VEGETATION DESCRIPTION AND CONDITION ASSESSMENT OF PROTECTED RANGELANDS OF ALAGAE AND NETELI, IN THE MAIN ETHIOPIAN RIFT VALLEY

BY

ALI SEID MOHAMMED

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE

IN

DRYLAND BIODIVERSITY

June 2004

Addis Ababa

To: my poor mother, who do not know saying I do not have, if it is for education; my son Nabiot; my beloved wife Tigest Tezera and the late Tezera Wobe.

ACKNOWLEDGMENTS

I wish to express my sincere thanks to all the individuals who through their support contributed to the successful completion of this work. First, I am highly indebted to my research advisors, Dr. Tamrat Bekele, Department of Biology, Addis Ababa University (AAU), and Miss Sue Edwards, Department of Biology, Addis Ababa University (AAU) and Institute of Sustainable Development (ISD) for giving me the benefit of their expertise, and generously given time.

I am gratefully acknowledge the following individuals and institutions for their assistance during the research and writing phase of the thesis: for allowing me to work freely in their sites the Alagae College of Agricultural Technique and ELFORA Private Limited Company; For covering the costs of the research RPSUD; For their help during the reconnaissance survey; ISD and IBCR; for providing rainfall and Temperature the National Meteorological Service Agency; For their compassion during my fieldwork the administrative board and staff of Alagae College of Agricultural Technique and the Neteli ELFORA Branch, specifically: Ato Mohammed Awel, Ato Seid Abu, Ato Mesifen Kasahun and Ato Shamil Awal of Alagae College of Agricultural Technique, Ato Lulseged, Aba Megal and the local people of Neteli; For providing the TWINSPAN software and showing major procedures professor Zerihun Woldu; For injecting valuable comments Ato Alemayehu Mengistu; For all their support throughout my stay and professional assistance Ato Melaku Wondafrash, Ato Solomon Kassea and W/t Showangiziew Lema ; and W/ro Zemen of the Science Faculty and Ato Demeke Nigusea of EARO.

My sincere appreciation goes to my classmates (Abate Ayelew, Getachew Tadesse, Leul Kidane, Peris k., Monica, and Victor W.) and all junior friends for the teamwork, encouragement and friendship. At last, but by any measure not least, I am indebted to my wife Tigist Tezera and my son Nabiot for their tolerance during my absence.

ABRIVATIONS AND ACRONYMS

a.s.l	Above sea level
AEZ	Agro Ecological Zone
AGL	Alagae Grazing Land
AHF	Alagae Hay Field
ASAL	Arid Semi arid Lands
EARO	Ethiopian Agricultural Research Organization
EMA	Ethiopian Mapping Authority
ETH	National Herbarium of Ethiopia
IBCR	Institute of Biodiversity Conservation
IFAD	International Food Agriculture Development
ILRI	International Livestock Research Institution
MER	Main Ethiopian Rift valley (Also called the Lakes Region)
MoA	Ministry of Agriculture
PET	Potential Evapo-Transpiration
RPSUD	Research Program on Sustainable Use of Dryland Biodiversity
SPSS	Statistical Package for Social Sciences
T/h	Tone per hectares
TWINSPAN	Two Way Indicator Species Analysis

ABSTRACT

Rangeland management aimed at animal production can reduce, maintain or even increase range plants diversity. Although the maintenance of biodiversity has become one of the goals in ecosystem management, the relationship between diversity and ecosystem characteristics such as level of herbivory, productivity, and vegetation structure are still poorly understood. The way that management actions constrain (or perhaps magnify) rangeland biodiversity must clearly be understood for sustaining both productivity and biodiversity in rangelands. The purpose of this study was to investigate the floristic diversity and productivity aspects of protected and/or managed rangelands in the Main Ethiopian Rift (MER), semi arid agro ecological zone. In this paper, the major issues addressed include floristic diversity, vegetation description, herbaceous biomass estimation, and range condition assessment. For the study we used a combination of ecological survey (Zürich Montpelier) method and a standard range condition assessment technique (adopted for the South-Eastern Ethiopian Rangelands). TWINSPAN computer program is used to make vegetation classifications. We examined the relationships between herbaceous biomass production and plant diversity in four native range sites differing in range condition in the Open Grasslands (2), and Wooded Grasslands (2) in semi-arid AEZ of MER. The results of this study have revealed the unique vegetation and rich plant diversity of the two rangelands. Range condition of the four range sites ranged from poor to good and found to be supported by herbaceous biomass production and grazing indicator species. Herbaceous biomass production follows a quadratic relationship with range condition. There is some indication that the humpback model appears to be functional in the MER rangelands. Important information generated has pictured the need for optimizing productivity and biodiversity conservation and elicited information on how agricultural and biodiversity conservation interest should be integrated for the sustainable utilization of rangelands.

Key Words: Vegetation Description, TWINSPAN, Range condition, Main Ethiopian Rift Valley

TABLES OF CONTENT

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

I. INTRODUCTION

1.1. Background and Justification

Range or rangeland is defined as uncultivated land that supports grazing and browsing animals. It is usually mean arid and semi-arid lands dedicated almost entirely to livestock production using natural vegetation. Rangeland is a kind of land on which the native vegetation, climax or natural potential consists predominately of grasses, grass-like plants, forbs, or shrubs. According IFAD (1999) rangelands may consist of natural grasslands, savannahs, shrub-lands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows. It includes lands supporting indigenous vegetation, naturally or artificially re-vegetated to provide a plant cover that is managed like native vegetation and being grazed or has the potential to be grazed. Range sites are subdivisions of rangeland for management purposes having more or less similar soils, climate and climax plant communities. This means two or more identical range sites that are spatially separated should respond in a similar manner to the same kind of management (IFAD, 1999).

According to Busby (1995), about 50% of the land area in the world can be considered as rangeland. Grasslands, shrub-lands, savannas and deserts comprise the majority of range ecosystems, with wetlands, forest, alpine grassland and tundra making up the remainder. Some rangelands are lands that are too rocky; steep, saline or seasonally wet and not suitable for cultivating crops or timber (Friendel *et al.*, 2000).

Occupying one third of the world land surface area, and supporting a population of about 20 percent of the world total, the dry lands are rapidly being degraded due to population growth, deforestation, overgrazing, cropping of marginal lands, inappropriate irrigation and bush encroachment (FAO, 2000). According to Kuchar (1995) the UNEP has found that at least 75% of the arid and semi-arid regions productive lands have already moderately desertified or lost more than 25% of the original productivity. The problem would particularly be serious in developing countries, where degradation of range and farming interface continuously accelerating.

Most of rangelands of Ethiopia areas are classified as marginal arable and non-arable land (Alemayehu Mengistou, 1998). They are mostly characterized by lowlands plains and have a relatively harsh climate with low, unreliable and erratic rainfall and regularly high temperatures. Rangelands are characterized by aridity with extremes of heat or cold. They include land that is rocky, steep, saline or seasonally wet for agriculture. Grasslands, scrublands, savannas and deserts constitute majority of range ecosystems compared to wetlands, forest, alpine grassland and tundra (Friendel *et al.*, 2000).

The topographic diversity of Ethiopia that emanates from the diverse geologic history has resulted in the formation of a multitude of agro ecological zones and sub zones suited for various farming systems and supporting diverse vegetation types. According to White (1983), Ethiopia is endowed with four regional centers of endemism. Like most African countries, Ethiopian economy is highly dependent on agricultural production. According to MoA (1998), the agricultural sector contributes more than half (52%) of the gross domestic product (GDP) and about 90% of total foreign exchange earnings. Of this, livestock sub-sector covers about twelve percent of the GDP (30% of the agricultural GDP), and comprises the second largest export sector. The fate of this sub-sector, however, depends on sustainable utilization of rangeland resources. Livestock production of the country is mainly found in the mid-altitude (1500–2000m a.s.l) and lowlands (Alemayhu Mengistu, 1998). Unfortunately, scientific studies supporting the sector are generally limited and agricultural production is far below the potential.

According to the FAO (2000), classification Ethiopia is one of the thirty-six dryland developing countries in the world. These countries have most of the their land belongs to the arid and semi-arid areas defined as having 100-600 mm annual rainfall. The lowlands, the major rangelands of Ethiopia form a wide apron surrounding the highland massif and part of the Great Rift Valley. It includes the lowest elevation in the country at 126m below sea level. According to Coppock (1994), the arid and/or hot zone has up to 90 growing days per year and suited mainly for animal production. The lowlands of Ethiopia, which make up nearly 61 - 65 percent of the total landmass Alemayehu Mengistu (1998), are the major pastoral areas.

The sensitivity of drylands to climatic fluctuation was dramatically illustrated by several droughts that affected Ethiopia in 1888- 1892 (Pankhurst, 1966) and more recently in 1984/5 and 2001/2 (Personal observation). The inter-annual change in rainfall is a common phenomenon in the drylands of east Africa. The mechanism and frequency of short and long-term rainfall fluctuations seems far from being understood (Dagnachew Legesse, 2001). However, the impact of human interference on vegetation seems clearly visible. Thus, it is at most priority to analyze the behavior of rangeland vegetation in response to human activities and changing climatic conditions.

The drylands of Ethiopia are reportedly biodiversity rich (Tewolde Brhane GebreEgziabher, 1990; Blench and Marriage, 1999) and any vegetation change may result in species decline or loss. For these and other reasons rangeland monitoring and assessment is an absolute need to plan and implement any conservation measures. According to Pratt & Gwynne (1977) if rangeland vegetation study is aimed at development, it requires information on range potential and condition, on water resources and on the population and distribution of people and livestock. One also needs to know the secondary products derived from rangelands, like honey production, food and feed values, materials for cultural artifacts and houses and income generation.

In the MER areas livestock, production was the major human activity for hundreds of years. The increased interest by the central government and subsequent malaria control activities were thought to be the reasons for the fast expansion of sedentary agriculture from the surrounding highlands (Zerihun Woldu and Mesfin Tadesse, 1990). According to Brown (1994) ten hectares of the best rangeland cannot possibly supports more than one person, where as ten hectares of maize can support up to 1600 people. Thus, in strict productive sense, it is preferable to have land under 'cultivation', because it is possible to support more people in small hectares of land. However, the present day rangelands are by definition not amenable to crop farming. Large areas of rangeland would rather support much livestock and moderate human population. This means that much of the Ethiopian lowlands (the nomadic pastoral areas) were though as stayed under the best possible land use, suited for the regional climatic constraints (Kuchar, 1995).

According to Bekure *et al.* (1991) livestock management is essentially grazing management, water development and livestock marketing. Long-term strategies of grazing management are closely interlinked to the long-term variations of forage supply. Traditionally, farmers in Ethiopia used to exclude their animals from grazing lands to reserve grasses for dry season. In contrast, most communal grazing lands are open and grazed year round. Grazing in enclosures during the dry season for two to three months and moving animals out to the open sites is another common grazing strategy. Permanent and seasonal enclosures of rangelands that made for forage preservation may also be important in biodiversity conservation. However, it may require shifting animals with appropriate timing and knowledge of the range condition. This study has tried to revel the conservation implication of seasonal grazing exclusion or rangeland protection in the MER area.

The processes of range degradation believed to have begun decades ago because of some climatic and/or management change (Pratt and Gwynne, 1977). Although both pastorlists and researchers in Ethiopia are aware of gradual deterioration of the rangelands, management actions are either absent or not based on condition and trend assessment of range sites at local or landscape level. This indicates that management actions to be taken should be based on understanding of the history, current condition, and future trend of rangelands.

Improper action based on misunderstanding range condition usually leads to crisis then sustainable development. According to Oba *et al.* (2000) in Sub-Saharan Africa the multi million dollar development projects of the last few decades have failed and end up in rangeland degradation, recurrent drought and donor withdrawal. The phenomenon is now named as "pastoral crises". The suggested reason for the crisis is wrong assumptions perpetuated by ecological models (climax community model) that appear to be inappropriate for Sub-Saharan Africa (Oba *et al.,* 2000). Grazing exclusion and water establishment are being recognized as factors that alter traditional land use patterns; leads in to food and feed insecurity as well as desertification (FAO, 2000).

Vegetation study in the MER area is not new. White (1983) classified the MER area as *Cenchrus ciliaris* grassland. Zerihun Woldu and Mesfin Tadesse (1990) studied the vegetation status and the recovery potential of degraded areas of the lake region. Recently, Amsalu Sisay *et al.* (2001) has made herbage composition study and range assessment of the region and recommended further and detailed studies. Perhaps for various technical and logistics reasons most, if not all, studies so far focused mainly on sites along the main highway. Therefore, this study has mainly focused on protected and/or managed rangeland vegetations of the Algae (formerly called 'Children Amba') and the Neteli ELFORA ranch.

Thus, this study on one-hand reveals the unique vegetation of the two rangelands and on the other compliments studies made so far. Furthermore, as the humpback model predicts seasonal grazing exclusion increase biodiversity until biomass accumulation reaches 500 g per square meter. Even though the model has developed for temperate zone vegetations, Oba *et al.*

(2001) reported as this model also works for tropical arid-land vegetation of Kenya. Thus, in this investigation, the two protected rangelands are tested against the humpback model and the model is tested under Ethiopian condition.

1.2. Objectives

1.2.1. General Objective

The major objective of this thesis was to make vegetation description and range condition assessment of the Alagae and Neteli rangelands. By investigating the forage and brows plant diversity and the impact of grazing management systems on range conditions as well as plant diversity, it has tried to see the way in which rangeland biodiversity will be conserved through sustainable livestock production and range management.

1.2.2. Specific Objectives

The specific objectives of the study were to:

- ☞ identify and document plant species diversity of the Alagae and Neteli rangelands;
- ☞ identify the rangeland plant communities of the study sites;
- ☞ investigate the relationship between herbaceous biomass productions, diversity parameters and range condition assessment;
- ☞ assess the over all rangeland biodiversity and production efficiency the different range sites in the study areas;
- ☞ investigate the impacts grazing management on rangeland plant diversity and herbaceous biomass production; and
- ☞ draw recommendations that help for the sustainable utilization of rangeland resources in the dryland areas of the country.

II. LITERATURE REVIEW

This review explores the fundamental concepts of rangeland vegetation study, rangeland biodiversity and range management. The first part is devoted for general overview of rangeland vegetation ecology. The second part begins with the defining and biodiversity concepts and discusses the different views and concepts of biodiversity conservation issues in rangelands. Finally, brief reviews of the fundamental range management concepts will be presented.

2.1. Rangeland Vegetation

Plants community structure and function are manifestations of a complex array of interactions, directly or indirectly by community members altogether. Understanding their composition, stand structure, dynamics, and spatial distribution of vegetation for any landscape requires a solid understanding of the site conditions, disturbance regimes, history, and processes of the landscape ecosystems of which they are an inherent part (Bonham, 1989). Vegetation as a component of ecosystems displays the effects of other environmental conditions and historic factors in an obvious and easily measurable manner. Thus, Careful analysis of vegetation used as a means of revealing useful information about other aspects of an ecosystem (Swain, 2001).

Plant communities are aggregations of organisms that happen to occupy a common segment of space. They are composed of individuals and species whose ecological amplitudes, mutuality related, and competitive abilities allow them to co-exist and have visually distinctive features of the landscape (Goldsmith *et al.*, 1986). Various vegetation parameters have proposed by ecologists to define communities in spatial and temporal scale. Andreucci *et al.* (2000) defined plant community as a state of vegetation system given by a combination of populations of plant species living together in a homogenous environment. Others include life form or growth form, species dominance, and presence or absence of certain diagnostic species in defining communities (Mueller-Dombois and Ellenberg, 1974).

The study of communities began with attempts to identify distinctive plant associations that could be given rigorous descriptions and then classified into a fundamental ordering of nature (Andreucci *et al.*, 2000). In addition to floristic composition, knowledge of the relationships among plant communities is essential for understanding of vegetation patterns of a landscape.

According to Blench and Sommer (1999) the existence of natural rangeland vegetation was controversial. More recently, natural rangeland vegetation is designated to exist between deciduous tropical forest and sub-tropical desert vegetation. Thus, rangeland vegetation can be natural (climatic or edaphic) or anthropogenic in origin. The latter can revert to forest vegetation if human influence and/or management cease. The rangelands of east African countries are almost exclusively found in dryland areas, where there is general moisture deficit (Coopok, 1994; Herloker, 1999). Therefore, understanding the natural vegetation and ecological systems in response to the changing climate and human activities is crucial for countries where the people way of life is primarily governed by available natural resources.

2.2. Rangeland Biodiversity Conservation

Misunderstanding range ecosystem and the concepts of biodiversity could be parts of the major problems in rangeland biodiversity conservation. According to Blench and Sommer (1999) 'Range Management' has different meanings for different people. For a classical range manager and pastoralist rangeland is strictly seen from livestock prospective. Thus, range management has typically meant preserving forage for livestock in one or another way to increase the productivity of range. Wildlife institutions on the other hand are mainly concerned for the preservation of fauna, and regard the conservation of rangeland as incidental to their main task. Because of such misunderstanding the national and international bodies, such as those exist for agriculture, wildlife, and forestry have not been created for rangelands. Indeed rangelands have seen to be everywhere regarded as a sort of scrap category, lands left over when other types of land use categorized. However, African rangelands are not only the basis of pastoral people subsistence but also home to huge biodiversity and need due attention.

Biological diversity is the variability of life and its processes, including the variety of living organisms, the genetic differences among them, as well as communities, ecosystems, and landscapes in which they occur, plus the interactions of these components. The term 'biodiversity' as a contraction of biological-diversity and its modern concepts came into existence following the Rio de Janeiro 1992 international convention (Stork, 1996). The convention has defined biodiversity as: "The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic system and ecological complexes of which they are a part, this includes diversity within species, between species and ecosystems " (WCMC, 1992; Stork, 1996).

More recently beside the hierarchy of life, the local people, their culture and indigenous knowledge are recognized as component of biodiversity. Since Rio 1992, the term and concepts of biodiversity have been remarkable events in the recent cultural transformation (Wilson, 1997). According to Lovejoy (1997), biodiversity has been perceived in many different ways. Someone may start looking at it from the overall evolutionary perspective. Others may view diversity at grass-root level as molecular and/or genetic diversity. Still others may view it as characteristics of communities or in terms of global diversity collectively.

Some authors prefer to view 'Diversity' like an optical illusion, 'the more it is looked at, the less clearly defined it appears to be, and viewing it from different angles can lead to different perceptions of what is involved.' Thus, they further warn that biodiversity should not be viewed as a single phenomenon, but as a "concept cluster". Though our knowledge is hierarchically structured into different levels of biological, organization biodiversity is a complex concept. West (1993) indicated biodiversity is a multifaceted phenomenon involving the variety of organisms, their environment and interaction at all level of organization. Thus, to make the living system simple to understand, biodiversity is generally perceived in terms of species, and is commonly used as synonym of species diversities (WCMC, 1992).

Conservation of rangeland biodiversity is actually the subset of global biodiversity conservation in general. However, the strongly anthropogenic character of most rangelands make conservation arguments somewhat problematic. Because, if we consider rangelands as human creations there is no 'original' state that can be conserved, maintained or restored. Indeed the argument must be turned on its head, for there is a strong case on both the economics and ecological grounds to think rangelands should be biodiversity rich.

The reputation of the world's dryland as having low biodiversity is, however, false (Cody 1989). Disturbance tends to favor those organisms with broad ecological adaptation and rangelands of the arid and semi arid regions could be repository centers of dryland biodiversity. For example, the floral diversity of Africa's rangelands is relatively high. The number of species per 10000 km2 is conventionally measures aerial richness; and the Arial richness of savanna is not far below that of rainforest (Menaut and Cesar, 1982).

According to Blench and Sommer (1999) society will increasingly value biological diversity and influence the passage of laws and writing of regulations involving biodiversity that rangeland managers will have to abide by over the coming decades. Thus, this issue will eventually influence all those concerned with rangeland management worldwide. If this could not happen even those private and developing world rangelands will get seriously affected. Thus, either we can wait for the influences to become evident and react after regulations in place or we become proactive.

2.3. Formations of Rangelands

Range management can only be successful if it is based on proper understanding of factors affecting rangeland vegetation. The basic determinant of the nature and productivity of rangeland ecosystem is its environment. According to Herlocker (1999) physical environmental factors such as climate, topography, and soil determine the potential of rangelands to support certain types of land use. Within the limit of this potential, the influence of biological factors (such as grazing, browsing, tree cutting, and shifting cultivation) and fire create different levels of productivity and vegetation types (solbrig, 1996; Barbier *et al.*, 1994).

According to Pratt & Gwynne, (1977) the most important environmental factor limiting vegetations in east Africa is climate, particularly rainfall. In order to initiate and maintain growth of rangeland plants minimal requirement of rainfall period should be meet. In other words, for each range site there is minimal rainfall, the period of time over which it occurs, to outweigh the evapo-transpiration demand and initiate plant growth. For example, in the arid northern Kenya, a minimum of 15 mm rainfall within a week is needed in order to initiate effective annual grasses growth. One-day rain is necessary to wet the grass seeds, and at least three more days' rainfall is required to compensate evaporation. In typical arid areas, unless there is rainfall of 25 mm lasting over ten days, an amount exceeding about a quarter of the PET growth remain insignificant (Herloker, 1999).

Temperature is another very important climatic factors the affect the productivity of rangeland vegetation. Except at high altitude temperature is seldom a limiting factor to plant growth (and Gwynne, 1977). However, in rangelands the effect of temperature is coupled with moisture availability for plants. Thus, the effect of temperature could be seen in connection with PET, which reflect the moisture demand of vegetation. In rangelands, rate of PET is in general very high and make the impact of high temperature pronounced. For instance, Coppock (1994) indicated in the lowlands of Ethiopia (below 1500m elevations) annual mean temperature ranges from 20 to 25°C and created annual water deficit.

Physiographic features are also significantly affecting the vegetation of a given region through their effect on climate, drainage and soil condition. According to Coopok (1994), the main factor influencing air temperature in Ethiopia is elevation. Hence, influence the distribution and pattern of individual plants or communities indirectly by regulating micro-climatic and hydrological processes. According to Zerihun Woldu (1999) the vegetation of Ethiopia is extremely complex; and the complexity arises from the great variation in altitude, spatial differences in moisture regimes as well as temperatures within very short horizontal distances. The divers geologic history, climatic conditions together with biological factors have resulted in the formation of various topographic features of landforms, soils and vegetation types of Ethiopia.

2.4. Major Disturbance Factors of Rangeland Vegetation

A. Grazing

Grazing is among the most important agents influencing range vegetation type and distribution. The evolution of large herbivores related with the formation and extension of grasslands. According to Blench and Sommer (1999), rangelands that have co-evolved with grazing species include: the savannas of African (antelopes and Zebras), the steppes of Asia and Eastern Europe (gazelles, goats, camels, bison and wild horses,) and the prairies of North

America (deer and bison). Numerous small mammals such as: marmots, pikas, ground squirrels, gerbils and voles, complement large herbivores. In additions, in Africa, Australia and South America termites are extremely important, consuming up to one-third of the total annual production of dead wood, leaves and grass.

