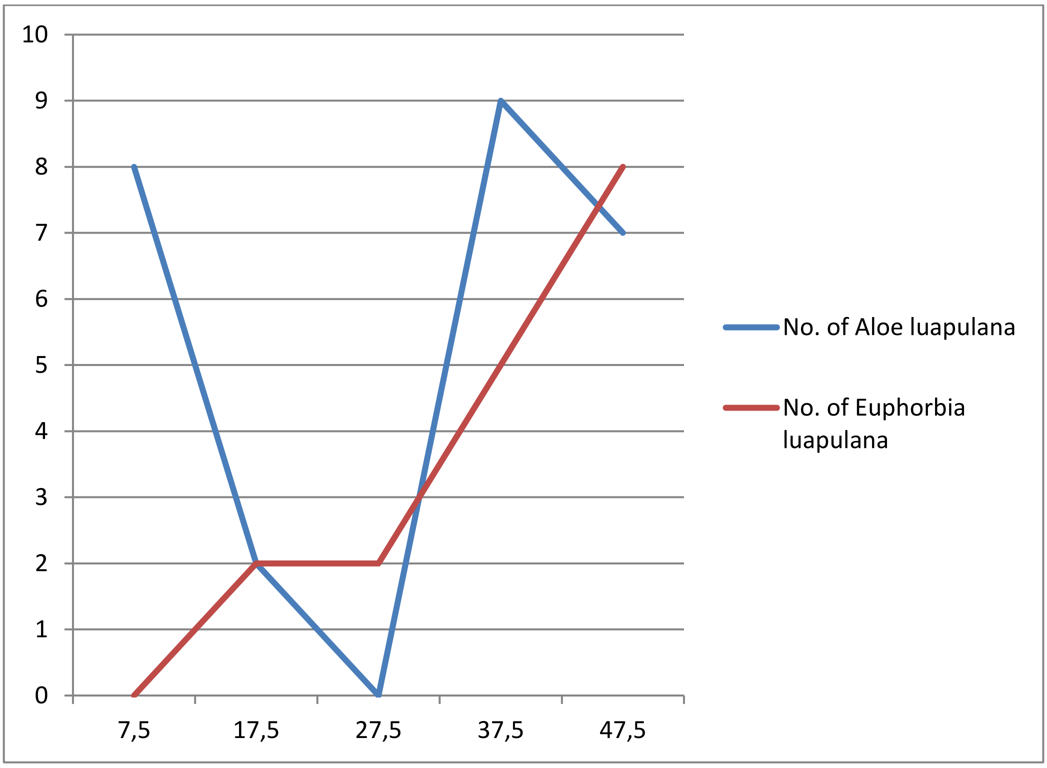

Figure 3.6 Graphical representation of numbers of endemic plant species along Transect 3.

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Table 3.4 Showing average numbers of endemic species along transects 1, 2 & 3.

Quadrat (25 m^2)	Distance (m).from water channel	No. of ***Aloe luapulana*** plants	No. of ***Euphorbia luapulana*** plants
1	07.50	**4.3**	**0.0**
2	17.50	**2.0**	**1.3**
3	27.50	**3.3**	**0.7**
4	37.50	**8.7**	**8.0**
5	47.50	**2.3**	**3.3**