According to some authors, although protected areas are considered as sites of biodiversity preservation, they often characterized by significantly fewer plant species both at a plot and point scale. This always brings contradiction especially in rangelands when there is grazing of variable intensity. As there are a number of studies indicating the negative impact of grazing, there are also researchers that have shown as grazing contributes to the increase of species diversity (Oba *et al.*, 2001, Lamprey, 1979; Zerihun Woldu, 1985). This is an indication, as many discussions on the effect of livestock grazing on plant species diversity have not led into consensus. Perhaps, due to the specific situation of their research environments there is no consensus and still some authors suggest as grazing increases plant species diversity while others report the opposite

However, it is clear that grazing and browsing animals have some influence on species composition, biomass production and biodiversity distribution. According to Oba *et al.* (2001), a model that has been developed for temperate zone vegetation describes the relationship of plant biomass and species richness as a humpback response. This model has stated that herbaceous species richness reach the maximum at intermediate biomass corresponding with moderate competition or disturbance level. Beyond the maximum, species richness declines due to increased competition (Grime, 1973 cited in Oba *et al.*, 2001).

According to this model, grazing can increase or decrease species richness depending on intensity of grazing and biomass availability of an area. Thus, the influence of grazing is associated with the intensity of grazing. According to Bekure *et al.*, (1991) overgrazing not only changes the grassland vegetation (by encouraging the growth of unpalatable and woody vegetation) but also causes environmental degradation. Cumulatively, overgrazing reduces plant vigor and carrying capacity of lands, the ultimate depletion of ground cover, increases gully erosion and the invasion of communities by unpalatable and usually thorny and/or poisonous vegetation. Thus, range deterioration is expressed to occur as a result of any one or combination of these and other phenomena.

In grazed sites of the Ethiopian highlands, Zerihun Woldu (1985) has found that the most important species like *Andropogon abyssinicus* and *Hyparrhenia* sp. either reduced or eliminated and replaced by less palatable species. Compared with moderately grazed sites where palatable species are present, grazed sites of extreme bad condition have vegetation crippled down to the ground level and only few resistant species remain. Such observations are the basis for the concept of indicator species in range assessment.

B. Fire

Fire has been a natural and very important environmental factor in the dry land tropics. It has a principal influence on species traits, life history as well as ecosystem characteristics (Nijhof, 1982). Resource mangers use fire in parks and wiled life reserve areas. Traditionally, farmers in Ethiopia also use to burn grasslands for different purposes: to have a quality grass for livestock, to control of harm full pests, and to protect their farmland against weed invasion.

However, the effective use of fire as a management tool requires a thorough understanding of this complexity of interaction and response of vegetation.

Regular fires are one of the characteristic features of tropical savannas. In this areas, while some are caused by lightning (Komarek, 1972; West, 1972), the main source of ignition for the past tens of thousands of years has been human being, for hunting, preparing land for cultivation, improving the quality of forage for livestock, and controlling the spread of woody plants (West, 1972). Such use of fire has been so pervasive that lead some authors to conclude that most savannas are anthropogenic systems derived from deforestation and repeated burning. Nevertheless, it is one of the few determinants, which can be readily manipulated and, as such, is an important variable in any management programs.

According to Frost and Robertson (1987) fire behavior, timing, intensity and frequency of occurrence are somewhat independent of one another and affect both the environment and the biota in a number of direct and indirect ways. Fires reduce plant biomass and litter, thereby altering energy, nutrient and water fluxes between the soil, plants and atmosphere. These changes in turn may affect the long-term nutrient status and productivity of the system (Cerment, 1996). Fires also kill individual organisms, damage or destroy unprotected living tissues, modify growth and reproductive rates, change the availability and use of resources and alter competitive and other relationships between organisms. According to Craig (1983) The effects of these impacts depend largely on the recent history of a site, the physiological and developmental state of an organism at the time of burning and the occurrence of future events such as rain fall, drought or herbivory. These effects in the longer term may result in changing the productivity and population structure of a species, the composition of communities, and ultimately, the probability and characteristics of future fires.

2.3. Fundamental Range Concepts

Rangeland is a kind of land on which the native vegetation, climax or natural potential consists predominately of grasses, grass-like plants, forbs, or shrubs. Tropical rangelands are primarily arid and semi-arid lands, because crop cultivation is not economically feasible but it may include areas that have past history of cultivation or future potential (Herlocker, 1999). In other words, fallowed fields and wooded areas where animals browse, as well as land used by wildlife, from which livestock are excluded by diseases, lack of water and palatable vegetation are also considered as rangelands. Smith (1978) defined 'range site' as piece of rangeland under the same climate, edaphic and floristic regime. It is like the actual or potential ecological vegetation type of plant with soils included. The primary factors distinguishing a site are soil, topography, and climate. Thus, range sites can be distinguished irrespective of present use or vegetation cover.

Though rangeland vegetation has multiple uses, feed for livestock is usually seen as the principal product of rangelands. However, in addition to herbage and forage production, rangelands provide a variety of other important products, services and values. Provision of feed and habitat for wildlife's; biodiversity products (construction and fuel wood, gums, resin, and honey); traditional values (cultural medicine, rituals, ceremonial activities); soil and water conservation; income generation through eco-tourism and aesthetic values are among the major values of rangelands. Therefore, rangeland biodiversity conservation must be associated with the existence, abundance, quality and sustainability of all these rangeland resources.

East African rangelands are also traditional living places of pastoral people together with diverse types of wildlife and plant resources on which their life is dependent. The rangelands unique resources have contributed to the food supply, culture and economy of the world for centuries through crop production, livestock grazing, building houses and household utensils, wildlife habitats, and soil and water conservation (Pratt and Gwynne, 1977). Because of their rich diversity, rangeland (especially grassland) communities are often times called flexible and resilient. However, due to improper management and population pressure most rangelands are becoming more fragile and susceptible.

In most East African countries livestock production on rangelands is dominated by the extensive nomadic pastoralist (migratory grazing) production system, which are found in the arid and semi-arid regions (Lampery, 1979). Thus, most of the rangelands characterized by aridity with temperature extremes (heat or cold) and moisture deficit. Thus, crop production is generally limited by the difficult climatic or topographic conditions. This makes traditional nomadic pastoralism or communal grazing with seasonal mobility a sustainable production system evolved through centuries (Herlocker, 1999).

2.3.1. Range Management

Conventional range management approaches include regulation of grazing to apply selective pressures on the plant community, application of disturbance (e.g. fire), introduction of new forage species, and reductions of undesirable species. Ideal range management would mean the utilization of the forage crop in a way that maintain the lands at their highest state of productiveness and at the same time afford the greatest possible return to the stock industry (Sampson, 1914; cited in Kuchar, 1995). According to Orr (2002) in 1975 a team of the Utah University defined rangeland management as: the science and art of optimizing the returns from rangelands in those combinations most desired by and suitable to society through the manipulation of range ecosystems. Heady and Child (1994) broadened the definition of rangeland management further:

"Range management is a discipline and an art that skillfully applies an organized body of knowledge accumulated by range science and practical experience for two purposes: (1) protection, improvement, and continued welfare of the basic resources, which in many situations include soils, vegetation, endangered plants and animals, wilderness, water, and historical sites; and (2) optimum production of goods and services in combinations needed by society...Management of rangeland requires selection of alternative techniques for optimum production of goods and services with no resource damage.... While emphasis is often placed on effects and management of domestic animals, the overriding goal is rangeland resource rehabilitation, protection, and management for multiple objectives including biological diversity, preservation, and sustainable development for people."

Thus, the objectives of range management are rehabilitation of degraded range sites, prevention of further degradation and insuring optimum and sustainable productivity (Mwangata, 1994). Range condition assessment is a management tool that helps to integrate grazing management activities with vegetation dynamics. It is a practical test of whether the principles of proper range use have been applied (Pratt and Gwynne, 1977).

2.3.2. Primary Productivity in Rangelands

The term 'primary productivity' refers to the energy fixed by plants, and perhaps is the most fundamental characteristic of an ecosystem. Because, all biological activities of plants, animals and human are depend on the gross energy of primary productivity (Bonham, 1989). Rangeland vegetation productivity determines agricultural development potential and hence human ecology. Primary productivity in rangeland is highly variable and often times life threatening. According to Ludwig (1987) in the last century, technology and culture have changed and alongside them, the pattern of exploitation of arid and semi-arid areas by humans. Population densities have increased greatly resulting in over-utilization of some areas, particularly around water points. The natural vegetation has been cleared for fuel and farming which has a positive feedback to intensify the rate of desertification.

Primary production measurement is a necessary tool for proper understanding of ecosystem dynamics. According to Bonham (1989), rangeland biomass production implies organic material production for food and feed, fuels, building materials and chemicals. Vegetation composition, based on dry weight, is one of the best indicators of species importance within a plant community. This is because the weight of live plant materials includes the inter-and intracellular water and any external moisture from vapor condensation, precipitation etc.

Therefore, the weight of freshly harvested plant materials is highly variable and hence biomass is expressed in terms of oven or air dry weight.

2.3.3. Major Problems of Rangelands

A. Draught

Range productivity depends on variations in climate (rainfall distribution, length of growing season, etc), soil, grazing intensity, and human pressure on the rangeland (Heady and Child, 1994). Drought is probably one of the most distractive factors of rangeland vegetation, especially when it is protracted. It is one of the most common factors causing extensive damage for the pastoral community and shaping their life style (society). Meteorological drought, a significant decrease in the climatologically expected precipitation, is a recurring phenomenon in east African rangelands and sometimes it is predictable. For instance, in Samburu district, Kenya, within a 30 years period 25, 10, and 5 extreme droughts are expected to occur in the very arid, arid and semi-arid rangelands respectively (Herloker, 1999).

B. Bush Encroachment

Bush encroachment, which commonly associated with fire and grazing management, is another most important and perhaps worldwide rangeland problem nowadays. Although this vegetation change is sometimes attributed to livestock grazing and decreased fire frequency, the specific mechanisms by which these disturbances promote woody plant encroachment seem not verified. According to Boutton *et al.*, (2002) simulation models suggested that an increase in woody plant on grasslands and savannas might be resulted from grazing-mediated changes, in the distribution and abundance of soil and water that favor the more deeply-rooted woody plants. However, because of methodological limitations, there have been no direct field evaluations of these suppositions. Isolated sub-canopy zone vegetation is often different from that found in the surrounding as a result of shade effects and the trees acting of trees as nutrient pumps by taking up nutrients from deeper soil layers and depositing it as litter from canopy and roots (Pratt and Gwynne, 1977).

According to Adair (1995) invasions are a reflection of habitat fragmentation, caused directly or indirectly by human activities, steep climatic and topographic gradients accompanied by exposure to high levels of invasive alien propagules. The African Savanna woodland, extensively exploited by man and wildlife is one such area (White, 1983). It is threatened by expanding settlements and land-use conversion to agriculture, tree felling for domestic wood supplies, overgrazing, overstocking parks and fire. Such disturbances diminish indigenous floral diversity and create opportunities for invasion by alien plants (Adair, 1995).

According to Boutton *et al.* (2002) the abundance of woody plants has increased in many grassland and savanna ecosystems throughout the world. Despite its potential local, regional, and global importance, we know little about the ecological significance and resource management implications of increased abundance of woody plants in different ecosystems. Few countries have recognized the threat currently posed by invasive and fewer have control programs (Lyons & Miller, 1999). However, these programs are mainly targeted at the 'control' of already known serious invasions not on prevention.

2.3.4. Range Condition and Trend

Grazing is among the important ecological (disturbance) factor most east African rangelands. According to West (1993) ungulate grazing is an important process in many ecosystems. Thus, removal of natural grazers and /or browsers destabilizes some systems. Livestock grazing is reportedly enhancing the survival chances of some species while suppressing others. Thus, in many instances, moderate livestock grazing is recommended to enhance community and landscape-level diversity (West, 1993).

Range condition is the current productivity of a rangeland relative to what it is naturally capable of producing. Range mangers use range condition to determine whether the existing management activities are adequate or require some modification in order to guard against rangeland degradation and optimize productivity (Herlocker, 1999). Different methods of range condition classification have emphasized different range features. For instance, Dyksterhuis (1949) stressed species composition and Hamphrey (1979) preferred forage productivity. However, many authors encourage the use of a combination of a number of different vegetation and soil attributes as indicator of condition and trends. According to Friedel *et al.* (2000) the most widespread usage places major emphasis on species composition, believing that ideal combinations of species also indicate highest density of plants, stable soil, and high production of both forage and animals.

According to Herlocker (1999) range condition classification have been developed and used primarily in the field of livestock production. The most commonly used method of classification assumes: a perennial grassland complex; a single linear pathway of specific vegetation communities under the influence of different grazing regimes, and grazing by livestock is the dominant land use. However, Smith (1978) has noted that range condition need not necessarily assume grazing to be the dominant land use. Thus, range condition is simply the point at which criteria of interest to an individual or organization are satisfied. It is associated with the type of land use supported by a rangeland. Therefore, different types of land uses are appropriate to have differing criteria for determining range condition. For instance, a rangeland classified in good condition for cattle production may be in poor condition for supporting camels and goat; or under medium condition for supporting the maximum amount of biodiversity.

According to Friedel *et al.* (2000), optimal rangeland traditionally viewed as of land in peak vegetation condition. This is a somewhat complex concept, because it combines the ideas of climax and condition. The view of rangeland as first developed in U.S.A. has its origin in the work of plant ecologists particularly Clement`s, whose ideas of climax vegetation ruled American ecology from the 1930 up to the 1950s (Kuchar, 1995). The basic principle of Dyksterhuis' (1949) range condition evaluation made climax concept its central idea. In this view range in optimal condition is a range with climax vegetation, which has, over a long period and under given natural conditions, achieved a certain component of plant species and a certain natural productive peak. Thus, range condition is viewed as the present state of the vegetation compared to that of the climax or original vegetation for the range site.

According to Kuchar (1995) change of a range with respect to climax is what is known as trend. Trend refers to change in plant species composition and abundance in a given area, causing to depart it from climax. A downward trend indicates that the land is becoming less like the potential climax, and therefore, going to progressively poorer conditions. An upward trend indicates that the land is getting more like the potential climax, and hence better for livestock production.

Condition and trend have been remained the cornerstone concepts of range management, as exemplified by the quote: 'the concept of range condition (and trend) is perhaps the most important one in range management' (Smith, 1978). Range trend has been the dominant them in range science for decades and much of the effort of range scientists has been toward quantifying trend in a given pieces of rangeland. The concepts of range site and range condition and trend are central to our understanding of rangeland management. They supposed to tell us what is there, its state or condition (health), and what is happening to the vegetation. Taken together they form a powerful description of rangeland, and the basis for development efforts aimed at improving or stabilizing rangelands.

2.3.5. Measuring Range Condition

Heady (1975) suggested evaluation of present range ecosystem in terms of (excellent, good, fair, and poor) defined standard of excellence. Kuchar (1995) has indicated as some authors linked range condition to the inventory of a store. If the shelf has full and the display of products complete, the customers have a wide choice and an excellent condition exists. If the shelves contain few goods, bare space spoils than a poor condition exists. Whatever might causes the decline, range condition is called low when desirable species replaced by poor species; when reduced soil cover exposes excessive bare surfaces; when erosion accelerates; when production of forage and/or animals drops; or when any combination of these effects are observed. In other words, one or more of the ecological parameters such as species composition, cover, erosion, and production are used to measure range condition.

There are a number of methods based on different criteria, which have been used by different countries and different scientists. For various reasons different inventory systems have used the above-mentioned parameters in various combinations to determine range condition. According to Friedel *et al.* (2000) the most widespread usage places major emphasis on species composition, believing that ideal combinations of species also indicate highest density of plants, stable soil, and high production of both forage and animals. This means, species composition is independent and the others are dependent. The major exception to this relationship occurs on steep slopes and unstable soils, which may erode after slight decrease in cover but little change in the species mix.

Strictly speaking, most of the factors are inter-dependent and wherever an independent factor is applied to evaluate range condition for management purposes, other factors should be considered as dependent. The gain in simplicity of sampling and interpretation of single factors outweighs loss of accuracy in measuring the whole system. This is especially important where managerial decision-making cannot take advantage of small differences (Friedel *et al.*, 2000). The authors also indicated as multiple factor consideration unnecessarily complicates the analysis beyond practical necessity and not applicable, except where operators can use computerized systems.

III. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location

According to Dagnachew Legesse (2001) "the Ethiopian Rift is subdivided into the South-Western Rift, which includes the Lake turkana and the Lake chamo rift in the south, the Main Ethiopian Rift (MER) in the center, and the Afar, Which is a triple junction between the MER, the Red Sea Rift and the gulf of Aden." The study was conducted in the rangelands of 'Alagae' and 'Neteli' within the Ziway-Shalla drainage basin (7°00 – ° 30' N Lat.; 38° 00 – 39°30` E. Long.) in the MER also known as the lake region of Ethiopia (see fig. 1) with altitude ranging between 1600 – 1700m above sea level.

Alagae or the Alagae College of Agricultural Technique (formerly called 'Children Amba') is found between the Alaba zone of the Southern Regional State and the western edge of east the Shoa zone of the Oromya Regional State. The total area of the compound is about 1600 hectares. It is located on the western side of Abijata - Shala Park (at 7°36` N & 38°25` E coordinate points). It is somewhere about 35 km southwest from Bulbul town, within the catchments of the ephemeral River 'Jido'. Alagae is situated at the foot of the highest peak mount Fike, which can be seen just between the two lakes. The altitude of the area ranges from 1540m to 2075m a.s.l.

The Netele rangeland is located between two administrative zones. It is situated on the northeastern side of Lake Ziway (at about 8°6` N & 38°58` E coordinate points) and is in the boundary between east Shoa and Arsi zone of the Oromya Regional State. The Neteli protected rangeland is currently one of animal production sites under the ownership of ELFORA Private Limited Company. The total area of the Neteli study site is about 1000 hectares, of which about half is fenced and mainly used as ranch and the remaining, unfenced are being used for cultivation and as unprotected grazing lands. It is found at about 25 km southeast from the town Meki on the way to Ogolcho (Arsi). The North Eastern part of the Neteli rangeland is densely vegetated with Acacia dominated woodland. The middle section is sparsely vegetative savanna and arable lands, while the lower part is pure grassland extending to the Lake Ziway seasonal flood plane.

3.1.2. Geomorphology and Soil

As part of the Great Rift Valley the geologic history of the study areas began from the late Mesozoic, when Africa become separate from the rest of the Gondwanaland. According to Sagri (1998) there is recent evidence that has confirmed as the geodynamic of the region is under the influence of perpetual aridity. Some 10000 years ago there was one macro lake encompassing the four present lakes (Ziway, Langano, Abijata, and Shala). Another trend of aridity that has started about 5000 years ago is continuing to create new environmental situations.

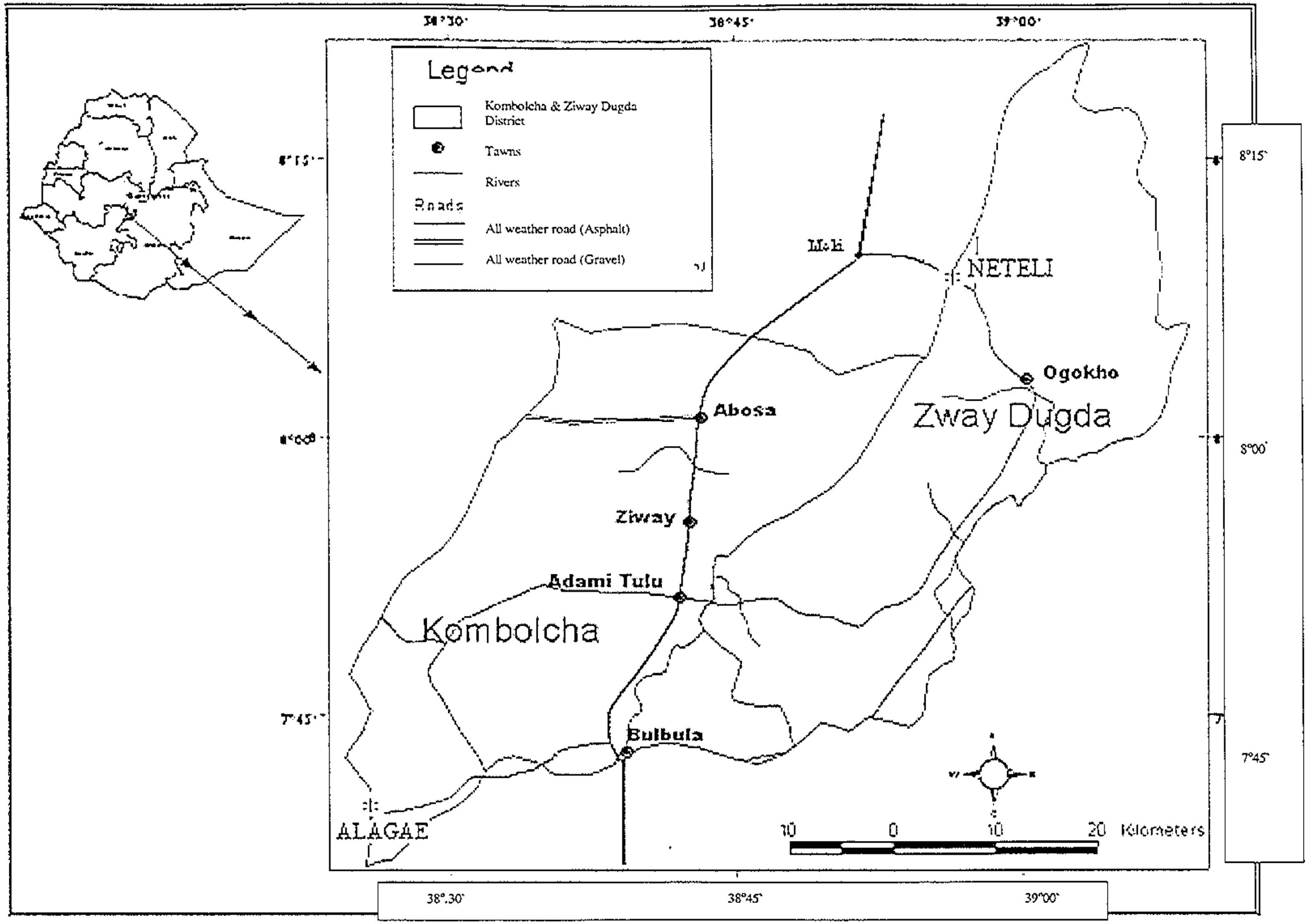


Figure 1. The Location Map of the Study Areas Source: EARO GIS Lab (2004).

The elevations of the MER area range between 1400 – 2200m above sea level. The different geomorphic features include: - rivers and lakes system; protected natural vegetation; the Abijata – Shala National Park; agro-pastoral and pastoral lands; and industrial and mining sites. These different unites make the region visually attractive and socio-economically important. The general topography of the study areas is gentle slope and plans. Since 4000 years ago, the Ethiopian rift thought as occupied by human.

The major soil unit of the MER floor or the Ziway – Shala basin is vertic Andosols (Makin *et.al.,* 1975; MoA, 2000; Dagnachew Legesse, 2002). According to Makin *et.al.* (1975) Soil types of the rift valley area are closely related soil parent material and its degree of weathering. The main parent materials are basalt, ignimbrite, acidic lava, volcanic ash and pumice, and reverin and lacustrine alluvium. There are four main soil types in the MER area: sandy loam soil, lateritic clay loams or clays, Dark clay soils and lithosols/regosols. Much of the rift floor (including the present study areas) is covered by soils developed on recent volcanic deposits. Soils in the central floor are classified as virtic Andosol of the FAO soil units and as Eutric / Chromic Cmbisol along the foot of escarpments. Around the lakes, the soils are developed on lacustrine deposits interbedded with pumic and they are generally grayish, coarse-textured sandy loams with a thickness of 1 to 2 m.

3.1.3. Climate and Hydrology

The physiographic history of the rift creates considerable variation on the climate, which is reflected in the growing seasons. The length of growing period is supposed to be in the range of 61 and 120 days (MoA, 2000). In the rift valley areas, a common climatic feature is that evaporation exceeds precipitation and hence annual water deficit. According to MoA (2000)

AEZ classification the MER falls under the arid semi-arid agro-ecological zone. Alagae is in SA2-2 and Neteli is in SM2-2 category.

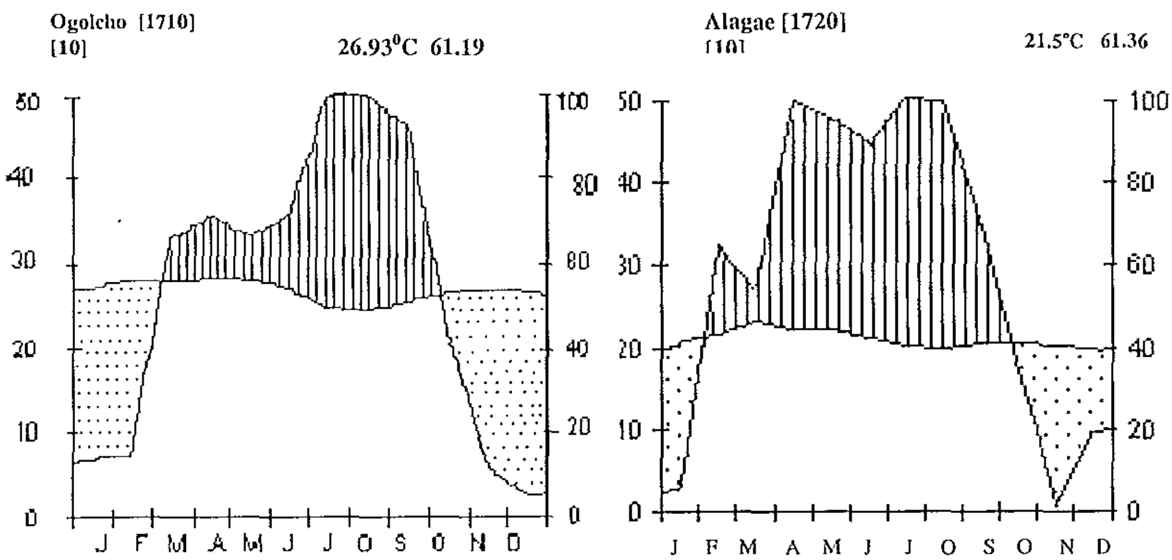


Figure 2. Climatic Diagram Showing Mean Annual Temperature and Mean Annual Rainfall for the Last 10 Years (1990- 2001) of: A. Neteli B. Alagea Constructed as Walter (1985).

Source: Original data were obtained from the National Meteorological Agency of Ethiopia.

The mean annual rainfall is in the range between 600 mm and 800 mm, and means temperature ranges between 18 – 27 °C. Generally, the day times are hot with colder nights. Figure 2. shows the climatic diagram of the study sites.

In the MER area, there are a number of perennial and intermittent streams originating from the highlands and flow on either sides of the rift to the rift floor. These rivers drain the highlands and the escarpments before entering the lakes in the rift floor. The major rivers in the MER include: Katar and Meki rivers that enter Lake Ziway; Jido river that enters Lake Shala;

Gedemso, Lepis and Huluka rivers that feed lake Langano. Within the rift floor Bulbula, river (the spill of Lake Ziway) and Horakelo River (the spill of Lake Langano) flow to the terminal Lake Abijata (EMA, 1997).

At present, the MER contains four major hierologically linked lakes: Lakes Ziway, Langano, Abijata and Shala. The four lakes represent about 8.5% of the MER and they lie in the lower part of the rift. Because, the rift floor is a rainfall deficit zone (evaporation exceeds rainfall) the lakes largely depend on surface water and ground water inflow from the adjacent plateaus and escarpments. Despite their geographic proximity and the similar climatic setup, these lakes have different chemistry, morphology and hydrology. Some of the basic characteristics of the four lakes are shown in Table 1.1.

Table 1. Basic Characteristics of the Four Lakes in the MER

Lake	*Alt. (m. a.s.l)*	*Depth (m)*	*Area (km^2)*	*Volume (Km^3)*	*Catchments area (Km^2)*	*Salinity (g/l)*
Ziway	*1636*	*9*	*485*	*1.7*	*6834*	*0.4*
Langano	*1585*	*47*	*226*	*4.8*	*1750*	*1.8*
Abijata	*1577*	*10*	*159*	*0.8*	*1100*	*16*
Shala	*1557*	*266*	*318*	*34*	*3297*	*19*

Source: Zinabu Gebrmariam and Elias Dedebo (1999)

3.1.4. Vegetation and Wildlife

The vegetation types of the semi-arid rangelands in Ethiopia include Acacia woodland, bush land and tickets, and open grasslands (Coppock, 1994). There are diverse types of forage grasses and woody species, which are important resources for indigenous people subsistence and livestock production. Characteristically these dry areas are potential livestock production centers.

The natural vegetation of the region is dominated by woodland savanna, where scattered trees and shrubs interspersed with herbaceous elements and open grasslands. Originally, the vegetation in the rift floor and escarpments were generally characterized by wooded grassland with *Balanites, Combretum* and various species of Acacia. Broad-leaved woodland dominated by *Combretum, Olea europaea, Ciltis, Dodonaea viscose* and *Euclea*, occupy the mid altitude of the escarpments (Zerihun Woldu and Mesfin Tadesse, 1990) and the lake margin and swamps of the main rift valley region are covered by swampy genera of *Typha, Pharagmites, Cyprus*, and *Sida monoica* of the alkaline soils (Alemayehu Mengistu, 1979).

The MER area includes wildlife of the proposed Abijata-Shalla Park, which might be avifauna diversity hot spot of the country. The park is supposed to be the home and feeding ground of about 360 species of residential and migratory birds. The major wildlife species mainly existing in the MER area are; Great white Pelican, Flamingo, Hippopotamus, Ostrich, Bushbuck, Duiker, Warthog, grant's Gazelle, Jackal, Caracal (MoA, 2000) and variety of Snakes (Personal observation). It is only 200 kilometers from Addis Ababa, having about 887 square kilometers size, of which 482 of being water body. It was created primarily for its aquatic bird life, particularly those that feed and breed on lakes Abijata and Shalla in Large numbers.

3.1.5. Population and Land Use

Generally, the rift floor area is relatively sparsely populated as compared to the escarpments and lower parts of the highlands. In effect, the latter represent one of the most densely populated parts of the country. Life in the MER, particularly within the rift floor, is organized around small-scattered villages. The majority of the population depends on subsistence rain fed agriculture and irrigation rarely practiced. The population distribution in 1989 and 1998 from selected towns is given in table 2. (CSA, 1990 and 1999). The mean annual population growth rate for these towns is estimated to be about 4 – 5 % with the exception of some emerging towns like Ziway, which have a much higher rate. The alarming population increase obviously leads to an increase in the demand for natural resources, including arable land, water, wood for constriction and burning.

Table 2. Human Population Number of Some Selected Towns in the MER in 1989 and 1998

Towns	*Population*	
	1989	*1998*
Butajira	*15872*	*26512*
Koffele	*6336*	*9390*
Meki	*13354*	*26177*
Arsi Negele	*17093*	*30081*
Shashemene	*38870*	*66633*
Ziway	*6722*	*25699*

Source: CSA, 1990 and 1999

According to the MoA (2000) both crop production and animal husbandry are important land uses practiced in the MER. Major annual crops are maize and sorghum; while livestock production include cattle, goat, sheep, donkey and mule. Livestock population of the two adjacent districts ('Woredas') is presented in Table 3. In the past animal husbandry was the dominant production system. However, for the last few decades much of the natural vegetation has converted into crop fields. In most of the woodlands, maize cultivation is becoming a norm and being expanding with the exception protected areas like those study sites at hand and few others.

Table 3. Proportion of the Different Livestock Population in Arsi-Negele and Ziway Woreda

Type of Livestock	*Number*	*Percent*	*TLU*
Cattle	*496226*	*50.58*	*347358.2*
Goat and Sheep	*319358*	*32.55*	*31935.8*
Equine	*55576*	*5.67*	*44460.8*
*Hens**	*109840*	*11.20*	-
Total	*981000*	*100*	*423754.8*

*Count does not include Ziway woreda ; TLU = Tropical Livestock Unit

Source: Arsi-Negelle and Ziway Woreda Agriculture office

Even though, prolonged moisture deficit makes agricultural production vulnerable and natural vegetation less resistant to grazing pressure, a number of agricultural products are being produced in the lakes region, especially around Koka, Ziway, Nazereth (Personal observation).

At present the MER region, as a whole is a zone of intensive farming activities. Increasing and progressive settlement has replaced the rangelands with small to medium scale farming and some of which are mechanized. The land use classification the adjacent woredas of the two study areas is shown in Table 4.

Table 4. Land Use of the Ziway and Arsi-Negelle Woreda in the MER

Land use	Ziway		Arsi Negele	
	Hectares	% Cover	Hectares	% Cover
Cultivated land	60444	43.1	50530	132.16
Bush and shrub land	6346	4.5	6346	16.80
Grazing land	27554	19.7	6039	82.61
Cultivated land	4546	3.2	38234	26.15
Water covered	22100	15.8	37766	25.83
Forest	13968	10.0	7310	5.00
Urban area	88	0.1	_	_
Fallow land	5165	3.7	_	_
Total	140211	100.0	146225	100.00

Source: Arsi-Negelle and Ziway woreda agriculture office

3.2. Method of Data collection

3.2.1. Environmental data

Meteorological data, temperature and rainfall of the Alagae (Formerly known as 'Children Amba'), and Ogolcho (the nearest station for Neteli) stations from the Ethopian Meteorological Service Agency were used to construct climatic diagram of the study sites. The environmental variables measured for every plot include altitude, slope, aspect (exposure), and soil parameters. Altitude was measured using an Everest Altimeter, slope was measured using clinometers, and Aspect was determined using Santo compass. Aspect, linked with solar energy, was estimated as codified according to Zerihun *et al.* (1989) and modified by Tamrat Bekel (1993).

Composite soil samples were collected from quadrates from where herbaceous vegetation was clipped for biomass estimation. The soil samples were collected from a depth of 0-10 cm for laboratory Physical and some chemical analysis. Moisture content was determined by gravimetric method. Measurement of Potential hydrogen (pH), Salinity, Electrical Conductivity (EC) and Moisture content were made by the method described by Juo (1978).

In each sampling plot, the probable source(s) of disturbance were recorded as reflected by actual presence of animals, their trails and droppings, the removal of plant material and soil due to animal grazing, browsing (hedging) and movement. Then, the levels of disturbance were recorded based on ordinal scale of 0-3 as described by Kumlachew Yeshitla and Tamrat Bekele (2002). The detail scale is: (0)- nil; (1)-low; (2)-moderate; (3)-heavy. Appropriate field notes were recorded on data sheet and photographs of particular interest were taken.

3.2.2. Vegetation Sampling

Reconnaissance survey and data collection field trips were made during December 2002 and September 2003. Based on the knowledge gained during the reconnaissance survey, attempts were made to sample from representative protected sites representing the region. Since the two rangelands are found in the two different agro-ecological sub-zones, they are considered as representing the protected rangelands of the MER areas. Systematically stratified random sampling design has been used in order to yield quantitative data that can be statistically analyzed. The number of sampling sites considered was dependant on the size and diversity of the range sites vegetation. A total of 65 and 50 relevés were considered from the Alagae and Neteli rangelands respectively. Since the two study sites are found in the different agro-ecological sub-zones of the region their vegetation classification were made separately.

Two dominant types of physiognomic formations (woodland and open field) were identified during the reconnaissance survey. These formations are also found to be under different management (treatments) in both rangelands. Thus, our sampling stratification was based on these features. In each of the four strata (two Woodlands/Grazing lands and two Open Grasslands/Hay fields) sampling transects were established along altitudinal gradient. The length of transects were variable depending on the size of homogenous vegetation unites. Adjacent transects were laid 100 – 200 m apart from each other and about 20 to 50 m away from: margins, roads, water points, permanent settlements and other infrastructures.

Following these transects grasses and other herbs were sampled from 1 m x 1 m quadrates, which were established at every 10 m interval in the open grasslands. In the woodlands, nested plots (of 20 m x 20 m for trees, 10 m x 10 m for shrubs and 1 m x 1 m for herbs) were established on a homogeneous stands. For proper representation of herbs in the nested plots, the 1m x 1m subplots were established at each corner and center. All species found within each plots were assessed for cover/abundance following the Zurich Montpelier method, using 1 – 9 modified Broun Blanquet (1932) scale (Maarel, 1979; cited in Zerihun Woldu, 1985). Cover/abundance is a semi-quantitative scale with qualitative intervals that the lower 4 scales estimate abundance (individuals per species) while the upper five scales refer to cover, in the plot. Each canopy layer is evaluated separately as described in Table 5. below.

Table5. A Table Showing the Cover/Abundance Scoring Method

Score	Description
1	*Rare-generally only one individual*
2	*Sporadic (few) –less than 5% cover of the total area*
3	*Abundant with less than 5% cover of the total area*
4	*Very abundant and less than 5% cover of the total area*
5	*5-12% cover of the total area*
6	*12.5-25% cover of the total area*
7	*25-50% cover of the total area*
8	*50-75% cover of the total area*
9	*75-100% cover of the total area*

3.2.3. Taxonomic Data Collection

Plant species in each quadrant were recorded and voucher specimens were collected following standard taxonomic method (Bridson and Forman, 1992). Identification was made both onsite with the help of Froman and Persson (1974) and published Flora volumes of Ethiopia and Eritrea (Edwards *et al.*, 1995, 1997, 2000; Hedberg and Edwards, 1989; Hedberg *et al.*, *1995,* 2003). Further confirmation and identification of specimens were made in ETH, Addis Ababa University, by the method comparison and with the help of ETH experts. Nomenclature follows the above-mentioned published Flora volumes of Ethiopia and Eritrea. All specimens collected and their full description are submitted to the ETH for incorporation.

3.2.4. Herbaceous Biomass Estimation

Biomass is usually determined by harvesting of plant material under investigation (Roberts et al., 1993). Sampling and measurement of herbaceous biomass was done by the common clipping method (Zerihun Woldu, 1985; Bonham, 1989; and Mannetje, 2000). Grasses and other herbaceous vegetation were clipped from randomly selected sub-quadrates of (0.25 m x

0.25 m) at the traditional harvesting height (about 5- 10 cm above ground) using sickle. The harvested plants were sorted into species and kept packed in labeled paper bags. The fresh herbage was air dried and then oven-dried at 80°C for 48 hrs (Whalley and Hardy, 2000) and finally re-weighed using a sensitive balance.

3.2.5. Range Condition Assessment

Range condition assessments were made by the scoring method (Tainton, 1981; and Baars *et al.*, 1996) as modified by Kuchar (1995) to suit for eastern Ethiopia rangelands (See appendix 1). The factors considered were: erosion, perennial grass, woody species and rock (yicib) abundance and cover, and animal signs (hedging, trailing and dung). These factors are all rated on a '0' to '4' point scale. It is more or less the rivers of the disturbance assessment given above and with a freedom to use part points (e.g. 2.4, 21/2). Grass species were classified into grazing indicators groups as classified by Du Plessis (1998). The details are presented in Appendix 1.

Weighting are applied as recommended by Kuchar (1995). The final range condition value is a number between 0 and 50 and is calculated by summing all the separate parameters with appropriate weighting (See Appendix 1). Lower numbers signify better range condition and higher numbers signify poorer condition. The final values that spread from 0 to 50 is apportioned into five equal five classes, representing very poor, poor, fair, good and very good condition. The fair and poor groups can be divided into an upper (Fa, Pa) and lower (Fb, Pb) group. The classes are:

- 0 – 10 Very good
- 10.1- 20 Good

- 20.1 – 30 Fair
- 30.1 – 40 Good
- 40.1 – 50 Very poor

Environmental factors that could possibly posed risk to range condition at landscape patch level are assessed qualitatively. The factors recorded include: soil and genetic erosion, unpalatable forbs cover, grass cover composition and grazing indicators, invading woody plant species and bush climax.

3.3. Data Analysis

Environmental data obtained from the study areas and secondary sources were analyzed by descriptive statistics. Range plant species dominance was assessed by plotting relative cover-abundance values. TWINSPAN (Hill, 1979) software was used to classify the vegetation data. The groups obtained were characterized as local community types and described as "type", which were provisionally characterized by dominating and/or characteristic species. A dominating species in this case is a species having higher mean cover/abundance value, mean frequency and mean cover-abundance (van der Maarel *et. al.*, 1979), and a characteristic species having a high mean cover-abundance value and fidelity in the types. The community types identified was further characterized by means of environmental factors, which appeared to be correlated to the floristic composition of the type.

One-way analysis of variance or ANOVA (from SPSS computer program) was performed to detect variation among different parameters. Parametric and nonparametric correlation coefficient calculated using SPSS is made to see the correlation of related variables.

Sorensen's similarity coefficient were calculated to analyze the effect of range management (land uses) and environmental factors on the plant diversity using the formula:

$$C_S = 2c/(2c+a+b)$$

Where: C_S Sorenson coefficient of similarity

'c' is the number of species shared by sites

'a' and 'b' are the number of species unique to each sites

The plant species diversity indices were calculated using the Shannon-Wieners diversity index that is calculated by:

$$H' = -\Sigma (Pi \times \ln Pi)$$

Where: H' = diversity index

Pi = proportion of individuals or the abundance of the 'i' th species expressed as a proportion of total biomass

ln = log base n (natural logarithm)

Species evenness was calculated using the Shannon Evenness Index that is calculated by the equation:

$$E = H' / H \max$$

Where: E = Evenness index

H max = ln S

H' = Shannon diversity index

ln S = the natural logarithm of the total frequency of species

S = total number of species

The variance and t-value of diversity indices were calculated following the formula as described by Magurran (1998).

$$\text{Var } H' = \frac{\Sigma pi (\ln pi)2 - (\Sigma pi \ln pi)2}{N} + \frac{S-1}{2N^2}$$

$$t = \frac{H'1 - H'2}{(\text{Var } H'1 + \text{Var } H'2)1/2} \qquad df = \frac{(\text{Var}H_1' + \text{Var } H_2')}{(\text{Var } H'_1)^2/N_1 + (\text{Var } H_2')/N_2}$$

A paired t-test also used for statistical comparison (test of significance difference) of different parameters.

IV. RESULTS

4.1. Environmental Information

Meteorological data obtained from the National Meteorological Agency of Ethiopia is used to construct the climatic diagram of the two study sites (figure 2). As the climatic diagrams diagram show that the Alagae has more or less good moisture distribution. While Alagae has higher soil moisture content, pH, Electrical Conductivity (EC) and Salinity, Neteli has only higher altitude and aspect (exposure to light) (Table 6). Soil moisture content and electrical conductivity of both study sites are significantly different from one another at 0.05 levels (Table 6). The pH results showed that soils of the Alagae rangeland are neutral (pH=7.02) and that of Neteli is slightly acidic (pH=6.61). Soil moisture content and pH values show significant correlation in both study sites. Table 7 and 8 provide the correlation results of the environmental variables in the two study sites.

Table 6. The Mean Values of Environmental Parameters and their Comparison by t-Test in the Two Study Sites

Environmental Parameters	*Alagae*		**Neteli**	
	Mean	*Standard Deviation*	Mean	Standard Deviation
Soil Moisture content (%)	*10.011*	*4.144*	2.0750	2.2302
PH	*7.024*	*.504*	6.6088	.1903
Electrical Conductivity (μs/cm²)	*305.546**	*177.91*	180.1313*	75.2536
Salinity (ppt)	*.124**	*6.98*	8.125E-02*	5.439E-02
Altitude (m a.s.l.)	*1623.78*	*193.30*	1725.8750	5.5242
Aspect (Exposure to light)	*1.83*	*1.08*	3.33	0.00
Disturbance	*1.07*	*0.75*	2.95	0.55

* Significant at the 0.05 level (2-tailed)

Table 7. Pearson Correlation of the Environmental Variables of the Alagae rangeland

	Moist. Cot.	*pH*	*Conductivity*	*Salinity*	*Altitude*	*Aspect*
pH	*-.21**					
Conductivity	*-.18*	*.68***				
Salinity	*-.19*	*.49**	*.82***			
Altitude	*.06*	*.01*	*.08*	*.09*		
Aspect	*.36**	*.31**	*-.02*	*-.04*	*.15*	
Disturbance	*.10*	*.43**	*.40**	*.44**	*.01*	*-.06*

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Table 8. Pearson Correlation of the Environmental Variables of the Neteli Rangeland

	Moist. Cot.	*pH*	*Conductivity*	*Salinity*	*Altitude*
PH	*-.44*				
Conductivity	*.51**	*-.15*			
Salinity	*.01*	*.04*	*.54**		
Altitude	*-.26*	*.17*	*-.320*	*-.01*	
Disturbance	*.28*	*-.29*	*-.04*	*.11*	*.27*

* Correlation is significant at the 0.05 level (2-tailed).

* * Correlation is significant at the 0.05 level (2-tailed)

4.2. Floristic Composition

Species richness refers to the total number of species found in a given area. A total of 213 species of plants representing 143 genera and 40 families were recorded from the study areas (See Appendix 2, for the complete list). Of these 72 (33.64%) were *Poaceae*, 32 (14.95%) *Fabaceae* and 18 (8.41%) were *Asteraceae*. Table 9 provides the families represented by three or more species and their proportion. There were about 137 naturally growing species per study sites. There were a total of 153 species in Alagae and 121 in Neteli rangelands. In addition to these about 20 exotic species are recorded in the Alagae rangeland.