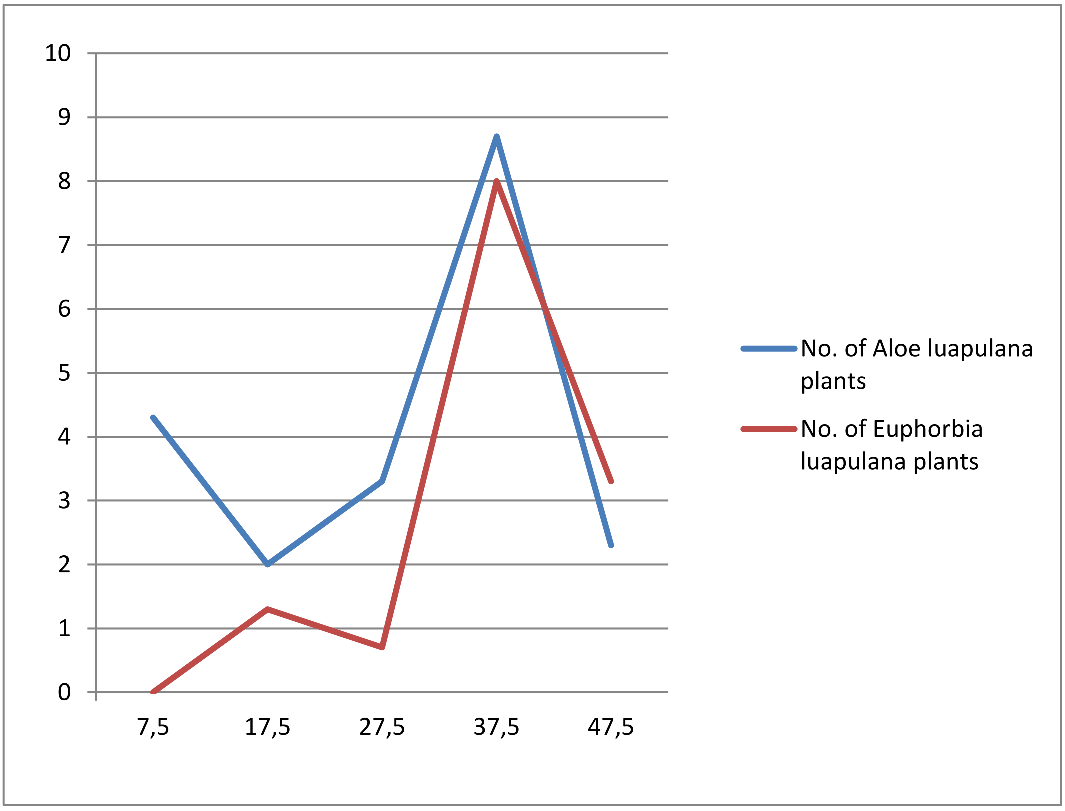

Figure 3.7 Graphical representation of endemic plant species along Transect 1, 2 & 3.

Table 3.5: Results of light intensity measures

Record attempts at research site.	Open place		Under shade of a big tree.	
	Maximum ((KiloLux)	Minimum (KiloLux)	Maximum (KiloLux)	Minimum (KiloLux)
1	115,4	106.8	3,9	18.6
2	116,2	109.1	19.1	13.7
3	120.9	112.9	73.8	15.2
Average	**117.5**	**109.6**	**96.8**	**51.5**

The population of endemic species are confined to an area located between 5 m and 50 m from water channel. In other words *Aloe luapulana* and *Euphorbia luapulana* are confined to a very narrow zone of the rock outcrops. There was no endemic species found in a zone less than 5 m from the water channel and no such plants appeared beyond 50 m from the water channel. The density of endemic species generally increased as the distance from water channel increased up to 37.5 m away from water channel. After 37.5 m from water channel the population size of both endemic species dropped drastically. The study provides useful estimates to the effect that the population of *Aloe luapulana* contains 16 plants per 100 m^2, whereas that of *Euphorbia luapulana* contains 11 plants per 100m^2. The population density of *Aloe luapulana* is more than that of *Euphorbia luapulana* though they occur as sympatric species.

Aloe luapulana and *Euphorbia luapulana* seem to be supported by a number of conditions for them to be naturally located in this particular area. The conditions under which these species grow are influenced by edaphic (soil), temperature, and sunlight intensity.

The population of both *Aloe luapulana* and *Euphorbia luapulana* occur on rocky outcrops situated on sloppy grounds. The shallower the soil depth, the high is the number of plants. This entails that these succulents are well adapted to substrates found in terrains with rock outcrops. Relatively deeper soils tend to exclude the establishment of succulents.