Species richness is the simplest measure of diversity regardless of density and proportional representation of individuals. In terms of simple species richness, Alagae is slightly higher than Neteli. In terms of the major structural groups, Alagae is trees and shrubs dominated

(57.52%) and Neteli is significantly herb dominated (71.9%). Figure 3 shows the proportion of the different structural groups.

Table 9. List of the Families Represented by Three or More Species in the Study Sites

No.	Family	No. of species	Percentage
1.	*Poaceae*	*72*	*33.64*
2.	*Fabaceae*	*32*	*16.29*
3.	*Asteraceae*	*18*	*8.41*
4.	*Cyperaceae*	*7*	*3.27*
5.	*Malvaceae*	*6*	*7.47*
6.	*Myrtaceae*	*6*	*7.47*
7.	*Solanaceae*	*4*	*1.40*
8.	*Boraginaceae*	*4*	*1.40*
9.	*Moraceae*	*4*	*1.40*
10.	*Anacardiaceae*	*4*	*1.40*
11.	*Acanthaceae*	*3*	*2.81*
12.	*Capparidaceae*	*3*	*2.81*
13.	*Convolvulaceae*	*3*	*2.81*
	Others families with 2 or 1 species	*48*	*22.43*
	Total	*213*	*100.00*

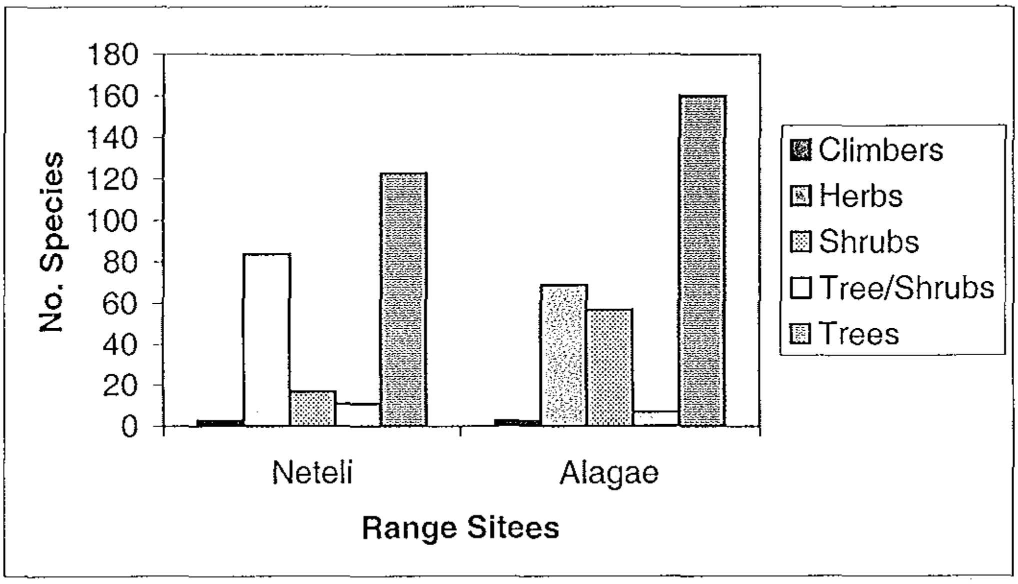


Figure 3. Bar Chart Showing the Proportion of the Different Structural Groups

Based on the congruence of naturally occurring species composition, the two study sites are found to have more species (>50 % similarity) and families (>40 % similarity) in common. The Sorenson similarity coefficient of two taxa is given in Table 10.

Table 10. Table Showing the Level of Similarity Between the Two Study Sites Based on Species Composition

Taxa	Alagae	Neteli	Species in common	Unique to Alagae	Unique to Neteli	Sorenson coefficient of similarity
Species	*153*	*121*	*72*	*66*	*47*	*0.554 (55.4%)*
Families	*37*	*30*	*26*	*9*	*3*	*0.406 (40.6%)*

Perhaps, a better way of expressing diversity is using diversity indices. Table 11 shows the species richness, diversity and evenness indices of the four range sites and the overall of the two study areas.

Table 11. Species Richness, Diversity and Evenness Indices of the Range-sites

Rangelands (Sites)	*Species Richness*	*Shannon-Wiener Index (H`)*	*Simpson Evenness (E)*
Algae Grazing land	*57*	*4.87*	*0.97*
Alagae Hay field	*64*	*2.97*	*0.71*
Alagae Over-all	*99*	*3.83*	*0.83*
Alagae Grazing Land	*35*	*3.18*	*0.89*
Neteli Hay field	*47*	*2.21*	*0.57*
Neteli Over-all	*87*	*3.69*	*0.83*

Evenness indices are only one way of assessing the opposite side of diversity, species dominance. The relative representation of species abundance is better seen from abundance plots (Magurran 1998). There were less than fifteen species that have relative Frequency (abundance) value greater then two in both rangelands. Figure 4 shows the dominance plots of the two study sites and the list of top twelve dominate species and their importance value (mean abundance and biomass) are provided in Table 12.

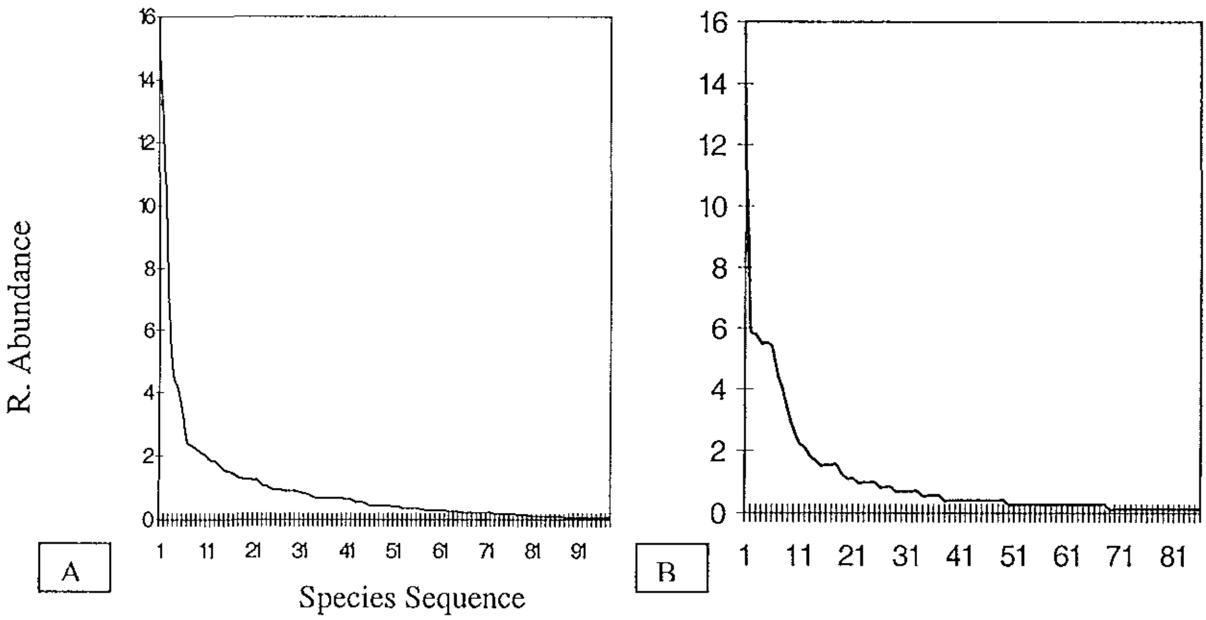
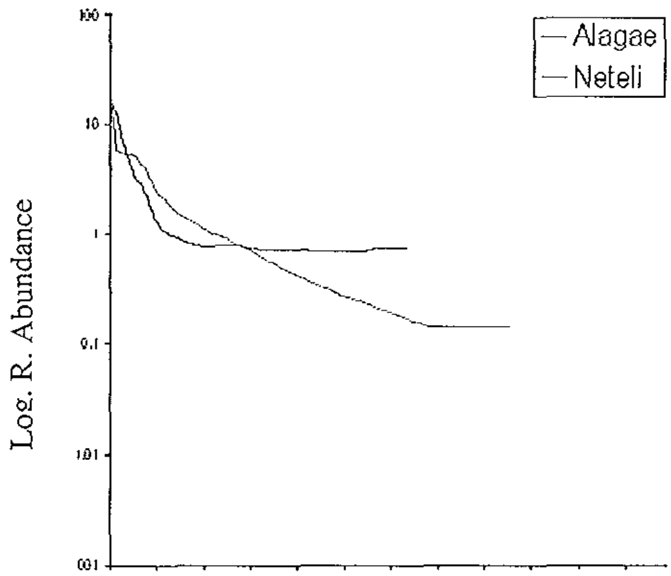


Figure 4. Rank Abundance Plot of Identified Species Arranged in Decreasing Order of Relative Abundance: A. Alagae B. Neteli (the top twelve species are given in table 12.)

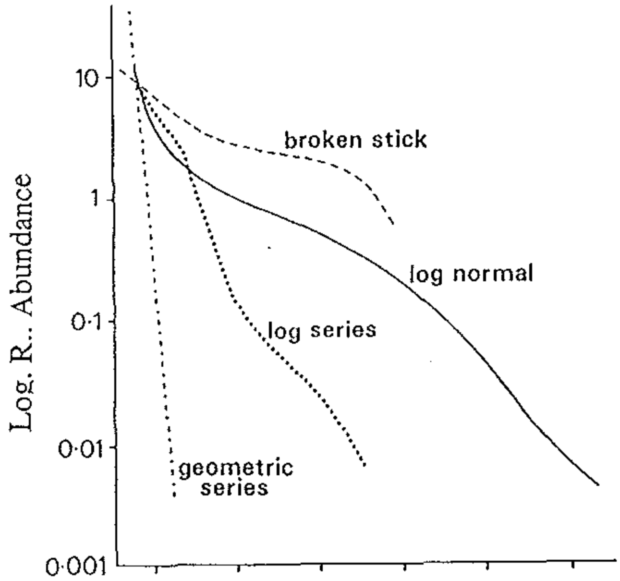
Table 12. List of the Top Twelve (High Relative cover-abundance) Ranked Species of the Study Sites in Descending order

NO.	**Neteli Rangeland**	**Alagae Rangelands**
1.	*Bothriochloa insculpta*	*Hetropogon contortus*
2.	*Cynodon dactylon*	*Eragrostis tenuifolia*
3.	*Hyparrhenia anthistirioides*	*Eragrostis heteromera*
4.	*Hyparrhenia hirta*	*Harpachne schimperi*
5.	*Hyparrhenia rufa*	*Dactyloctenium aegyptium*
6.	*Hyparrhenia anamesa*	*Acacia tortilis*
7.	*Glycine wightii*	*Eleusine indica*
8.	*Themeda triandra*	*Aristida kenyensis*
9.	*Hyparrhenia nyassae*	*Panicum subalbidum*
10.	*Heteropogon contortus*	*Aristida adoensis*
11.	*Indigofra sp.*	*Sporobolus pyramidalis*
12.	*Dactyloctenium aegyptium*	*Hyparrhenia hirta*

Although species abundance data is frequently described by distributions, diversity is usually examined in relation to four main models (Magurran, 1998; Kent and Coker, 1993). These models are: the geometric series; the log normal distribution; the logarithmic series, and Mac Arthur's broken stick model. These models explain the progressively higher evenness of diversity respectively. In all models, plots are made on a logarithmic scale. Figure 5. is used to shows the log. abundance curve of the two rangelands (4.A) and for comparison the typical appearance of the four models (B).



Species Sequence



Species Sequence

Figure 5. Plots Showing Abundance Curve of: A. The Two Rangelands B. Typical shape of the Four Models (Kent and Coker, 1992; Magurran, 1998)

As a worldwide major threat of rangelands, species recorded in the study sites were screened against lists of invasive alien plants in Ethiopia and else where in Africa. There were 17 species that are considered invader/encroacher due to their biological characteristics (Table 13.) and recorded in either or both of the study sites.

Table 13. List of Invasive / Encroaching Species Recorded from the Study Sites

No.	*Species*	*Alagae*	*Neteli*	*Status and History*	*Source*
1	Acacia brevispica	++	+	Encroaching, Native	3
2	*A. melanoxylon*	+		Normal, Introduced	*1*
3	*Achyranthes aspera*	++	++	Invading, native	2
4	*Datura stramonium*	+		Weed of farmlands, Native	1
5	*Dichrostachys cinerea*	++	+	Encroaching, Native	2
6	*Eucalyptus* spp. *(4-species)*	+		Normal, Introduced	1
7	*Jacaranda mimosifolia*	+		Normal, Introduced	1
8	*Lantana camara*	+		Normal, Introduced	2
9	*Lucaena leucocephala*	+		Normal, cultivated as fodder plant	1
10	*Prosopis juliflora*	+		Normal, Introduced as honey-bee fodder	2
11	*Ricinus communis*	+		Farm Weed, Introduced as honey-bee fodder	1
12	*Solanum incanum*	+	++	Encroaching, Native	1
13	*Solanum nigrum*	+	+	Normal, Native	1
14	*Nicandra pasaloides*		++	Encroaching, Native	3
15	*Tagetes minuta*	+	+	Encroaching, Native	2
16	*Xanthium strumarium*	++		Encroaching, Native	2
17	*Sorghum arundinaceum*	++		Invading, Introduced as forage grass	3

Key: +Present with low abundance; ++ found invading or encroaching

Source: 1 = Anon (1995), 2 = Desalegn Disissa and Benggli (2003), 3 = Personal observation

4.3. Vegetation Classification

Based on the TWINSPAN output and ecological evaluation, seven community types were identified from Alagae and six communities types from Neteli. The communities were identified at the third level of the relevés groupings. All the communities identified in the two rangelands are named after the dominant and/or character species and labeled with Roman and Arabic numerals respectively. The relation between environmental variables and the local communities are given in appendix 4. Descriptions of the communities found in the two study sites are given below.

4.3.1. Community Types of the Alagae Rangeland

From the two-way structured table of the TWINSPAN out put (Appendix 5) seven communities and residual plots are easily being identifiable. Dominant and/or character species are used to name communities (See Table 14.). Descriptions of the communities are as follow:

Community I: ***Capparis tomentosa – Achyranthes aspera*** **Type**

It is a community found at altitude of about 1671m a.s.l. The dominant woody species of the community are: *Capparis tomentosa, Maytenus senegalensis, Dovyalis abyssinica, Ricinus communis* and *Acacia tortilis* in the tree shrub layer and *Ehretia cymosa, Guizotia abyssinica,* and *Aloe elegans* in the shrubby layer. *Datura stramonium* and *Sporobolus festivus* are common associated species found in the herbaceous layer. This community is a type of pure woodland vegetation.

Community II: ***Acacia senegal – Dichrostachys cenarea Type***

It is a community found at altitude 1675m a.s.l. The dominant woody species are: *Acacia brevispiaca, Balanites aegyptica, Acacia senegal, Croton macrostachys, Dichrostachys cinerea,* in the tree-shrub layer; *Asparagus setaceus, Hibiscus cannabinus, Flueggea virosa, Hygrophila auriculata, Jasminum grandiflorum, and Launaea intybacea* in the shrub layer. The herb layer was inhabited by: *Heteropogon contortus, Sporobolus ioclados, Aristida adoensis, Digitaria ternata, Eleusine floccifolia, Eragrostis papposa, Sporobolus palluicidus,* and *Themeda triandra.*

Community III: ***Acacia Brevispica – Sporobolus consimilis*** **Type**

This community is found at altitude 1508m a.s.l. It is dominated by the population of: *Sporobolus consimilis, Digitaria abyssinica, Bothriochloa insculpta, Digitaria velutina, Eragrostis papposa, and Heteropogon contortus.* While *Stylosanthes fruticosa* and *Bidens sp.* are common low-shrubs, *Acacia brevispica, Acacia abyssinica* and *Dichrostachys cinerea* are the only associated woody species.

Community IV: ***Acacia tortilis – Chloris virgota*** **Type**

This community is found at altitude of about 1635m a.s.l. *Acacia tortilis* is the only tree species in this community. The dominant grass species are: *Sporobolus confines, Eragrostis cilianensis, Dactyloctenium aegyptium, Sporobolus festivus, Cenchrus ciliaris, Sporobolus pyramidalis, Eleusine africana,* and *Hyparrhenia anthistirioides* with a more or less decreasing importance. *Kalanchoe lanceolata* and *Tagetes minuta* are common associated forbs. Thus, it is a community of the open grassland, which is associated with sparsely found *Acacia tortilis* trees, the only woody species.

Community V: ***Heteropogon contortus – Themeda triandra*** **type**

This community is found at altitude of about 1683m a.s.l. The dominant species are: *Hyparrhenia rufa, H. nayassea, Sporobolus pyramidalis, Themeda triandra,* and *Glycine wightii of the herb layer,* with decreasing importance. Other common grasses are: *Dactyloctenium aegyptium Cynodon* spp., *Digitaria abyssinica, Heteropogon contortus, S. pyramidalis, S. consimilis, S. ioclados, and S. pallucidus.* Thus, it is grasses and forbs dominated community.

Community VI: ***Acacia tortilis – Sporobolus pyramidalis*** **type**

It is found at altitude of about 1650m a.s.l. The dominant species are grasses: *Hyparrhenia anamesa, H. hirta, Eleusine indica, E. floccifolia, Aristida adoensis, Sorghum arundinaceous, Digitaria ternata, Eragrostis papposa,* and *Panicum maximum* with decreasing importance. *Achyranthes aspera* and *Sonchus* sp. are common associated forbs. It is a community type of the open grassland.

Community VII: ***Hyparrhenia hirta – Bothriocloa insculpta*** **type**

This community is found at altitude of about 1650m a.s.l. In this community, *Bothriochloa insculpta, Cynodon dactylon,* and *Hyparrhenia hirta* are dominant grass species. The common associated grasses are *Cynodon dactylon* and *Hyparrhenia* spp. *and Cyperus longus; Glycine wightii* and *Indigofra* sp. are sedge and forbs members of this community. Thus, it is a purely open field type of vegetation.

Table 14. Synoptic Table of the Alagae Vegetation with Diagnostic Species Having High Mean Cover Abundance Value and Fidelity

Species	Community						
Community	I	II	III	IV	V	VI	VII
Cluster Size	7	15	15	7	7	7	7
Capparis tomentosa	**4.00**	0.00	0.00	0.00	0.00	0.00	0.00
Datura stramonium	**3.67**	0.00	0.00	0.00	0.00	0.00	0.00
Maytenus senegalensis	**3.00**	0.00	0.00	0.00	0.00	0.00	0.00
Ehretia cymosa	**3.00**	0.00	0.00	0.00	0.00	0.00	0.00
Achyranthes aspera	**4.43**	0.00	**3.00**	0.00	1.00	**3.14**	0.00
Balanites aegyptica	**4.00**	**3.50**	0.00	**3.00**	0.00	0.00	0.00
Croton macrostachys	0.00	**4.00**	0.00	0.00	0.00	0.00	0.00
Acacia Senegal	0.00	**4.00**	0.00	0.00	0.00	0.00	0.00
Senna didymobotria	0.00	**2.50**	0.00	0.00	0.00	0.00	0.00
Senna occidentalis	0.00	**2.00**	0.00	0.00	0.00	0.00	0.00
Heteropogon contortus	0.00	**2.89**	**1.80**	0.00	0.00	0.00	0.00
Aloe elegans	**3.67**	**7.00**	**2.50**	0.00	0.00	0.00	0.00
Dichrostachys cinerea	0.00	**4.08**	**4.00**	0.00	0.00	0.00	0.00
Acacia abyssinica	0.00	**3.00**	**5.00**	0.00	0.00	0.00	0.00
Acacia brevispica	0.00	**2.50**	**5.00**	0.00	0.00	0.00	0.00
Sporobolus consimilis	0.00	0.00	**7.00**	0.00	0.00	0.00	0.00
Digitaria abyssinica	0.00	0.00	**2.00**	0.00	1.67	1.00	0.00
Acacia seyal	0.00	**5.00**	**4.00**	**4.00**	**3.00**	0.00	0.00
Chloris virgota	0.00	1.50	1.90	**7.00**	0.00	0.00	0.00
Digitaria sp	0.00	0.00	0.00	**1.00**	0.00	0.00	0.00
Cyperus longus	0.00	0.00	1.67	**3.50**	**3.00**	0.00	2.00
Kalanchoe lanceolata	0.00	0.00	2.50	**3.40**	**5.00**	0.00	0.00
Eragrostis cilianensis	0.00	1.50	2.00	**1.60**	**4.00**	0.00	0.00
Acacia tortilis	2.00	0.00	0.00	**3.75**	**2.00**	**3.50**	0.00
Themeda Triandra	0.00	2.33	0.00	0.00	**3.67**	1.00	0.00
Hyparrhenia nayasae	0.00	0.00	0.00	0.00	**3.30**	0.00	0.00
Sporobolus palluicidus	0.00	1.80	1.67	0.00	**2.50**	0.00	0.00
Sporobolus ioclados	0.00	0.00	1.33	0.00	**2.50**	0.00	0.00
Hetropogon contortus	0.00	0.00	0.00	0.00	**2.00**	0.00	0.00
Eleusine floccifolia	0.00	2.33	2.00	0.00	**3.00**	**2.80**	0.00
Hyparrhenia anamesa	0.00	0.00	0.00	0.00	**3.00**	**3.57**	**5.12**
Bothriochloa insculpta	0.00	3.00	1.90	0.00	**3.29**	1.00	**5.00**
Sporobolus pyramidalis	0.00	0.00	2.00	2.00	2.17	**3.75**	0.00
Eleusine indica	0.00	0.00	0.00	0.00	0.00	**2.63**	0.00
Sorghum arundinaceum	0.00	0.00	2.00	0.00	0.00	**3.00**	0.00
Hyparrhenia hirta	0.00	0.00	0.00	0.00	0.00	1.50	**4.33**
Hyparrhenia rufa	0.00	0.00	0.00	0.00	**4.20**	1.50	**5.50**
Hyparrhenia nyassae	0.00	0.00	0.00	0.00	0.00	1.00	**3.00**
Terannus labialis	0.00	0.00	0.00	0.00	0.00	0.00	1.50

4.3.2. Community Types of the Neteli Rangeland

Based on the TWINSPAN output it was possible to identify six clusters (noda) at level three of the relevés groupings (Appendix 6). After careful scrutiny, the six clusters are identified as local communities types. Communities are numbered 1 – 6, and named after the dominant and/or characteristic species. The descriptions of communities are as follow:

Community 1: ***Hyparrhenia anthistirioides – Eleusine indica*** **Type**

This community is found at an altitude of about 1730m a.s.l. The dominant species in this community are: *Eleusine indica, Hyparrhenia anthistirioides, Aristida adoensis, Tagetes minuta* and *Hypoestes vorticillaris* with a more or less decreasing importance. The common associated grass species are: *Heteropogon contortus, Aristida adoensis, Sporobolus pyramidalis, S. spicatus, Panicum maximum* and *P. subalbidum, Tagetes minuta, Pluchia ovalis and Mareua angolensis* are the only sedge; and *Brucea antidysenterica* and *Capparis fascicularis* are associated woody members.

Community 2: Croton macrostachys – Eragrostis tenuifolia Type

This community is found at an altitude of about 1722m a.s.l. Chloris pycnothrix and *Cyperus* spp. are the only characteristic grass and sedge species of the community. Though they have cosmopolitan (none preferential) nature *Dactyloctenium aegyptium, Harpachne schimperi* and *Heteropogon contortus, Cynodon dactylon* and *Eragrostis tenuifolia* are very common grasses of this community. *Croton macrostachys* and *Mareua angolensis* are the only woody species found in this community.

Community 3: Cynodon dactylon – Digitaria abyssinica type

This community is found at altitude of about 1725m a.s.l *Cynodon dactylon* and *Digitaria abyssinica* appear to be characteristic species with good fidelity. *Sporobolus spicatus, Urochloa panicoides, Aristida kenyensis* are common grasses and *Cynoglossum* sp.; *Kalanchoe lanceolata* and *Aspilia mossambicensis* are associated forbs identified.

Community 4: ***Maytenus senegalensis - Bothriochloa insculpta*** **type**

This community is found at an altitude of about 1727m a.s.l. The dominant species in this community are: *Acacia tortilis and Maytenus senegalensis* in the woody layer; Forbs like: *Pappea capensis, Crotalaria laburnifolia, Glycine wightii, Indigofra dendroides;* and grasses like: *Bothriochloa insculpta, Eragrostis papposa, Heteropogon contortus, Hyparrhenia rufa, Harpachne schimperi.*

Community 5: *Capparis fascicularis – Acokanthera schimperi* type

This community is found at an altitude of about 1730m a.s.l. The dominant species in this community are: *Capparis fascicularis* and *Cordia ovalis* of the woody layer; *Ehretia cymosa, Flueggea virosa* and *Heteropogon contortus*. Other common species include: *Acacia tortilis, Carissa spinarum, and Acokanthera schimperi* in the woody (tree-shrub) layer; *Crotalaria laburnifolia, Solanum nigrum, Hypoestes forskaoli, and Bidens* sp. are common in the bushy layer; and Aristida *kenyensis, Cynodon dactylon, Eragrostis cilianensis, E. heteromera, Harpachne schimperi, Hyparrhenia dregeana, H. hirta,* and *Setaria incrassate* are common grasses in the community.

Community 6: ***Acacia – Balanites aegyptica*** **type**

This community is found at an altitude of about 1721m a.s.l. The dominant species Include: *Acacia abyssinica, Acacia albida, A.senegal, Acacia tortilis, Balanites aegyptica, Ziziphus* spina-christi and *Capparis fascicularis* in the tree-shrub layer: *Hypoestes vorticilaris, Ocimum urticifolium, Pluchia ovalis, Sida alba, Solanum nigrum* and *Oxygonum sin*uatum are among the forbs; and: *Cynodon dactylon, Dactyloctenium aegyptium, Digitaria abyssinica, Hyparrhenia anamesa, Sporobolus pallucidus*, and *Urochloa panicoides* are among the common grasses.

Table 15. Synoptic Table of the Neteli Vegetation with Diagnostic Species Having High Mean Cover Abundance Value and Fidelity

Species	Community					
	1	2	3	4	5	6
Cluster Size	7	18	7	3	7	7
Hyparrhenia anthistirioides	**1.70**	0.00	0.00	0.00	0.00	0.00
Eleusine indica	**3.00**	1.00	0.00	0.00	0.00	0.00
Tagetes minuta	**3.00**	1.00	0.00	0.00	0.00	0.00
Maerua angolensis	**1.50**	1.00	1.00	1.00	0.00	0.00
Chloris pycnothrix	0.00	**1.60**	0.00	0.00	0.00	0.00
Chloris virgota	0.00	**2.00**	0.00	0.00	1.00	0.00
Croton macrostachys	0.00	**3.00**	0.00	0.00	0.00	0.00
Eragrostis cilianensis	0.00	**2.00**	0.00	0.00	1.60	0.00
Xanthium strumarium	0.00	**2.00**	0.00	0.00	0.00	0.00
Entada abyssinica	0.00	**1.50**	0.00	0.00	0.00	0.00
Nicandra physaloides	1.00	1.00	**2.00**	0.00	0.00	0.00
Digitaria abyssinica	0.00	0.00	**2.00**	0.00	0.00	1.00
Setaria pumila	0.00	0.00	1.00	0.00	0.00	0.00
Kalanchoe lanceolata	0.00	0.00	1.00	0.00	0.00	0.00
Aspilia mossambicensis	0.00	0.00	1.00	0.00	0.00	0:00
Bothriochloa insculpta	0.00	1.00	0.00	**3.00**	0.00	1.00
Glycine wightii	0.00	1.00	0.00	**2.00**	0.00	0.00
Maytenus senegalensis	0.00	0.00	0.00	**2.00**	0.00	0.00
Commicarpus plumbagineus	0.00	0.00	0.00	1.00	0.00	0.00
Hyparrhenia rufa	0.00	1.00	0.00	1.00	0.00	0.00
Cissus quadrangularis	0.00	0.00	0.00	1.00	0.00	0.00
Eragrostis papposa	1.00	1.00	0.00	**2.00**	**3.00**	0.00
Capparis fascicularis	1.00	0.00	0.00	0.00	**2.00**	1.00
Panicum maximum	1.00	0.00	1.00	0.00	**2.00**	0.00
Hyparrhenia hirta	0.00	1.00	0.00	0.00	**2.00**	0.00
Solanum incanum	0.00	0.00	0.00	0.00	**2.00**	0.00
Acokanthera schimperi	0.00	0.00	0.00	0.00	**1.50**	0.00
Acacia tortillis	0.00	0.00	0.00	**2.00**	**2.00**	**3.50**
Urochloa panicoides	1.00	**2.00**	1.00	1.00	0.00	**3.00**
Sporobolus pallucidus	0.00	0.00	0.00	0.00	0.00	**3.30**
Balanites eagyptica	0.00	0.00	0.00	0.00	0.00	**2.00**
Sida alba	0.00	0.00	0.00	0.00	0.00	**2.75**
Pappea capensis	0.00	0.00	0.00	1.00	0.00	**2.60**
Ocimum urticifollium	0.00	0.00	0.00	0.00	0.00	**2.00**
Acacia albida	0.00	0.00	0.00	0.00	0.00	**2.00**
Acacia senegal	0.00	0.00	0.00	0.00	0.00	**2.00**
Ziziphus spina-christi	0.00	0.00	0.00	0.00	0.00	1.00
Blepharis integrifolia	0.00	0.00	0.00	0.00	0.00	1.00
Sporobolus confines	0.00	0.00	0.00	0.00	0.00	1.00

4.4. Estimation of Herbaceous Biomass Production

According to Digby and Kempton (1987) vegetation classification has one very practical function that is to serve as a basis of inventory and mapping. This can be an objective either by itself or as a basis for management planning. This is present in all the traditional systems of classification, and at its most empirical represents a convenient partition of a range of variation, which may or may not be continuous. Rangelands are usually classified in to different range sites and management is based on this classification (Heady, 1975; Kuchar 1995). Thus, to make our discussion in line with the practical situation herbaceous biomass and range condition assessment results are treated following the range site classification approach.

The herbaceous biomass (total above ground herbaceous dry weight production) of the two study sites was estimated by averaging two-subsequent years (2003 and 2004) peak production. There was 448.61 g /m^2 (4.486 T/h) average peak dry weight production in the two rangelands as a whole (Table 16.).

Table 16. Herbaceous Biomass Production of the Study Sites

Range Sites	*Mean dry weight (g/m^2)*
Alagae Hay Field	*579.58 $\pm$ 16.31*
Alagae Grazing land	*439.50 $\pm$ 25.97*
Neteli Hay Field	*453.03 $\pm$ 21.75*
Alagae Hay Field	*322.31 $\pm$ 24.78*
Overall mean (Total)	*448.61 $\pm$ 11.22*

The Peak herbaceous dry weight production of the four range sites was compared by a multivariate comparison (Table 17.) and the result of homogeneity test is presented in Table 18.

Table 17. Multiple Comparisons of Range Sites in terms of Herbaceous Biomass Production

		Mean Difference (I-J)	Std. Error	Sig.	95%	Confidence Interval
(I) GROUPING	(J) GROUPING				Lower Bound	Upper Bound
AHF	AGL	140.08	76.47	.35	-79.15	359.31
	NOG	126.55	67.96	.33	-68.29	321.39
	NGI	257.27*	74.34	.01	44.15	470.39
AGL	AHF	-140.08	76.47	.35	-359.31	79.14
	NHF	-13.53	84.41	.99	-255.52	228.46
	AGL	117.19	89.62	.64	-139.74	374.13
NGL	AHF	-126.55	67.96	.33	-321.39	68.28
	NHF	13.5312	84.41	.99	-228.46	255.52
	AGL	130.72	82.49	.48	-105.75	367.20

* The mean difference is significant at the .05 level

N.B: *Dependent Variable: Dry-weight; Statistics: Scheffe; and Comparison is based on observed means.*

Table 18. Homogeneity Test of the Range sites Herbaceous Dry Weight Production

		Subset	*Subset*
	GROUPING	*1*	*2*
Duncan	*NGL*	*322.31*	
	AGL	*439.50*	*439.50*
	NHF	*453.03*	*453.03*
	AHF		*579.58*
	Significance	*0.12*	*0.10*

- Alpha = .05.

It was clear form the outset that grasses have the highest relative frequency and could contribute the lion share of the herbaceous biomass production in both the rangelands. Table 19. shows the proportion of the different vegetation groups that contribute for the herbaceous dry weight production.

Table 19. Proportion of Major Functional (Dry-weight Contributing) Groups of Herbs

	AGL	AHF	NGL	NHF
Grasses	*77.26*	*92.29*	*80.23*	*3.55*
Sedges	-	-	-	*1.91*
H. Legumes	*1.73*	*1.95*	-	*6.24*
O. Herbs	*21.01*	*5.76*	*19.77*	*12.46*

Dry weight contribution is only one factor that needs due consideration in assessing the importance of a species. Knowing the ecological and agricultural significance of the species (group of species) is very important for proper understanding the value of a rangeland vegetation unit. From the agricultural point of view, it is clear that not all grasses are equally important for grazing animals. Thus, looking for their composition in relation with grazing pressure will be important. Table 20 shows important (high cover-abundance and Biomass contributing) grass species of the four range sites based on their abundance and dry weight contribution.

Table 20. The top Fourteen Important Grasses of the Four Range Sites and their Responce to Grazing

NO.	*Scientific Name*	*AGL*	*AHF*	*NHF*	*NGL*	*GRAZING REACTION*
1.	*Hyparrhenia nyassae*		*10.65*	*1.72*	*1.92*	*Decreaser*
2.	*Hyparrhenia hirta*		*5.37*	*4.38*	*2.55*	*Decreaser*
3.	*Hyparrhenia rufa*		*4.88*	*2.03*		*Decreaser*
4.	*Hyparrhenia anthistirioides*	*12.55*	*4.71*	*3.34*		*Decreaser*
5.	*Hyparrhenia anamesa*		*3.36*		*6.50*	*Decreaser*
6.	*Panicum subalbidum*		*3.31*	*5.76*		*Decreaser*
7.	*Cynodon dactylon*	*12.10*	*10.45*	*6.63*	*13.29*	*Increaser*
8.	*Bothriochloa insculpta*	*12.01*	*9.83*	*3.68*	*1.77*	*Increaser*
9.	*Dactyloctenium aegyptium*	*6.93*	*3.51*	*4.34*	*2.23*	*Increaser*
10.	*Eragrostis tenuifolia*	*9.50*	*1.29*	*2.80*	*7.48*	*Increaser*
11.	*Hetropogon contortus*		*2.70*	*7.73*	*6.97*	*Increaser*
12.	*Digitaria abyssinica*	*4.63*	*1.84*			*Invader*
13.	*Eleusine indica*			*6.68*	*4.11*	*Invader*
14.	*Harpachne schimperi*			*4.85*	*6.25*	*Invader*

4.5. Range Condition Assessment

Range condition as the status of range sites is evaluated in both quantitative and qualitative terms. The average rating and the qualitative expressions of the four range sites are presented in Table 21.

Table 21. A Table Showing the Summary Result of the Range Condition Assessment

Major Parameter	*Sub parameter*	*Weighted Av. Score*			
		Alagae		*Neteli*	
		Wood land	*Open Field*	*Open Field*	*Woodland*
Soil surface	*Erosion*	*0.62*	*0.00*	*1.78*	*1.03*
	Litter	*4.00*	*2.25*	*3.34*	*2.85*
Grass layer	*Grass Abundance*	*19.68*	*1.88*	*13.78*	*13.73*
	Grass Cover	*2.08*	*5.00*	*1.81*	*1.35*
Woody layer	*Woody Cover*	*0.00*	*3.00*	*4.5*	*24.00*
	Hedging	*5.38*	*0.44*	*1.67*	*1.88*
Animal signs	*Trailing*	*1.54*	*0.56*	*0.57*	*0.08*
	Dung	*0.92*	*0.50*	*0.22*	*0.13*
Total Score		*34.22*	*13.63*	*27.67*	*45.045*
Range Condition		**Poor (P1)**	**Good**	**Fair (F2)**	**Very poor (VP1)**

As the results above have shown there is some correlation between the range condition of sites and herbaceous biomass production. Thus, both the parametric and nonparametric tests revels the strongly significant correlation between range condition rating and herbaceous biomass production. Table 22 provides the two correlation results.

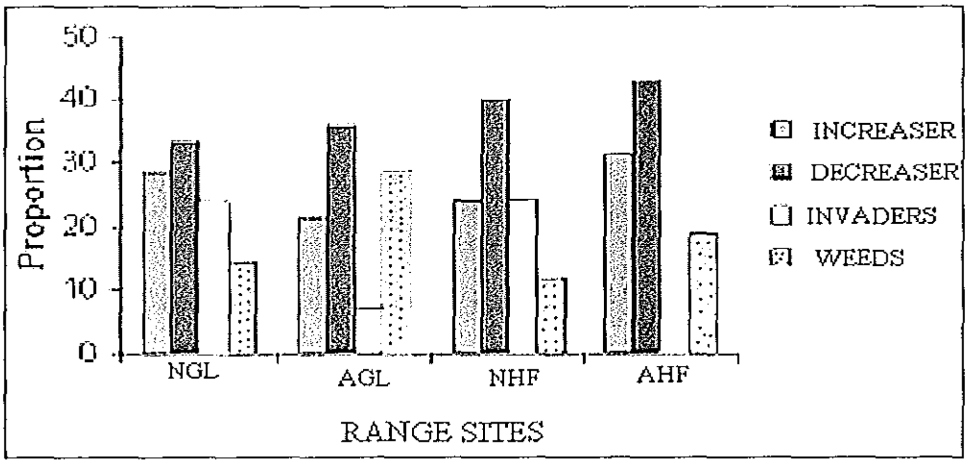


Figure 6. A Bar Graph Showing the Proportion Important Grass Grouped Based on their Reaction to Grazing

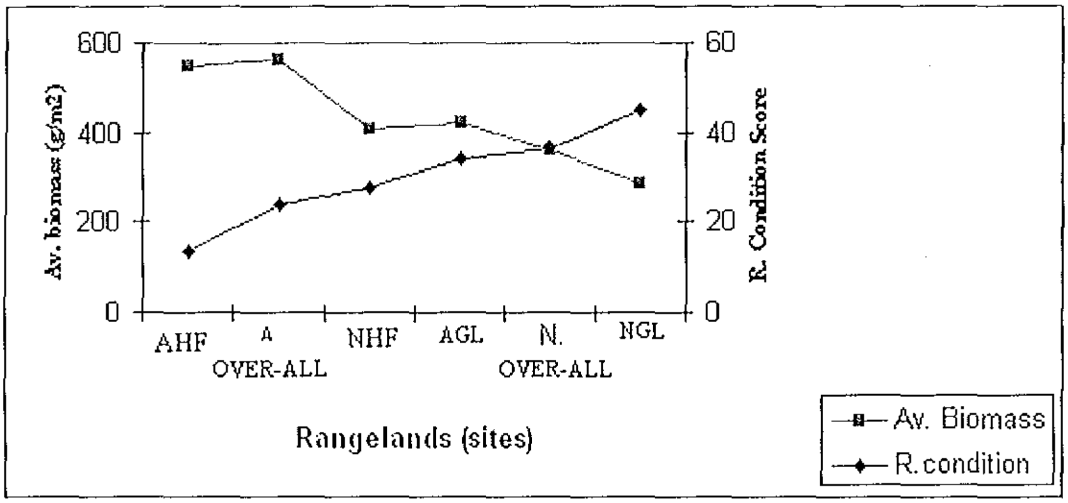


Figure 7. A Plot showing the Inverse Relationship between Herbaceous Biomass Production and Range Condition Assessment Score

To make prediction of one parameter using the other possible it is preferable to see their correlation results by curve fitting. Perhaps, it is reasonable to see which curve best explains the observed relationship between range condition assessment and herbaceous biomass production. The relationship between biomass and range condition (inverse of the condition score, i.e. 50- score) look like quadratic curve than the logarithmic (Figure 8.)

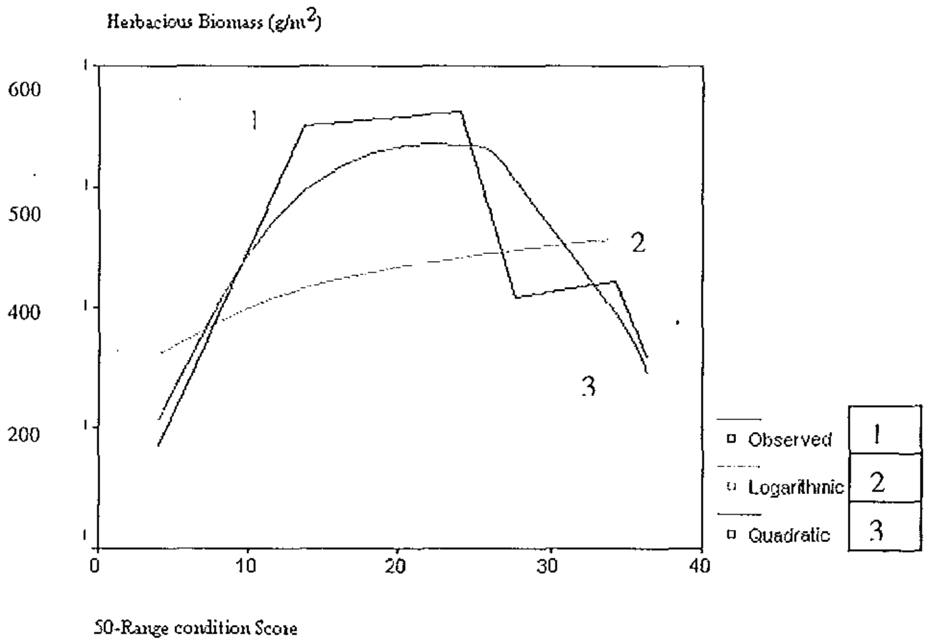


Figure 8. A Figure Showing the Curve Fitting Result of the Relationship Between Herbaceous Biomass and Range Condition

V. DISCUSSION

5.1. Floristic Composition

Though there are different recommended diversity and evenness indices, most discussions are based on species richness (Kent and Coker, 1992). From the results of this study, it is possible to say that the MER in general and the protected and/or managed rangelands in particular are rich in floristic diversity. About two-third of the species, mostly trees and shrubs, recorded by Zerihun Woldu and Mesfin Tadesse (1990) are found in the study sites. The total number of species the recorded in this study is also found to be comparable, if not superior, to the major forests of the country. This observation is in line with the assertion that states 'drylands are not far less diverse than rain forests' (Blench and Sommer, 1999). That is to say, dry areas are not necessarily floristically dry.

In terms of both diversity and evenness, the woodlands of the two study sites are superior to the open grasslands. This might be associated with the greater impact of grazing and/ or management actions that deter the succession of grasslands. In both rangelands, the open fields are mainly used for hay production and aftermath grazing. Thus, trampling by human and grazers, mechanized harvesting as well as removal of forbs (weeding) could certainly reduce the floristic diversity by destroying forbs and tree seedlings. The very high diversity and evenness of the Alagae Grazing land is therefore associated with less exposure to grazing and disturbance. The The logarithmic species abundance plot of the study sites look like either the logarithmic, or the Mac Arthur's broken stick model (figure 4.2). The latter model is supposed to represents the highest evenness ever observed in natural communities (Magurran, 1998). Thus, the study sites 'approach', if not achieved, the maximum species evenness and can be called more or less natural.

At present the vegetation of the study, sites are generally unique in the MER area (see color plate 1 and 2), and perhaps, their natural vegetation might not be far removed. In the broad classification of White (1983), the region is labeled as *Cenchrus ciliaris* savanna. Since grazing pressure is lower in the protected sites that could not be a reason. Thus, either the absence of this species might be explained by the unique microclimate or it is competitively excluded from these habitats. More recently, Amsalu *et al.* (2001) indicated that more than half of the herbaceous composition of the region (specifically enclosures and seasonal grazing lands) is covered by *Cenchrus ciliaris*. However, the present study sites appear to be quit different in terms plant diversity and harbor unique species of plants (especially grasses).

The very palatable and flag species, *Cenchrus ciliaris* is however poorly represented in only one of the two study sites. The dominant grasses in the study areas are *Hyparrhenia* spp. and *Heteropogon cotortuse*. *Hyparrhenia filipendula*, the very common tall grass of the ranches and protected areas (Amsalu *et al.*, 2001) is totally absent in the present study sites. Furthermore, *Sporobolus consimilis*, the elegant tussocky and cane like grass, while it is very common in Alagae Grazing lands it was not reported by former workers. This grass and *Vernonia galamenses* were not reported from this region and at this altitude in the Flora of Ethiopia and Eritrea. Further more, *Aloe elegans* (Aloaceae), *Bolbostylis hispidula* (Cyperaceae), and *Vernonia galamensis* (Asteraceae), despite they are being in the proposed red data list (Anon, 2001), they are among the easy to found type of species in either or both of the study areas.

One possible explanation for the uniqueness of these vegetations is rangeland protection and/or management. The study sites are under protection and management for at least three decades. Being the boundary between different ethnic groups and owned by the government, they were well-protected form intruding local people at least for three decades. In both sites wet season exclusion and aftermath grazing of the open grasslands is a common management practice. The woodlands are either used as standing hay for fattening cattle, or as cut and carry type of feeding (especially for dairy cows in Alagae). Hay production plus late harvesting allows the perennial grasses to produce seeds and grazing animals enhance seed dispersal. Thus, both practices contribute positively to floristic diversity.