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CHAPTER 4: CONSERVATION STATUS AND RECOMMENDATIONS.

4.1 Introduction

Earlier researchers did not consider the conservation status of endemic plant species occurring at Musonda Falls area. These could be attributed to the fact that *Aloes luapulana* and *Euphorbia luapulana* were described as new species based on living specimens cultivated in Harare, Zimbabwe. The conservation status of a group of organisms, for instance the endemic species, indicates whether the group is extant (members of it are still alive) and how likely the group is to become extinct in the near future (Craig, 1995). Many factors are taken into account when assessing the conservation status of an organism; not simply by considering the number of individuals remaining, but taking into account the overall increase or decrease in the population overtime, breeding success rates and the known threats.

The threats to a number of plant populations are manifold. Threats range from such factors as: unsound agricultural practices, urban expansion, industrial development, non-sustainable plant collecting by enthusiasts and increasing need for plant materials by sources and suppliers of traditional natural products and, sometimes, simply ignorance about the plight of the environment in general. It is an indictment against the unscrupulous hand of man that several species of succulent plants have become extinct. Species and the communities to which they belong are adapted to local conditions. As long as the conditions remain unchanged, species and communities tend to persist in the same place over a long time. The ranges of species will sometimes expand as a result of chance dispersal events as a result of increased competition and predation by other species (Primack, 1995)

The major threats to biological diversity that exist from human activity are habitat destruction, habitat fragmentation, habitat degradation, the introduction of invasive species, the increased spread of diseases and the over-exploitation of many species for human use. These above stated six threats on biological diversity are all caused by an increasing use of the world's natural resources by the expanding human population (Primack, 1993, van Wyk and Smith, 2001). In order to successfully maintain a biological species under the restricted condition imposed by human activities, conservation biology must determine the stability of population under certain circumstances. The ability of a species to persist in a protected area can often be predicted using the methods of population biology. These techniques can be used to estimate the minimum viable size, the smallest number of individuals needed to maintain a long-term population. Even without human disturbance, a population of any species may be stable, in a state of increasing or decreasing and population

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undergoing fluctuation in size. In general, the effect of wide spread human disturbance is to destabilize population of native plant species often sending them into sharp decline (Primack, 1993).

4.2 Threats

Specific threats to the endemic succulent plants in the Musonda Falls area include rapid urbanisation, industrial development (ZESCO hydroelectric station), the establishment of invasive species such as *Phyllanthus muellerianus* and *Lantana camara*, the non-sustainable collecting of plants by enthusiasts and an increasing need for plant materials.

Figure 4.1 The photo of fast-growing urban settlement at Musonda Falls area (taken by the researcher on 25th December, 2013).

Figure 4.2 *Euphorbia luapulana* showing the harvested stems.

According to IUCN Conservation Criteria regarding Threats Classification Scheme, the presence of *Phyllanthus muellerianus* and *Lantana camara* at Musonda Falls Conservation area suggest the prevalence of invasive alien species that are associated with human settlement. The harvesting of stems of *Euphorbia luapulana* can be attributed to biological resource use, associated with the gathering of plants with intentional use where species being assessed is the target. The motivation behind is Unknown/Unrecorded.

4.3 Assigning IUCN Conservation Category.

The IUCN Red List of Threatened Species is the best-known worldwide conservation status listing and ranking system to each taxon at both local and global level. Species are classified by the IUCN Red List into groups set through criteria such as rate of decline, population size, area of geographic distribution, and degree of population and dispersion through fragmentation. According to Hilton-

Taylor (1995) there are 9 categories with a set of criteria to which a species can be assigned. Such categories are described below:

Extinct (EX): taxa which are no longer known to exist in the wild after repeated searchers of their type localities and other known or likely places. This category is also used for a tax on which no longer occurs in the wild but survives in at least some form in cultivation or a seed bank, but is probably so genetically impoverished or altered as to make it impossible to return it to a natural habitat.