According to Olsving-Whittaker *et al.* (1992), as time of range protection increases tall grasses gradually increase in dominance and those tall grasses whose seeds are incapable of germinating under shade will gradually eliminated. The same authors have also indicated that *Heteropogon contortus* and *Themeda triandra* are among grasses that cannot germinate under shade. This could explain the difference in the type of dominant grasses in the two rangelands. Both the above-mentioned species are pushed to margins in the *Hyparrhenia* spp. dominated tall grass field of the Alagae rangeland. In the Netell Hay field, while *Heteropogon contortus* one of the dominant species, *Themeda triandra* is weakly represented. This is probably due to the more palatability of the later species.

Since, there are also protected areas (park and ranches) along the main highway protection alone could not explain the floristic richness of the present study sites. Another possible reason could be seen in association with the extent of range resources exploitation. In the

MER, particularly along the high way, road access and hotels around lake Langano are among the factors that encourage overexploitation of rangeland resources. However, the present study sites are off road rangelands and are less pron to charcoal and fuel wood producing local people.

5.2. Vegetation Classification

Whittaker (1975) indicated as vegetation classification to be based on species presence both on a local or regional basis. Numerical and non-numerical approaches of classification have in common the aim of producing final groups, which are as homogeneous in composition as possible. Since the Psudo-species cut levels used in TWINSPAN classification were similar, it is possible to say that Algae has more local community types than Neteli. One possible reason for this would be the difference in size. The Alagae rangeland is more than three times wider than that of Neteli. Therefore, the major reason for this difference could be the difference in size of the two sites.

Simple vegetation classification is also possible by the structural appearance (physiognomy) of the vegetation units (Pratt and Gwynne, 1977). Though this method is controversial, it is still be under use by a number workers especially none ecologists (Chapman, 1976). It is also a common way of vegetation classification by people engaged in range management. Thus, to be inline with practical situation this approach was used for describing vegetation in the field. The major vegetation types recognized by the structural method were: woodlands, open grasslands and less clearly differentiated shrub lands.

The different community types identified by the floristic method are more or less related to the generalized structural groupings of range specialists. Thus, it is possible to label that, in the Alagae rangeland communities: I and II as woodland vegetation types (with decreasing woody species dominance); communities V, VI and VII as pure open field type of vegetation; and the rest two (II and IV) are intermediate forms. The same broad structural description can be made to the vegetation types of the Neteli rangeland. Communities 1, 2, and 3 are open field types; 4 and 5 can be called shrub land type communities; and community 6 is woodland type vegetation.

Based on the proportion of relevés found in the different communities, it is possible to identify the dominant vegetation types of the rangelands. Community II and III (with 26 % of the relevés each) represent the typical mixed wooded-savanna type of vegetation in the Alagae rangeland. The other four communities, sharing equal number of relevés, represent either woody or herbaceous dominated vegetation types, occupying opposite sides of the two major vegetation formations and facing different level of disturbances.

In the Neteli rangeland only on vegetation type (community 2, with the highest number of relevés) can be called the dominant vegetation unit. However, from its species composition it is possible to describe this community as less differentiated (Anthropogenic) vegetation formation. Even though, they are smaller, the others communities are more or less natural (homogeneous) formations ranging from open grassland types (communities: 1 and 3) to the complete woodland types (community 4 - 6).

Based on the composition of naturally occurring species, the two study sites are found to be floristically diverse. The two rangelands are found to have species abundance curve, which look like either the logarithmic, or the Mac Arthur's broken stick model (Figure 5.). The species abundance curves of the two rangelands indicate the more natural type of species dominance (Magurran, 1998). This means that the two protected and managed rangelands have good species abundance indicating that their vegetation is more or less natural. According to Zerihun Woldu (1999) the grasses of the MER area do not form a true savannah, height not exceeding 1 m. However, in the two study sits grasses are found to grow up to 2.5 m. Unlike the rangelands found along the center (along the main highway), *Hyparrhenia* spp. and *Heteropogon cotortuse* are the dominant grasses of the Alagae and Neteli rangelands respectively. Thus, The two rangelands are more or less equivalents of true savanna. All these can only be associated with protection of the rangelands.

5.3. Herbaceous Biomass Production

The result of this study has shown that there was apparent increase of the herbaceous biomass production because of rangeland protection and management. The peak herbaceous biomass productions of the study sites are relatively high. Amsalu Sisay *et al.* (2001) reported 0.8 T/h dry weight production as the highest biomass recorded in the central rift floor (the lake region). The overall mean production in present study sites, 448.61 g/m^2 (4.49 T/h), which is about five times higher than the highest production reported before. Of course, not all the four range sites are found to be equally productive. From the multiple comparisons of results, it is possible to observe, that the Neteli Hay-field dry weight production is relatively lower compared to the other three range sites.

High dry weight production is a desirable thing, from forage production (agricultural) point of view. However, if biomass is concentrated only on few dominant species it will become dangerous in terms of diversity conservation. Based on a study made in Kenya, Oba *et al.* (2001) has indicated as the humpback model works for tropical rangelands. The model states that, as production goes above 500-g/m^2-plant diversity starts to become affected. Of the four range sites the Alagae Hay-field is found to be well above the supposed limits (579.58 + 81.56) and if the model is applicable to the rangelands of the MER area this range site is being in the state of diversity decline.

The Shannon – Weiner diversity index of the Alagae Hay-field (H` = 2.92) is found to be significantly lower (p = .05 level) than the woodland vegetation (H`= 4.87) of the same area. Therefore, based on this investigation the Alagae Hay field is not in a good plant diversity condition. Furthermore, this result also supports the applicability of the humpback model to the MER rangelands.

5.4. Range Condition

The results of range condition assessment have shown that the four range sites have conditions ranging form very poor to good. The direct implication of this result is that the need for some range management action that improves productivity of all range sites. However, the range assessment results need to be supported by other scientific and/or range monitoring parameters so that proper adjustment will be made.

The range condition rating and herbaceous biomass production are found to have strong inverse correlation. Since, the lower the condition rating is the better the rangelands, the two factors are actually directly proportional. This indicates that there is a possibility of range condition assessment using either of these parameters. Even though, it is a tedious method, biomass (as indicator of level of forage production) measurement is a good range condition assessment (Kuchar, 1995; Heady, 1975). The proportion of decreasers and increasers in the four range sites seem to be correlated with the range conditions. Thus, it is possible to deduct at least two important information based on the results. One, the range condition assessment method used is appropriate (supported with biomass production and indicator species) to be used in other rangelands of the Ethiopian rift valley areas. Two, it shows that not all protected or managed rangelands are really in good conditions.

There were 12 species of grasses identified as having high importance (frequency, cover-abundance and biomass) in either of the four range sites (Table, 12). Only the *Hyparrhenia* spp. and *Panicum subalbidum* species form the decreasers. Even though these species are found to decrease under grazing pressure, they have moderate grazing value and grazed mainly when they are young (Alemayehu Mengistu, 1979; Froman and Persson, 1974). Thus, the grazing response groups indicate that the rangelands are composed of mainly increasers and invaders. This is also in line with the condition assessment result that is skewed to the poor side.

Invasion is different from succession. Succession is the gradual and predictable community replacement leading towards a climax community. According to Adair (1995) susceptibility of vegetations to be invaded by invasive and/or alien species varies depending on the vegetation condition. Climax community is the stable community that is in balance with the climate of the region and remains unchanged indefinitely. It is resistant to invasion by other species. The climax community is constantly influenced by disturbance that allows intermediate community species to remain as members of the climax community. Perhaps, due to the stability of the vegetation the study sites are not that mach affected by invasive species. This can be seen from the the number of introduced species only few are found to be invading some habitats.

Of the 17 species of invasive plants recorded *Solanum incanum* and *Nicandra physaloides* (Solanaceae); *Acacia brevispica* and *Dichrostachys cinerea* (Fabaceae) (see Figure 1B; *Xanthium strumarium*, *Tagetes minuta* (Asteraceae) and *Achyrantes aspera* (Amarantaceae) are found to encroach and taking over the places of grasses in both range sites. While, the Solanaceaes are very serious threat for the Nerteli rangelands, *Xanthium strumarium* in the Alagae rangelands.

An important thing at this particular junction is to consider the relationship between things that require both ecologists and range specialists' decision. In the previous section, we have seen the existence of diversity decline besides the high biomass production. Based on the knowledge of the two range sites, the Alagae Hay-field (high biomass producing site) and the Neteli Grazing land (relatively good plant diversity), it is possible to elicit the need for optimizing forage production and maintenance of rangeland biodiversity. Although there is a long list of alien species in the Alagae rangeland, many of them including *Prosopis juliflora*, the notorious invasive plant in Afar region, are not invasive there. None of the fodder plants cultivated in the study areas are observed in the wild. This might be associated with the stability (resistance) of the rangeland vegetation. However, *Sorghum arundinaceum* that has introduced as a forage grass some ten years ago is found to invade open grasslands especially fallow lands. This could be associated with the time of adaptation. Since this might be associated with the conditions, this observation indicates as there is a need for thorough investigation and follow up of all introduced plants.

According to Zerihun Woldu and Mesfin Tadesse (1990) the depletion of *Acacia* woodland vegetation (to 4%) in the MER took only 50 years, and the rate was about 50 times faster than the deforestation of the highlands. The authors also indicated as the characteristic species of the pre-cultivated vegetation have eroded and the genetic erosion thought to continu. While the herb-layer of the region thought to reveal the kind and magnitude of human interface, the tree-shrub layer indicates over-all ecological condition. The diversity and evenness measurement results as well as the range condition assessment in this study are found to support the work of the above authors.

The people of the MER region have had rich and well developed indigenous knowledge as coping mechanisms with the difficulty and comfort of the environment (Zemede Asfaw, 1999). In the mid Rift Valley of Ethiopia livestock, production was the major human activity for hundreds of years. The increased interest by the central government and subsequent malaria control activities were thought to be the reasons for the fast expansion of sedentary agriculture from the surrounding highlands (Zerihun Woldu and Mesfin Tadesse, 1990). Perhaps it is due to such cultural transformation, that the rangelands of the MER floor are currently producing far below the potential of the natural vegetation production.

VI. CONCLUSION AND RECOMMENDATIONS

7.1. Conclusion

Biodiversity is valued and has been studied because it is used, and could be used better to sustain the ever-increasing human population. Only through understanding the importance of biological diversity can conservation measures become a priority and diversity can be utilized in different ways. The MER region is rich in biological resources. Indigenous people of the surrounding areas were originally pastoralists. At present, most pastoral lands have changed into farming which is clamed as the major threat of the natural vegetation. So far in both study sites livestock raring have been practiced, as a major type of land use, cultivation was minimum and irrigation being mainly for horticulture. However, irrigation scheme and water accessibility have been attracting many investors to the MER region and land use practice is changing in and around the study sits.

The vegetation descriptions of the two range sites have shown that the two protected and Managed rangelands have diverse types of species and communities. Their productivity is also found to be higher than other protected and communal grazing lands of the region. Thus, non-traditional grazing management systems or seasonal exclusion is superior in enhancing herbaceous biomass production. Because of protection and/or management, the two rangelands are found to have better vegetation condition and floristic richness. The different plant communities of the study site provide habitat for different wild animals, which are parts of the national heritage. Thus, the two rangelands are of great significance to the wildlife of the Abijgata –Shala National Park, the people living in and around and the whole nation.

However, as the humpback model predicts, some range sites are found to show diversity decline. Even though the scope is limited, the results of this study indicated the applicability of the humpback model in the dryland vegetation of the MER areas. From the ongoing discussion, it seems clear that any farming practice, weather intensive or extensive, entails some ecological modification that results in either qualitative or quantitative change of the flora and fauna.

The range-condition assessment results have shown that the four range sites range from very poor to good condition. There is strong correlation between the range-condition assessment of the range sites and herbaceous biomass production. The proportions of the important grass species also support the synergy between range health and its productivity. This means that there is a need for some range management action that improves the productivity of all range sites. However, this is just only one and direct implication of this results, because the vegetation study and the humpback model functioning are reminding us the need for careful decision-making.

In both rangelands, the hay-fields are being used mainly for hay production and aftermath grazing and are likely to have good inspection. Besides the better management of these lands, the Grazing lands (woodlands) are superior in terms of both diversity and evenness. This implies that the majority of the observed floristic diversity is mainly contributed from the woodlands. The open grasslands on the contrary have better range condition and herbaceous biomass productivity. This is the point, where interests for biodiversity conservation (of the ecologists or botanists) and forage productivity (of the range-people) appear to be in conflict.

Because of this conflict, both approaches will not be comfortable for management decision unless they are compromised.

Thus, the results of this study can possible lead to at least two important conclusions. First, the range condition assessment method employed is appropriate (supported with biomass production and indicator species composition) to be used for other Ethiopian rangelands, particularly in the rift valley areas. Second, based on our knowledge of the two rangelands, it is possible to elicit the need for optimizing forage production and maintenance of rangeland biodiversity.

This floristic survey more or less shows that the vegetation and the current condition the two protected and /or managed rangelands. The impact of human interference on vegetation seems clearly visible in the MER. Crop production is pushing from all directions overtaking the position of livestock raring. In every farming system of Ethiopia, keeping as many animals as possible is a norm. The sensitivity of drylands to climatic fluctuations was dramatically evidenced by several droughts that affected our country. The traditional grazing management systems that evolved for millennia are generally under threat. Thus, conservation the remnant rangelands in the region need to promote biodiversity loss and indigenous grazing management systems.

Pastoralism is a major activity in rangelands and is the basis for cultures, profit making and conservation. Governments, conservation groups and managers are concerned about keeping grazing pressure within certain limits. Identifying when these limits may be exceeded remains a challenge for researchers and managers. The synergies between deliberate and background agents of change must be understood to predict system response accurately. New knowledge of plant-animal interactions, practice of managing total grazing pressure and methods for integrating systems involving different herbivore species need to be explored in order to identify the limits to sustainable grazing pressure. Rangeland resources management requires holistic and sustainable approach taking into consideration the spatial, temporal and socio-cultural features of rangelands and pastoral communities.

If properly managed, biodiversity can provide us with essential products indefinitely and at the same time can remain a home for wildlife and a vital source of water supplies. However, the management of the rangelands for each of the many products, services and benefits presents a complex problem. This is particularly important for people living in areas with drought-susceptible soils of marginal cropping potential like the MER area.

Controlling ecological modification is a question seat for both ecologists and range specialists. If there is integrated management action controlling ecological change will become a matter of scale. At small scale farming exploitation can be easily monitored with any of the available methods; medium and vast zone exploitation may be controlled by extrapolation cautiously selected, tested and fine-tuned scientific findings. The prospect of biodiversity crisis has raised much concern. The question of how to respond to the craises is a major challenge. Urgency and the demand for practical management seems calling for a problem-oriented response.

7.2. Recommendations

Based on the knowledge of this project and personal experience it is possible to extract recommendations, which will be useful for developing livestock agricultural systems that minimize impacts on rangeland resource base and improve the balance between biodiversity conservation and Livestock production. The important recommendations for concerned people and institutions are:

1. In order to remedy the generally poor results of livestock development to date in Ethiopia it is necessary to understand better the way how pastoral production system function and significantly increase the involvement of pastoralists in the development process to improve their living standards and national economy.
2. A thorough ecological investigation is needed for future management of rangelands so as biodiversity is conserved. We lack data on which to make the most basic biological inventories and the criteria and methods for formulating policy and knowing when and how to manage biodiversity. Thus, the use of system survey techniques in planning provides opportunity to look at species ranges and patterns of biodiversity.
3. Conservation education that focuses on range utilization is an immediate priority. The preservation of different land uses and resources should be the main theme in conservation works of the region.
4. It is important to determine the available vegetation biomass of rangeland for animals' in order to measure the effects of management (e.g. fertilization, grazing, cutting) on the vegetation. Vegetation biomass is important also for assessment of rangeland condition.

5. Dryland ecologists should focus: on developing ecological simulation models that will provide information for policy and land use decisions, educating personnel to use these different forms of information, eliciting input from stakeholders, mostly pastoralists, whose livelihood depends upon their continued ability to utilize the grazing ecosystem, who place a high value on having wildlife populations and a healthy environment.

6. It is important to harmonize the ecological conservation and forage production, in order to obtain a clear description of every unit of pastoral vegetation, because it is necessary for range managers to be able to recognize ecological modifications.

7. Evaluation of range condition offers the range management specialist a starting point, a practical means of controlling ecological changes must be provided by ecologists. The methodology of rangeland evaluation and control of the evaluation must become the subject of ecologists.

8. Ecological as well as auditing of the range science requires adaptive frameworks that enhance sustainable strategic responses and the state of art assessment method should be formulated. We need to monitor the capacity of healthy rangeland to support a broad suite of ecosystem services for a wide range of stakeholders.

9. Conventional range rehabilitation using controlled grazing followed by range condition assessment of either species composition; phytomass dynamics or combination of these must be practiced in both protected and communal rangelands. Promotions of controlled grazing which encourages people to see their animals in economic value than social aspect, so that they can practice cut and carry system of feeding.

10. Development programs, especially land use change in the MER area should be based on environmental impact assessment.

11. To put all these in to effect there is a need to develop: a sustainable livestock management program for the control of range deterioration in Ethiopia, capacity to diagnose range health and a means of interaction and communication for ecologists and governmental as well as non governmental organizations dealing with pastoral problems.

VII. REFERENCE

Adair, R. J. (1995). *The Threat of Environmental Weeds to Biodiversity in Australia*: A search for solutions. In: Conserving Biodiversity: Threats and Solutions. (Bradstock, R. A. ed.). Pp 184-201. Surrey Beatty and Sons Pty ltd, NSW

Alemayehu Mengistu (1979). *Grassland Conditions in the Chilalo Awraja, Arsi Province, Ethiopia: An Ecological Study.* Ethiopian Journal of Agri. Sci. 1:2

Alemayehu Mengistu (1998). Natural Pasture Improvement Study. MoA, Addis Ababa.

Amsalu Sisay, Robert, B., Zinash Sileshi (2001). *Herbaceous Species Composition, Dry-matter Production and Condition of the Major Grazing Areas in the Mid Rift Valley of Ethiopia.* Proceedings of the 9th Annual Conference, Ethiopian Society of Animal Production (ESAP). Pp 267 – 283.

Andreucci, F., Biondi, E., Feoli, E. and Zuccarello, V. (2000). *Modeling environmental responses of plant associations by fuzzy set theory. Community Ecology* 1(1): 73-80.

Anon (2001). Red List of Endemic and threatened plants of Ethiopia, working document with Herbaceous Endemic taxa (Ethiopia and Eritrea), second draft 1.1. Addis Ababa, Ethiopia.

Anon (1995). Invasion Rates and Risks: [online]

http/aliens.csir.co.za/plants/global/content/Africa/south Africa

Baars, R.M.T; Chileshe, E. C.; and Kalokoni, D. M. (1996). *Range Condition in High Cattle Density areas in the Western Province of Zambia.* Tropical Grassland, 31:569 – 573.

Barbier, E.B., Burgess, J.C and Folke, C. (1994) *Paradise Lost? The ecological economics of biodiversity.* London: Earth scan.

Bekure, S.; de Leew, P. N.; Grandin, B. E. and Neate, P. J. H. (1991). *Massai herding: Analysis of livestock production of massai pastoralist in eastern Kajiado District,* Kenya, ILCA, Addis Ababa, Ethiopia.

Blench, R. and Sommer, F., (1999). *Understanding Rangeland Bio*diversity. Oversea Development Institute (ODI), Chameleon Press, London.

Blench, R. M. and Marriage, Z. (1999). *Drought and livestock in semi-arid Africa and the Near East. An essay and an annotated bibliography*, ODI working Paper. London. [Online]: http:// WWW. FOA. Org/ag/ aga/ agap/ lps/ drougHT/html

Bonham, C. D. (1989). *Measurements for Terrestrial Vegetation*. John Willy and Sons. New York.

Boutton, T. W., Archer, S. R. and Zitzer, S. F. (2002). *Hydrologic Mechanisms Determining Plant Species Interactions in Grazed Savannas*. Texas A&M University Grant Document. Date submitted: 12/15/98 USDA/CSRS Rangelands Research Program. [online]: http ://www/ rangeweb.tamu.edu/abstracts/newgrantrpt.html.

Bridson, D. and Froman, L. (eds.)(1992). *The herbarium handbook*. Royal Botanical Gardens Kew. Whit stable Litho Printers Ltd. Great Britan. 303 Pp.

Brown, G. (1994). Factors to Consider in the Development of ASAL areas, p.47-55. D. Herloker, S.B. Shaabani and K.S.A. Buigott, eds., *Range Management Handbook of Kenya*, Vol. 1. Republic of Kenya, Min. Agr., Livestock Devel. & Marketing (MALDM), Nairobi.

Busby, F. E. (1995). *Sustainable use and management of the world's rangelands*. **In**: Range management in arid zones. *Proceedings*: the second international conference on range management in the Arabian Gulf. (Eds. Omar, S. A. S.; Razzaque, M. A. and Alsdirawi, F.). Kegan Paul international Ltd, London.

Cerment, T. (1996). *Nutrient Cycling in Savanna Ecosystems*. **In**: Biodiversity and savanna ecosystem process, Ecological studies, Vol. 121: 46-67. (O.T. Solbrig, E. Medina, and T.F. Silva, eds.)Springen-Verlog, Heiddboery, Berlin.

Chapman, S. B. (Ed.)(1976). *Methods in Plant Ecology*. Blackwell Scientific Publication, USA.

Cody, M. L. (1989). *Discussion: Structure and assembly of communities*. **In**: Perspectives in ecological theory (J. Roughgarden, R. M. May, & S. A. Levin, Eds.). Pp 227 – 241. Princeton University Press, Prinston, New Jersey.

Coppock, D. L. (1994). *The Borana Plateau of Southern Ethiopia: Synthesis of pastoral Research, Development and change, 1980-1991.* ILCA. Addis Ababa, Ethiopia

Craig, C. (1983). Fire in Forestry. Volume I. Willey and Sons Inc. USA

CSA (1990). *Statistical Abstract.* Addis Ababa, CSA, Ethiopia

CSA (1999). *Statistical Abstract.* Addis ababa, CSA, Ethiopia

Dagnachew Legesse (2002). ANALYSE DE LA REPONSE HYDROLOGIQUE DU BASSIN LACUSTRE DE ZIWAY-SHALA (RIFT ETHIOPIEN0 AUX CHANGEMENTS DU CLIMET ET DES ACTIVITUS HUMANUS. Ph.D. Dissertation. UNIVERSITE D'E DROIT, France.

Deselagn Desissa and Benggli, P. (2003) Species checklist. [Online]: http://members.lycos.co.uk/ethiopianplants/invesives/species/html.

Digby, P.G.N. and Kempton, R.A. (1987). *Multivariate Analysis of Ecological Communities.* Chapman and Hall, London.

Du Plessis, W. P., Bredenkamp, G.J. and Trollope, W.S.W. (1998) "*Development of a technique for assessing veld condition in Etosha National Perk, Namibia, using key herbaceospecies*". Koedoe, 41(1) 19-29.