Endangered (E): taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included here are taxa whose numbers of individuals have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.

Vulnerable (V): taxa believed likely to move into the Endangered category in the near future if the factors causing decline continue operating. Included here are taxa of which most or all of the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbance. Taxa with populations that have been seriously depleted and whose ultimate security is not yet assured, and taxa with population that are still abundant but are under threat from serious adverse factors throughout their range.

Rare (R): taxa with small world population that are not at present endangered or Vulnerable, but are at risk as some unexpected threat could easily cause a critical decline. These taxa are usually localised within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

Indeterminate (I): taxa known to be Extinct, Endangered, Vulnerable, or Rare but for which information is insufficient to decide which of the four categories is appropriate.

Insufficiently known (K): taxa that are suspected but not definitely known to belong to any of the above categories because of the lack of information. It also means **uncertain (U).**

Not threatened (nt): this is used for taxa which are no longer in one of the above categories due to an increase in population sizes or to subsequent discoveries or to subsequent discovery of more individuals or population.

No information (?): taxa for which there is no information available.

Out of Danger (O): which is used for taxa formerly included in one of the threatened categories, but which are now considered relatively secure because effective conservation measures have been taken, or because the previous threat to their survival has been removed.

Note that in some instances where it is uncertain as to which category is most appropriate, hybrid categories are used. For example: Rare/Vulnerable (R/V) or Vulnerable/Endangered (V/E) are given, so as to avoid using the lower status categories of indeterminate or insufficiently known. When discussing the IUCN Red List, the official term "threatened" is a grouping of three categories: Endangered and vulnerable.

According to the findings of this study and considering the IUCN Red List of categories, *Aloe luapulana* and *Euphorbia luapulana* are localised within a restricted geographical area meaning that the taxa is rare (R). The indicators of threats against the existence of endemic species are evident and prevalent. These include the occurrence of invasive alien species and evidence of some cuttings of *Euphorbia* stems. Hence, endemic species are vulnerable in this area. The conservation status of endemic species occurring at Musonda Falls conservation area is therefore that of a hybrid category best described a **Rare/Vulnerable** (R/V). The impact of threats on endemic species might give rise to ecosystem transformation and imposition of species stresses through indirect species effects such as competition.

4.4 Recommendations

Conservation actions have traditionally been divided into *in-situ* and *ex-situ* conservation (Gaston, 2004). The best strategy for the long-term protection of biological diversity is the conservation of natural communities and population in the wild which is known as *in-situ* or *on-site* conservation. Only in natural communities are populations truly large enough to prevent genetic drift. Species are able to continue the process of evolutionary adaptation to a changing environment within their natural communities (Primack, 1993). If a remnant population is too small to persist, or all the remaining individuals are not found outside the protected area then *in-situ* conservation may not be effective. In such circumstances it is likely that the only way a species can be prevented from going into extinction is to maintain individuals in artificial conditions such as the botanical gardens under human supervision (Primack, 1993). This strategy is known as *ex-situ* or off-site conservation

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Ex-situ conservation methods can help in several ways to re-stock a species in the wild. Firstly, individuals from *ex-situ* conservation institutions can be periodically released into the wild to maintain numbers and genetic variability in natural environments. Secondly, studies on captive population can provide some insight into the basic biology of the species and thus help suggest new conservation strategies. Thirdly, populations under *ex-situ* conservation that are self monitoring can reduce the need to collect individuals from the wild for display and research purposes. Lastly, it is important to preserve the species and to protect other keystone members of the woodland community (Primack, 1993).

Taking into account that the Musonda Falls area is fast growing into an urban settlement, with the consequent demand for the utilization of plant natural resources, there is an urgent need to enforce measures that will protect the relict woodland whose dominant flora acts as keystone species to sustain the survival of the endemic species occurring at this site. In this regard the Zambia Heritage Conservation Commission is urged to collaborate with ZESCO to apply existing regulatory legislation to protect the natural vegetation surrounding the waterfalls area. Besides, ZESCO can also be sensitized in the realization that the conservation of the country's natural woodlands will enhance the conservation of water, and thus sustain the perennial discharge of water into rivers on which hydroelectric power stations have been constructed.

APPENDICES

Appendix 1: Overall plant inventory of woody plants at Musonda Falls, Luapula province, Zambia.

S/N	Local name	Botanica l name	Growth form
1	Mupapa	*Afzelia quanzensis*	Tree
2	Kapetansofu	*Albizia adianthifolia*	Tree
3	Musase	*Albizia antunesiana*	Tree
4	Iposwe/ itembusha	*Aloe luapulana*	Shrub
5	Mufungo	*Anisophyllea boehmii.*	Tree
6	Mulolo/ Uluta	*Annona senegalensis*	Tree
7	Kemyanshinge	*Asparagus lumosis*	Shrub
8	Mupala	*Baphia bequaertii*	Tree
9	Chibangalala	*Borassus aethiopum*	Tree
10	Mwimbe bwe	*Brachystegia microphylla*	Tree
11	Muputu	*Brachystegia spiciformis*	Tree
12	Nabubale	*Chrysophyllum bangweolense*	Tree
13	Mufuka	*Combretum adenogonium*	Tree
14	Kalongwe	*Dalbergia nitidula*	Tree
15	Muntufita	*Diospyros batocana*	Tree
16	Mwenge	*Diplorhynchus condylocarpon*	Tree
17	Isasha mubili	*Embeliia schimperi*	Liane
18	Kayimbi	*Erythrophleum africanum*	Tree
19	Chibeka	*Euphorbia luapulana*	Shrub
20	Lunsonga	*Euphorbia tirucalli*	Shrub
21	Mufifi	*Harungana madagascariensis*	Tree
22	Mukundukundu	*Hexalobus monopetalus*	Tree
23	Kapempe	*Hymenocardia acida*	Tree
24	Mutobo	*Isoberlinia angolensis*	Tree
25	Mpasa	*Julbernardia globiflora*	Tree
26	Mufungufungu	*Kigelia africana*	Tree
27	Nakabumbu	*Lannea discolor*	Tree
28	Tusepo	*Lantana camara*	Shrub

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29	Mukuwe	*Maranthes floribunda*	Tree
30	Chimpampa	*Monotes spp.*	Tree
31	Muonga	*Oldfieldia dactylophylla*	Tree
32	Musengu	*Oxytenanthera abyssinica*	Shrub
33	Mufuta	*Ozoroa bredoi*	Suffrutex
34	Mupundu	*Parinari curatellifolia*	Tree
35	Mubanga	*Pericopsis angolensis*	Tree
36	Mupetwalupe	*Phyllanthus muellerianus*	Shrub
37	Musangati	*Pseudolachnostylis maprouneifolia*	Tree
38	Mulombwa/ mukwa	*Pterocarpus angolensis*	Tree
39	Nacisungu	*Rourea orientalis*	Tree
40	Kapolopolo	*Steganotania araliacea*	Shrub
41	Mwemwe tuseko	*Sterculia quinqueloba*	Tree
42	Sansa	*Strychnos innocua*	Tree
43	Ndale	*Swartzia madagascariensis*	Tree
44	Musafwa	*Syzygium guineense*	Tree
45	Namwinshi	*Terminalia erici-rosenii*	Tree
46	Mwikala-cisaka	*Tetracera masuiana*	Suffrutex
47	Mufilu	*Vangueria infausta*	Shrub
48	Muchinka / mufutu	*Vitex doniana*	Tree
49	Cifuti	*Xerophyta equisetoides*	Shrub

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