Dyksterhuis, E. J. (1949). *Condition and management of range land based on Quantitative ecology.* Journal of Range manage. 2: 104-115

Edwards, S., Mesfin Tadesse and Hedberg I. (1995). *Flora of Ethiopia and Eritrea.* Vol. 2, part 2. Canellaceae to Euphorbiaceae. Addis Ababa, Ethiopia, Uppsala, Sweden. 456Pp.

Edwards, S., Sebsebe Demissew and Hedberg, I. (1997). Flora of Ethiopia and Eritrea vol 6. Hydrochritaceae to Arecaceae. Addis Ababa, Ethiopia, Uppsala, Sweden. 586 Pp.

Edwards, S., Sebsebe Demissew and Hedberg, I. (2000). *Flora of Ethiopia and Eritrea.* Vol 2, Part 1. Magnoliaceae to Flacourtiaceae. Addis Ababa, Ethiopia; Uppsala, Sweden. 532 Pp.

EMA (1997). Topographic Map of Ethiopia (1:250000). Ethiopian Government, Addis Ababa, Ethiopia.

FAO (2000). Challenges and Hopes for the 2000s: *The Rangelands of Arid and Semi-Arid Areas*: A Review. [Online]: http//www/org.com

Friedel, M. H., Laycock, W. A. and Bastin, G. N. (2000). Assessing Rangeland Condition and Trend. In: Field and laboratory methods for grassland and animal production research (L. T. Mannetje and R. M. Jones, Eds.). CAB International, Walling, UK. Pp 227-262

Froman, B. & Persson, S. (1974). *An Illustrated Guide to the Grasses of Ethiopia*. CADU, Assela, Ethiopia.

Frost, P. G. H. and Robertson, F. (1987). *The Ecological Effects of Fire in Climax Vegetation in Rhodesia*. Proceedings: the Tall Timbers Fire Ecology Conference, **11**: 121-145.

Goldsmith, F.B., Harrison, C.M. and Morton, A.J. (1986). *Description and analysis of vegetation*. In: methods in plant ecology, 2nd edition (P. D. Moore, and S.P Chapman, eds.). Blackwell Scientific publications, Oxford.

Hamphrey, P. R. (1979*). Field Comments on The Range Condition Method of Forage survey.* Journal of range Management, **2**: 1-10.

Heady, H.f. (1975*). Range Condition and Range Trend*, **In**: Evaluation and Mapping of Tropical African rangelands, Pp 177 – 179. *Proceedings*, Seminar, Bamako, Mali, 3 – 8 Mar. 1975. ILCA, Addis Ababa, 399 Pp.

Heady, H. F. AND child, R. D. (1994*). Rangeland Ecology and Management.* Westview, Bulder, Colorado.

Hedberg, I. And Edwards, S. (eds.) (1989). *Flora of Ethiopia, Vol. 3*: Pittosporaceae to Araliaceae. Addis Ababa, and Asmara, Ethiopia, Uppsala, Sweden. 660Pp.

Hedberg, I., Edwards, S. (eds.) (1995). Flora of Ethiopia and Eritrea. Vol. **7**. Poaceae (Graminea). Addis Ababa, Ethiopia; Uppsala, Swiden.

Hedberg, I., Edwards, S. and Sileshi Nemomessa (2003). *Flora of Ethiopia and Eritrea,* Vol. *4*. part *1*. Apiaceae to Dipsacaceae. Addis Ababa, Ethiopia.

Herlocker, D. (1999). *Rangeland Ecology and Resource Development in Eastern Africa.* GTZ, Nairobi, Kenya.

Hill, M. O. (1979). TWINSPAN: A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of individuals and attributes. *Ecology and sytematics,* Cornell University, Ithaca, New York.

IFAD (1999). Livestock development and Rangeland Management. [online] http:// www.ifad.org

Juo, A. S. (1978). *Selected methods for soil and plant analysis.* International Institutes of Tropical Agriculture. Ibadan, Nigeria.

Kent, M. and Coker P. (1992). *Vegetation Description and Analy*sis: A Practical Approach. Belhaven Press, London.

Komarek, E. V. (1972). Lightning the fire ecology in Africa. *Proceedings:* The Tall Timbers Fire Ecology Conference, **11**: 473-509.

Kuchar, P. (1995). Range Monitoring and Evaluation: A Range Survey Methods. South East Rangeland Project (SERP) Technical Report. Richard Woodruff and Associates, MoA, Addis Ababa.

Kumlachew Yeshitla and Tamrat Bekele (2002). *Plant Community Analysis and Ecology of Afromontane and Transitional rainforest vegetation of South-western Ethiopia.* SINET: Ethiop. J. Sci. 59: 247-265

Lamprey, B. H. (1979). *Structure and function of semi-arid grazing land ecosystem of Serengeti region,* Tanzania, UNESCO.

Lovejoy, T. E. (1997). *Biodiversity: what it is*? **In:** Biodiversity II, (L. Marjorie R. In: Huntley, B.J. & Walker, B.H. Eds.).

Ludwig, J. A. (1987*). Primary productivity in arid lands*: myths and realities. Journal of Arid Environment, **13**: 1-7.

Lyons, E. E and Miller, S. E., (eds.) (1999). Invasive Species in Eastern Africa: Proceedings of a Workshop held at ICIPE, July 5-6, 1999, ICIPE Science Press, Nairobi, Kenya.

Magurran, A. E. (1998). *Ecological Diversity and its Measurement.* University of Oxford, Oxford.

Makin, M. J. Kingham, T. J. Waddams, A. E., Birchall, C. R. and Tefera, T. (1975). Prospects for Irrigation Development around Ziwai, Ethiopia. Tolworth, Land Resources Div. U,K. Min. Overseas Deve. l: 270

Mannetje, L. T. (2000). *Measuring biomass of vegetation.* **In**: Field and laboratory methods for grassland and animal production research (L. Mannetje and R.M. Jones, Eds.). CAB International, Walling, UK. Pp 151-177.

Menaut, J. C. and Cesar, J. (1982). *The structure and dynamics of a West African Savanna.* Ecology of Tropical Savannas, pp. 80-100. Springer-Verlag: Berlin.

MoA (1998). *National Livestock Development Project.* MoA Project document, Addis Ababa, Ethiopia.

MoA (2000). *Agro-Ecological Zones of Ethiopia.* MoA, Addis Ababa , Ethiopia

Mueller-Dumbois and Ellenberg, H. (1974). *Aims and methods of vegetation ecology.* John Willey and Sons, Inc, U.S.A. 547Pp.

Mwangata, J. H. N. (1994). *The Application of Range Management in Kenya*: example and Proposals, **In**: Range Management Handbook of Kenya, Vol. **1:** 27-31 (D. Herloker, S.B. Shaabani and K.S.A. Buigott, eds.). Republic of Kenya, Min. Agr. Livestock Devel. & Marketing (MALDM), Nirobi.

Nijhof, M. (1982). *Forest fire prevention and control DRW.* Junk publishers

Oba, G., Stenseth, N. C. and Lusigi, W. J. (2000). *New perspective on sustainable grazing management in arid zones of sub-saharan Africa.* Bioscience, **50**: 35-51.

Oba, G., Vetaas, O. R. and Stenseth, N. C. (2001). *Relationships between biomass and plant species richness in arid-zone grazing lands.* Journal of Applied Ecology, **38**: 836-845.

Olsving-whittaker, L. S., Naveh, Z., Giskin, M. and Nevo, E. (1992). *Microsite differentiation in a Mediterranean Oak Savena.* Journal of Vegetation science **3**: 209 – 216.

Orr, B. (2002). Defining Rangeland Management: A comparison of three Textbooks. The University of Arizona.

Pankhurst, R. (1966). *The Great Ethiopian Famine of 1888 –1892: a new assessment, part two*. Journal of history and Medicine and Allied Science, XXI (3): 271 –294. Press, Washington D.C.

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

Sagri, M. (1998). Land Resources Inventory, Environmental changes analysis and their Applications to Agriculture in the Lake region (Ethiopia). Florence, University of Florence: 181

Smith, E.L. (1978). *A critical Evaluation of Range Condition Concept*, In: *Procedings* (D.N. Hyder, ed.) Pp.266-267. First International Rangeland Congress. Denver, Colorado.

Solbrig, O. (1996). '*The diversity of the savanna ecosystems.*' In: Biodiversity and Savanna Ecosystem Processes. (O.T.Solbrig, E. Medina, and J.F. Silva, eds.), PP. 1-30. Springer, Berlin.

Stork, N. (1996). *Introduction to Biodiversity*, In: Biodiversity Assessment, A Status of the Earth's Living Resources, (B. Groombridge ed.). Chapman & Hall, London.

Swain, M. (2001). Community Ecology. Lecture Note, The University of Abadan. UK. [online]: http://www.abdn.ac.uk/biology/lectnotes.doc

Tainton, N. M. (1981). *The ecology of main grazing lands of South Africa*. In: Veld and Pasture management in South Africa (ed. N M Tainton). Shuter and Shooter, Pietermarizburg.

Tamrat Bekele (1993). *Vegetation ecology of remnant Afromontane forests on the central plateau of Shoa*, Ethiopia. *Acta Phytogeographica*, Sukecica, **79**:1-59.

Tewolde Brhane GebreEgziabher (1990). *Diversity of Ethiopian flora*. **In:** *plant genetic resources of Ethiopia* (Engles, J. M. M., Hawkes, J. G. and Melaku Worede, eds.) Pp 75-81. Cambridge University Press, Cambridge van der Maarel, E. (1979). *Transformation of cover/abundance values in phytosociology and its effect on community similarity.* Vegetatio **39**: 97-114.

Walter, H., (1985). *Vegetation of the Earth and Ecological Systems of the Geobiosphre.* Third edition. Berlin, Heidelberg, New York. 318 Pp.

WCMC (World Conservation Monitoring Center) (1992). *Global Biodiversity:* status of the earth's living resources. Chapman and Hall, London. 585 Pp.

West, N. E. (1993). Synthesis Paper on Overview of How the Issues Of Biodiversity May Influence Planning, Research, and Management of Rangelands. J. Range Manage, **46**:2-13.

West, O. (1972). *Fire Man And Wildlife as Interacting Factors Limiting the Development of Savannas.* **In**: DETERMINANTS OF TROPICAL SAVANNAS, Presentations made by savanna researchers at a workshop in Harare, Zimbabwe, December 1985. Brian H. Walker (Ed.). The International Union of Biological Sciences, IRL Press, Oxford

Whalley, R.D.B. and Hardy, M.B. (2000). *Measuring botanical composition of grassland.* **In**: Field and laboratory methods for grassland and animal production research, Pp 67-101. (L. T. Mannetje, and R.M. Jones, Eds.). CAB International, Wallingford, UK.

White, F. (1983). *The vegetation of Africa*: A description Memoir to Accompany the UNISCO/AETFAT/UNIDO Vegetation Map of Africa. Nat. Resources Res. (Paris) **20**: 356 Pp. UNESCO, Switzerland. 356 Pp.

Whittaker, R. H. (1975). *Community and ecosystems.* 2nd edition. MacMillan. London.

Wilson, E. O. (1997). *Introduction.* **In**: *Biodiversity II*, (L. Marjorie R. Kudla, D. E. Wilson, and E.O. Wilson eds.) pp. 1-6. Joseph Henry Press.

Zemede Asfaw (1999). *How they cope in the Ethiopian Drylands, Indigenous Modes of Living that Evolved under Uncertainties of the Arid and Semi-arid Ethiopian Rift system.* RPSUD, Newsletter **3**:2-8

Zerihun Woldu (1985). *Variation in grassland vegetation on the central plateau of Shoa, Ethiopia, in relation to edaphic factors and grazing conditions.* Ph.D Thesis, Uppsala University. Printed in Germany by Strauss and Cramer.

Zerihun Woldu (1999). Forests in the vegetation types of Ethiopia and their status in the geographical context. **In**: *proceedings:* the national forest genetic resources conservation strategy development workshop (Edwards, S. Abebe Demissie, Taye Bekele and Haase, G. eds.) June 21-22, 1999, Addis Ababa, Ethiopia. 1-39 Pp.

Zerihun Woldu and Mesfin Tadesse (1990). *The Status of the Vegetation in the Lake Region of the Rift Valley of Ethiopia and the Possibility of its Recovery.* SINET: Eth. J. Sci., 13(2) pp 79-120

Zerihun Woldu and Saleem, M. A. M. (2000). *Grazing induced biodiversity in the highland eco-zone of East Africa.* Agriculture, Ecosystems and Environment 79 pp 43-52

Zinabu G/Mariam and Elias Dadebo (1999). *Liminology in Ethiopia.* **In:** *Liminology in Developing Countries*, (C. Tudorancea ed.) pp. 63 – 118. International Association for Liminology.

APPENDICES

Appendix 1. Range Condition Rating Guidelines

EROSION 0 = nil (none detectable, or non-erodible)

1 = light ; 2 = moderate , 3= Severe/irreversible

Note that the erosion assessment is combined wind and water erosion. The signs and effects of wind and water erosion will be the more important agent. See Appendix d for details on soil erosion indicators.

TRAILING The presence and intensity of tracks and trails caused by livestock.

The higher the rating the denser (and often more deeply grooved) the track networks.

LITTER The less litter there is, the worse the rating. Litter distribution (spatial pattern) should also be noted. The more evenly it is distributed the better. Conversely, highly clumped litter (due to wind redistribution or termite activity) means poorer soil surface cover, which translates to poorer condition rating.

GRASS Ab. Abundance of perennial grasses.

GRASS CR. Health and vigor of perennial grasses (grass crown condition). It includes size, height, robustness, and abundant production of leaf and shoots/tillers, big denser root system, color.

HEDGING

0 = Highly palatable and palatable shrubs share dominance. Most palatable plants are lightly to moderately hedged and few or no decumbent plants.

Hedging describes when a woody plant is browsed so that the growth becomes dense and bushy, like a cut hedge. Do not be confused by unpalatable shrubs, which tend not to be hedged even under high stock impact. Where these dominate, you may have to look around carefully for individuals of the 'palatable species, because it is their state that determines the hedging rating.

1 = Palatable plants are dominant. 'Hedgeable" plants moderately to heavily hedged, and some shrub decadent due to hedging.

2 = Palatable and Less palatable plants dominant. 'Hedgeable' plants heavily to very heavily hedged. Considerable number of decadent shrubs present and some may be dead due hedging.

3 = Less palatable and unpalatable shrubs are dominant. Some normally unchangeable shrubs are hedged. 'hadegable' shrubs very heavily haged, the crowns often reduced to nubbins. Many shrubs decadent and Dead from Hedging.

DUNG: More livestock dung means poorer condition rating.

% GREEN: is an estimate of the % of all plants in the stand that are leafed out. Disregard: evergreens and naturally leafless species. There may well be a correlation between some cover or condition parameters and degree of leafiness, and when that can be estimated, a correction factor will be calculated.

Appendix 1. Continued

Weighting of Parameter Score

Parameter	Percent Cover Rating	Weighting
1. Erosion	0 –2	2(normal)
	2.1- 2.5	5
	2.6 - 3	10
2.Perennial grass abundance	>1.5	2 (normal)
	1 – 1.5	5
	<1	8
3. Total woody cover	>15 5 %	3
	8 – 15 %	5
	< 8%	8
4. Yicib (rock and pebble) cover	< 1 5 %	0
	1 – 3 %	-1
	4 – 8 %	-3
	> 8 %	-5

Grass species and grazing indicators

This involved the classification of grass species into either 'Decreasers' or 'Increasers' (after Trollope, 1990) depending on how the species responded to grazing pressure.

Category 1: Species dominant in under utilized veld ('Increaser 1' species)

Category 2: Species abundant in lightly grazed veld, decreasing with under or over utilized veld ('Decreasers')

Category 3: Species with low abundance in under utilized or lightly grazed veld which tends to increase in abundance when vegetation is moderately grazed ('Increaser 2a')

Category 4: Species that are more abundant in moderately over utilised veld ('Increaser 2b')

Appendix 2. List of Species Found in the Two Study Sites

(* introduced species, + = present, H= Herb, S=shrub, Succ. = Succulent T=Trees, T/S= Tree or Shrub)

R. No.	Scientific Name	Habit	Family	Alagae	Neteli
1.	*Abutilon hirtum* (Lam.) Sweet.	S	Malvaceae	+	+
2.	*Acacia senegal* (L.) Willd.	T	Fabaceae	+	+
3.	*Acacia tortilis* (Forssk.) Hayne	T	Fabaceae	+	+
4.	*Acacia abyssinica* Hochst. ex Benth.	T	Fabaceae	+	+
5.	*Acacia albida* Del.	T	Fabaceae		+
6.	*Acacia brevispica* Harms	T	Fabaceae	+	+
7.	*Acacia melanoxylon* R. Br.	T	Fabaceae	+	
8.	*Acacia seyal* Del.	T	Fabaceae	+	+
9.	*Achyranthes aspera* L.	S	Amaranthaceae	+	
10.	*Acokanthera schimperi* (A.DC.) Benth.	H	Apocynaceae	+	+
11.	*Albizia anthelmintica* (Benth.) Brenan	S	Fabaceae	+	
12.	*Alyscicarpus rugosus* (Willd.) Dc.	S	Fabaceae	+	
13.	*Aloe elegans* Tod.	Sac.	Aloaceae	+	
14.	*Aristida adoensis* Hochst.	H	Poaceae	+	+
15.	*Aristida kenyensis* Henr.	H	Poaceae	+	+
16.	*Asparagus setaceus* (Kunth) Jessop	S	Asparaginaceae	+	
17.	*Aspilia africana (Pers.) Adams*	H	Asteraceae	+	
18.	*Aspilia mossambicensis* (Oliv.) Wild.	H	Asteraceae		+
19.	*Astripomoea malvaceae* (Klotzsch) Meeuse	H	Convolvulaceae		+

Appendix 2. Continued

R. No.	Scientific Name	Habit	Family	Alagae	Neteli
20.	*Balanites aegyptica* (L.) Del.	T/S	Balanitaceae	+	+
21.	*Barleria proxima* Lindau	S	Acanthaceae	+	
22.	*Bidens* sp.	H	Asteraceae	+	+
23.	*Blepharis integrifolia* (L.F.) Schinz	H	Acanthaceae		+
24.	*Bothriochloa insculpta* (Hochst. Ex A. Rich) A. Camus	H	Poaceae	+	+
25.	*Brachiaria semiundulata* (A. Rich.) Stapf	H	Poaceae		+
26.	*Brucea antidysenterica* J. F. Mill.	T/S	Simaroubaceae		+
27.	*Bulbostylis hispidula* (Vahl) R. Haines	H	Cyperaceae	+	+
28.	*Cadaba farinosa* Forssk.	S	Capparidaceae	+	
29.	*Calpurnia aurea* (Ait.) Benth.	S	Fabaceae	+	
30.	*Capparis fascicularis* DC.	T/S	Capparidaceae		+
31.	*Cardiospermum halicacabum* L.	C	Sapindaceae	+	
32.	*Carissa spinarum* L.	H	Apocynaceae		+
33.	*Capparis tomentosa* Lam.	S	Capparidiaceae	+	
34.	*Casimiroa edulis* La. Lave*	T	Rutaceae	+	
35.	*Celtis africana* Burm. F.	T/S	Ulmaceae	+	
36.	*Cenchrus setigerus* (Vahl) Maire	H	Poaceae		+
37.	*Cenchrus ciliaris* L.	H	Poaceae	+	
38.	*Chamaecrista mimosoides* (L.) Greene	H	Fabaceae		+
39.	*Chloris virgata* Sw.	H	Poaceae	+	+
40.	*Chenopodium album* L.	H	Chenopodiaceae		+
41.	*Chenopodium procerum* Moq.	H	Chenopodiaceae		+
42.	*Chloris pycnothrix* Trin.	H	Poaceae	+	+

Appendix 2. Continued

R. No.	Scientific Name	Habit	Family	Alagae	Neteli
43.	*Chloris gayana* Kunth*	H	Poaceae	+	
44.	*Chloris virgata* Sw.	H	Poaceae	+	+
45.	*Chrysopogon aucheri* (Boiss.) Stapf	H	Poaceae	+	
46.	*Cissus quadrangularis* L.S.	H	Vitaceae		+
47.	*Clerodendron myricoides* (Hochist.) Vetke	H	Verbenaceae		+
48.	*Coccinia megarrhiza* C. Jeffrey	H	Cucurbitaceae		+
49.	*Coccinia* sp.	H	Cucurbitaceae		+
50.	*Commicarpus plumbagineus* (Cav.) Standley	S	Nyctaginaceae		+
51.	*Cordia ovalis* R.Br. ex Dc.	T/S	Boraginaceae		+
52.	*Crotalaria incana* L.	S	Fabaceae	+	
53.	*Crotalaria laburnifolia* L.	S	Fabaceae		+
54.	*Crotalaria spinosa* Hochst. ex Benth.	S	Fabaceae		+
55.	*Croton macrostachys* Del.	T	Euphorbiaceae	+	+
56.	*Casuarina equisetifolia* L.*	T	Csuarinaceae	+	
57.	*Cynodon aethiopicus* Clyton & Harlan	H	Poaceae	+	
58.	*Cynodon dactylon* (L.) Pers.	H	Poaceae	+	+
59.	*Cynodon nlemfuensis* Vanderyst	H	Poaceae	+	
60.	*Cynoglossum* sp.	H	Boraginaceae		+
61.	*Cyperus bulbosus* Vahl	H	Cyperaceae		+
62.	*Cyperus longus* L.	H	Cypraceae	+	
63.	*Cyperus rotundus* L.	H	Cyperaceae	+	+
64.	*Cyperus rubicundus* Vahl	H	Cyperaceae	+	

Appendix 2. Continued

R. No.	Scientific Name	Habit	Family	Alagae	Neteli
65.	*Cyperus* sp.	H	Cyperaceae		+
66.	*Cyperus squarrosus* L.	H	Cyperaceae		+
67.	*Dactyloctenium aegypticum* (L.) Willd.	H	Poaceae	+	+
68.	*Datura stramonium* L.	H	Solanaceae	+	
69.	*Delonix regia* (Boj. Ex Hook) Raf.*	T	Fabaceae	+	
70.	*Desmodium uncinatum* (Jacq.) DC.*	Cl	Fabaceae		
71.	*Dichrostachys cinerea* (L.) Winght & Arn.	T	Fabaceae	+	+
72.	*Dicoma tomentosa* Cass.	S	Asteraceae	+	
73.	*Digitaria abyssinica* (Hochst. ex. A. Rich.) Stpf	H	Poaceae	+	+
74.	*Digitaria eriantha* Steud.	H	Poaceae	+	
75.	*Digitaria ternata* (A. Rich.) Stapf	H	Poaceae	+	
76.	*Digitaria velutina* (Forssk.) P. Beauv.	H	Poaceae	+	
77.	*Dodonaea angustifolia* L. F.	S	Sapindaceae	+	
78.	*Dovyalis abyssinica* (A. Rich.) Warb.	S	Flacourtiaceae	+	
79.	*Digitaria ciliaris* (Retz.) Koel.	H	Poaceae	+	
80.	*Echinocloa pyramidalis* (Lam.) Hitchc. & Chase	H	Poaceae	+	
81.	*Echinops macrochaetus* Fresen	H	Asteraceae	+	
82.	*Ehretia cymosa* Thonn.	C	Boraginaceae	+	+
83.	*Ekebergia capensis* Sparrm.	T	Meliaceae		+
84.	*Eleusine floccifolia* (Forssk.) Spreng.	H	Poaceae	+	+
85.	*Eleusine indica* (L.) Gaertn.	H	Poaceae	+	+

Appendix 2. Continued

R. No.	Scientific Name	Habit	Family	Alagae	Neteli
86.	*Eleusine intermedia* (Chiov.) S.M. Phillips	H	Poaceae		+
87.	*Eleusine africana* Kenn,-O`Byrne	H	Poaceae	+	
88.	*Entada abyssinica* Steud. ex A. Rich	S	Fabaceae	+	+
89.	*Eragrostis papposa* (Roem. & Schult.) Steud.	H	Poaceae		+
90.	*Eragrostis heteromera* Stapf	H	Poaceae		+
91.	*Eragrostis cilianensis* (All.) Vign. ex Janchen	H	Poaceae	+	
92.	*Eragrostis cilianensis* (All.) Vign. ex Janchen	H	Poaceae		+
93.	*Eragrostis tenuifolia* (A. Rich) Steud.	H	Poaceae		+
94.	*Eragrostis tenuifolia* (A.Rich.) Steud.	H	Poaceae	+	
95.	*Eragrostis papposa* (Roem. & Schult) Steud.	H	Poaceae	+	
96.	*Eriochloa fatmensis* (Hochst. & Steud.) Clayton	H	Poaceae	+	
97.	*Eriochloa procera* (Retz.) C. E. Hubb.	H	Poaceae	+	
98.	*Erythrina brucei* Schweinf.	T/S	Fabaceae	+	+
99.	*Eucalyptus camaldulensis* Dehnh.*	T	Myrtaceae	+	
100.	*Eucalyptus citriodora* Hook*	T	Myrtaceae	+	
101.	*Eucalyptus grandis* Maiden*	T	Myrtaceae	+	
102.	*Eucalyptus microtheca* F. Von Muall*	T	Myrtaceae	+	
103.	*Evolvulus alsinoides* (L.)	C	Convolvulaceae		+
104.	*Ficus ovata* Vahl	T	Moraceae		+
105.	*Ficus sycomorus* L.	T	Moraceae	+	
106.	*Ficus thonningii* Blume	T	Moraceae	+	
107.	*Ficus vasta* Forssk.	T	Moraceae	+	

Appendix 2. Continued

R. No.	Scientific Name	Habit	Family	Alagae	Neteli
108.	*Flueggea virosa* (Wild.) Voigt	S	Euphorbiaceae	+	+
109.	*Glycine wightii* (Wight & Arn.) Verdc.	C	Fabaceae	+	+
110.	*Gnaphalium rubriflorum* Hilliard	H	Asteraceae	+	
111.	*Heteropogon contortus* (L.) Roam. & Schult.	H	Poaceae	+	+
112.	*Hibiscus cannabinus* L.	S	Malvaceae	+	+
113.	*Hygrophila auriculata* (Scum.) Heine	S	Acanthaceae	+	
114.	*Hyparrhenia anamesa* W. D. Clayton	H	Poaceae	+	+
115.	*Hyparrhenia anthistirioides* (Hochst. ex A. Rich.) Stapf	H	Poaceae	+	+
116.	*Hyparrhenia collina* (Pilg.) Stapf	H	Poaceae	+	
117.	*Hyparrhenia dregeana* (Nees) Stent	H	Poaceae	+	+
118.	*Grewia bicolor* A. Juss	T/S	Tiliaceae	+	
119.	*Grewia ferruginea* Hochst. ex A. Rich.	T/S	Tiliaceae	+	
120.	*Guizotia abyssinica* Cass.	H	Asteraceae	+	
121.	*Harpachne schimperi* Hochst. ex A. Rech	H	Poaceae	+	+
122.	*Heliotropium cinerascens* L.	H	Boraginaceae	+	
123.	*Hyparrhenia hirta* (L.) Stapf	H	Poaceae	+	
124.	*Hyparrhenia nyassae* (Rendle) Stapf	H	Poaceae	+	
125.	*Hyparrhenia quarrei* Robyns	H	Poaceae		+
126.	*Hyparrhenia rufa* (Nees) Stapf	H	Poaceae	+	+
127.	*Hyparrhenia variabilis* Stapf	H	Poaceae	+	+
128.	*Hypoestes forskaoli* (Vahl.) Soland ex Roem. & Schult.	S	Acanthaceae	+	
129.	*Hypoestes verticilaris* (L. F.) R. Br.	S	Acanthaceae	+	+

Appendix 2. Continued

R. No.	Scientific Name	Habit	Family	Alagae	Neteli
130.	*Indigofera dendroides* Jacq	C	Fabaceae		+
131.	*Indigofera* sp.	S	Fabaceae	+	
132.	*Ipomoea hochsteteri* House	C	Convolvulaceae	+	
133.	*Jacaranda mimosifolia* D. Don. *	T	Bignoniaceae	+	
134.	*Jasminum grandiflorum* sub sp. *floribundum* (R. Br. ex Fresen.) P.S.Green	S	Oleaceae	+	
135.	*Juniperus procera* Hochst. ex Endl. *	T	Cupressaceae	+	
136.	*Kalanchoe lanceolata* (Foressk.) Pers.	H	Crassulaceae	+	+
137.	*Laggera rubiflorum* Hilliard	H	Asteraceae		+
138.	*Lannea schimperi* (A. DC.) Schweinf.	T	Anacardiaceae	+	
139.	*Lantana camara* L. *	S	Verbanaceae	+	
140.	*Launaea intybacea* (Jacq.) Beatuverd	H	Asteraceae	+	+
141.	*Leucas martinicensis* (Jacq.) R. Br.	H	Asteraceae	+	
142.	*Lucaena leucocephala**			+	
143.	*Macroptilium atropurpureum* (DC.) Urb.	Cl	Fabaceae	+	
144.	*Mangifera indica* L.*	T	Anacardiaceae	+	
145.	*Maytenus senegalensis* (Lam.) Exell	T/S	Celesteraceae	+	+
146.	*Melinis repens* (Willd.) Zizka	H	Poaceae		+
147.	*Maerua angolensis* DC.	S	Capparidaceae	+	+

Appendix 2. Continued

R. No.	Scientific Name	Habit	Family	Alagae	Neteli
148.	*Microchloa kunthii* Desv.	H	Poaceae	+	+
149.	*Myrtus communis* L.	S	Myrtaceae		+
150.	*Nicandra physaloides* (L.) Gaertn.	S	Solanaceae		+
151.	*Panicum subalbidum* Kunth	H	Poaceae		+
152.	*Pappea capensis* Eckl. & Zeyh.	H	Sapindaceae	+	+
153.	*Pennisetum mezianum* Leeke	H	Poaceae	+	+
154.	*Pennisetum sphacelatum* (Nees) Th. Dur. & Schinz	H	Poaceae		+
155.	*Peristrophe paniculata* (Foresk.) Brummitt	H	Acanthaceae		+
156.	*Perotis patens* Gand.	H	Poaceae		+
157.	*Pluchea ovalis* Dc.	H	Asteraceae	+	+
158.	*Portulaca* sp.	S	Portulacaceae	+	
159.	*Prosopis juliflora* (Sw.) DC.*	T/S	Fabaceae	+	
160.	*Sida schimperina* Hochst.ex Rich	S	Malvaceae	+	
161.	*Psidium guajava* L.*	T	Myrtaceae	+	
162.	*Oncoba spinosa* Forssk.	T/S	Flacourticeae	+	+
163.	*Ocimum urticifollium* Roth.	S	Lamiaceae	+	+
164.	*Oxygonum sinuatum* (Meisn.) Dammer	H	Polygonaceae		+
165.	*Panicum atrosanguineum* A. Rich.	H	Poaceae		+
166.	*Panicum maximum* Jacq.	H	Poaceae	+	+
167.	*Panicum granitum* L.	T/S	Lythraceae	+	
168.	*Pinus patula* L.*	T	Pinaceae	+	
169.	*Prunus persica (l.) Batsch**	T/S	Rosaceae	+	
170.	*Rhipsalis baccifera* (J. Mill) Stearn.	S	Myrtaceae	+	
171.	*Rhus glotinosa* A. Rich.	T	Anacardiaceae	+	+

Appendix 2. Continued

R. No.	Scientific Name	Habit	Family	Alagae	Neteli
172.	*Rhynchosia minima* (L.) Dc.	S	Fabaceae	+	
173.	*Ricinus communis* L.	H	Euphorbiaceae	+	+
174.	*Schinus molle L.**	T/S	Anacardiaceae	+	
175.	*Senna didymobotria* (Fresen.) Irwin & Barneby	S	Fabaceae	+	+
176.	*Senna occidentalis* (L.) Link	S	Fabaceae	+	+
177.	*Senecio inoranthus* DC.	S	Asteraceae	+	
178.	*Setaria incrassata* (Hochst.) Hack.	H	Poaceae		+
179.	*Setaria pumila* (Poir.) Roem. & Schult.	H	Poaceae		+
180.	*Sida rhombifolia* L.	H	Malvaceae	+	+
181.	*Snowdenia polystachya* (Fresen.) Pilg.	H	Poaceae		+
182.	*Solanum glabralum* Dunal.	S	Solanaceae	+	
183.	*Solanum incanum* L.	H	Solanaceae	+	+
184.	*Solanum nigrum* L.	H	Solanaceae		+
185.	*Sonchus* sp.	H	Asteraceae	+	
186.	*Setaria sagittifolia* (A. Rich.) Walp.	S	Poaceae	+	
187.	*Sida alba* L.	H	Malvaceae		+
188.	*Sida massaica* Vollesen	H	Malvaceae	+	+
189.	*Sorghum arundinaceum* (Desv.) Stapf	H	Poaceae	+	
190.	*Sporobolus africanus* (Poir) Robyns & Tournay	H	Poaceae		+
191.	*Sporobolus confinis* (Steud.) Chiov.	H	Poaceae	+	+

Appendix 2. Continued

R. No.	Scientific Name	Habit	Family	Alagae	Neteli
192.	*Sporobolus consimilis* Fresen.	H	Poaceae	+	
193.	*Sporobolus discosporus* Nees	H	Poaceae	+	+
194.	*Sporobolus festivus* Hochst. ex A. Rich.	H	Poaceae	+	+
195.	*Sporobolus ioclados* (Trin.) Nees	H	Poaceae	+	+
196.	*Sporobolus pellucidus* Hochst.	H	Poaceae		+
197.	*Sporobolus pyramidalis* P. Beauv.	H	Poaceae	+	+
198.	*Sporobolus spicatus* (Vahl) Kunth	H	Poaceae	+	+
199.	*Stylosanthes fruticosa* (Reth.) Alston	H	Fabaceae	+	+
200.	*Tagetes minuta* L.	H	Asteraceae	+	+
201.	*Tamarix nilotica* (Ehrnb.) Bunge	S	Tamaricaceae	+	
202.	*Tephrosia pumila* (Am.) Pers	S	Fabaceae	+	
203.	*Teramnus labialis* (L.F.) Spreng	S	Fabaceae	+	
204.	*Tetrapogon cenchriformis* (A. Rich.) Clayton	H	Poaceae	+	
205.	*Themeda triandra* Forssk.	H	Poaceae	+	
206.	*Tephrosia pumila* (Lam.) Pers.	S	Fabaceae	+	
207.	*Tragus berteronianus* Schult.	H	Poaceae	+	+
208.	*Tragus racemosus* (L.) All.	H	Poaceae	+	
209.	*Urochloa panicoides* P. Beauv.	H	Poaceae	+	+
210.	*Vernonia galamensis* (Cass.) Less. var. *aethiopica* M. G. Gilbert	H	Asteraceae		+
211.	*Vicia spp.**	H	Fabaceae	+	
212.	*Xanthium strumarium* L.	H	Asteraceae	+	+
213.	*Ziziphus spina-christi* L. Desf.	H	Rhamnaceae	+	+

Appendix 3. List of Important herbs and their Importance Values

3.1. Major Dry weight Contributing Herbs of Alagae Wood land

N0.	Scientific Name	% D.Wt. contribution	R.Friq.	*Importance*
	Grasses			
1.	*Hyparrhenia anthistirioides* (Hochst. ex A. Rich.) Stapf	13.47	11.63	12.55
2.	*Cynodon dactylon* (L.) Press.	10.24	13.95	12.10
3.	*Bothriochloa insculpta* (A. Rich) A. Camus.	14.71	9.30	12.01
4.	*Eragrostis tenuifolia* (A.Rich.) Steud.	9.70	9.30	9.50
5.	*Dactyloctenium aegyptium* (L.) Willd.	4.56	9.30	6.93
6.	*Cenchrus ciliaris* L.	4.97	6.98	5.98
7.	*Sporobolos pellucidus* Hochst	1.50	9.30	5.40
8.	*Digitaria ternata* (A. Rich.) Stapf	3.80	6.98	5.39
9.	*Digitaria abyssinica* (Hochst. Ex. A. Rich.) A. Camus	4.61	4.65	4.63
10.	*Hyparrhenia collina* (Pilg.) Stapf	6.58	2.33	4.46
11.	*Hyparrhenia dregeana* (Nees) Steud	4.20	2.33	3.27
	Other Herbs			
12.	*Hypoestes verticilaris* (L. F.) R. Br.	13.85	4.65	9.25
13.	*Solanum incanum* L.	5.14	4.65	4.90
14.	*Abutilon hirtum* (Lam.) Sweet.	1.88	2.33	2.11
15.	*Gnaphalium rubriflorum* Hilliard	0.78	2.33	1.56
	Total	100.00	100.00	100.00

Appendix 3. Continued

3.2. Major Dry weight Contributing Herbs of Alagae Hay Field

NO.	Scientific Name	% D. Wt. contribution	R. Friq.	Importance
	GRASSES			
1.	Hyparrhenia nyassae (Rendle.) Stapf	**20.5**	0.79	10.65
2.	*Cynodon dactylon* (L.) press.	3.44	**17.46**	10.45
3.	*Bothriochloa insculpta* (A. Rich) A. Camus.	4.57	**15.08**	9.83
4.	*Hyparrhenia hirta* (L.) Stapf	4.39	6.35	5.37
5.	*Hyparrhenia rufa* (Nees) Stapf	3.4	6.35	4.88
6.	*Hyparrhenia anthistirioides* (Hochst. ex A. Rich.) Stapf	2.28	7.14	4.71
7.	*Dactyloctenium aegypticum* (L.) Willd.	1.45	5.56	3.51
8.	*Hyparrhenia anamesa* W.D. Clayton	3.55	3.17	3.36
9.	*Panicum subalbidum* Kunth..	**5.03**	1.59	3.31
10.	*Chloris virgota* Sw.	4.62	1.59	3.11
1.	*Heteropogon contortus* (L.) Roem. & Schult.	4.61	0.79	2.70
12.	*Cenchrus ciliaris* L.	3.69	0.79	2.24
13.	*Eragrostis cilianensis* (All.) Vigen. ex. Janchen	1.68	2.38	2.03
14.	*Digitaria abyssinica* (Hochst. Ex. A. Rich.) A. Camus	1.3	2.38	1.84
15.	*Eriochloa fatmensis* (Hochst. & Steud.) Clayton	1.5	1.59	1.55
16.	*Hyparrhenia variabilis* Stapf	1.2	1.59	1.40
17.	*Eragrostis tenuifolia* (A.Rich.) Steud.	1.79	0.79	1.29
18.	*Eleusine floccifolia* (Forssk.) Spreng.	1.77	0.79	1.28
19.	*Themeda triandra* Foresk.	1.76	0.79	1.28
20.	*Sporobolus pryamidalis* P. Beauv.	1.68	0.79	1.24
21.	*Sporobolus consimilis* Fresen.	1.57	0.79	1.18
22.	*Sporobolus festivus* (Hochst. ex A. rich.) Stapf	1.44	0.79	1.12
23.	*Sporobolos pellucidus* Hochist	0.95	0.79	0.87
24.	*Ergrostis papposa* (Roem. & Schult) Steud.	0.7	0.79	0.75
25.	*Cynodon nlemfuensis* Vanderyst	0.54	0.79	0.67

Appendix 3.2 Continued

	SEDGE			
26.	*Cyperus longus* L.	1.91	2.38	2.15
	HRBACIOUS LEGUME			
27.	*Glycine wightii* (Wight & Arn.) Verdc.	1.65	3.97	2.81
28.	*Indigofera* sp.	2.38	1.59	1.99
29.	*Rhynchosia minima* (L.) Dc.	2.2	0.79	1.50
	NON LEGUME HERBS	0		0.00
30.	*Xanthium strumarium* L.	5.23	4.76	5.00
31.	*Solanum glabralum* Dunal.	1.82	1.59	1.71
32.	*Ipomoea hochsteteri* House	1.49	0.79	1.14
33.	*Ocimum urticifolium* Ruth	1.42	0.79	1.11
34.	*Abutilon hirtum* (Lam.) Sweet.	1.28	0.79	1.04
35.	*Achyranthes aspera* L.	1.22	0.79	1.01
	Total	**100**	**100**	100.01

3.3 Major Dry weight Contributing Herbs of Neteli Grazing land

	Scientific Name	% D.Wt. contribution	R.Frq.	Importance
	GRASSES			
3.	*Cynodon dactylon* (L.) Pers.	7.53	**19.05**	13.29
5.	*Eragrostis tenuifolia* A. Rich	5.43	**9.52**	7.48
2.	*Heteropogon contortus* (L.) Roam. & Schult.	**7.99**	5.95	6.97
1.	*Hyparrhenia anamesa* W. D. Clayton	**10.6**	2.38	6.5
15.	*Harpachne schimperi* Hochst. ex A. Rich.	1.79	**10.71**	6.25
9.	*Panicum atrosanguineum* A. Rich.	3.66	5.95	4.81
6.	*Aristida kenyensis* Henr.	4.4	4.76	4.58
8.	*Aristida adoensis* Hochst.	3.89	4.76	4.33

Appendix 3.3 Continued

4.	*Eleusine indica* (L.) Gaertn.	5.84	2.38	4.11
12.	*Eragrostis cilianensis*	2.32	4.76	3.54
7.	*Eragrostis heteromera* Stapf	4.05	2.38	3.22
10.	*Sporobolus pallucidus* Hochst.	3.48	2.38	2.93
14.	*Hyparrhenia dregeana* (Nees) Stent	1.85	3.57	2.71
11.	*Hyparrhenia hirta* (L.) Stapf	2.72	2.38	2.55
13.	*Dactyloctenium aegyptium* (L.) Willd.	2.07	2.38	2.225
16.	*Hyparrhenia nyassae* (Rendle) Stapf	1.45	2.38	1.915
17.	*Penisitum mezianum* Leeke	1.37	2.38	1.875
18.	*Bothriochloa insculpta* (Hochst.ex A. Rich.) A. Camus	1.16	2.38	1.77
	HERBACIOUS LEGUME			
19.	*Stylosanthes fruticosa* (Reth.) Alston	1.73	2.38	2.06
	NON LEGUME HERBS			
20.	*Solanum incanum* L.	**13.9**	2.38	8.15
21.	*Solanum nigrum* L.	7.08	2.38	4.73
22.	*Sida rhombifolia* L.	5.64	2.38	4.01
	TOTAL	100	100	100

3.4. Major Dry weight Contributing Herbs of Neteli Hay field

NO.	Scientific Name	% D.Wt. contribution	R.Frq.	Importance
	GRASSES			
1.	*Sporobolus ioclados* (Trin.) Nees	**12.74**	2.86	7.80
2.	*Heteropogon contortus* (L.) Roam. & Schult.	**9.75**	5.71	7.73
3.	*Eleusine indica* (L.) Gaertn.	4.79	**8.57**	6.68
4.	*Cynodon dactylon* (L.) Pers.	3.26	**10**	6.63
5.	*Panicum subalbidum* Kunth	4.37	**7.14**	5.76
6.	*Harpachne schimperi* Hochst. ex A. Rich.	2.56	7.14	4.85
7.	*Hyparrhenia hirta* (L.) Stapf	4.46	4.29	4.38

Appendix 3.4 Continued

8.	*Dactyloctenium aegyptium* (L.) Willd.	2.96	5.71	4.34
9.	*Bothriochloa insculpta* (Hochst. ex A. Rich.) A. Camus	4.5	2.86	3.68
10.	*Hyparrhenia anthistirioides* (Hochst. Ex A. Rich.) Stapf	3.82	2.86	3.34
11.	*Aristida kenyensis* Henr.	3.72	2.86	3.29
12.	*Aristida adoensis* Hochst.	1.91	4.29	3.10
13.	*Pennisitum mezianum* Lecke	3.22	2.86	3.04
14.	*Eragristis papposa* (Roem. & Schult.) Steud.	1.73	4.29	3.01
15.	*Eragrostis tenuifolia* A. Rich	2.73	2.86	2.80
16.	*Eleusine floccifolia* (Forssk.) Spreng.	3.93	1.43	2.68
17.	*Hyparrhenia variables* Stapf	3.65	1.43	2.54
18.	*Eragrostis heteromera* Stapf	1.99	2.86	2.43
19.	*Hyparrhenia rufa* (Nees) Stapf	2.63	1.43	2.03
20.	*Urochloa panicoides* P. Beauv.	2.62	1.43	2.03
21.	*Sporobolus pyramidalis* P. Beauv.	2.4	1.43	1.92
22.	*Setaria pumila* (Poir.) Roem. & Schult.	2.34	1.43	1.89
23.	*Panicum maximum* Jacq.	0.73	2.86	1.80
24.	*Hyparrhenia nyassae* (Rendle) Stapf	2.01	1.43	1.72
25.	*Sporobolus festuvus* Hochst. Ex A. Rich.	0.29	1.43	0.86
	SEDGE			
26.	*Cyperus sp.*	3.17	1.43	2.30
	HERBACIOUS LEGUME			
27.	*Glycine wightii* (Wight & Arn.) Verdc.	1.95	1.43	1.69
	NONE LEGUME HERBS			
28.	*Pluchea ovalis* Dc.	1.95	2.86	2.41
29.	*Tagetes minuta* L.	2.71	1.43	2.07
30.	*Hypoestes verticillaris* (L.F.) R. Br.	1.09	1.43	1.26
31.	TOTAL		100	100.00

Appendix 4. Tukey Test of Homogeneity between Local Community Types and Environmental Variables of the two Study sites (different letter notations in each column indicate homogenous types)

Alagae							
Community	**Moisture Content**	**pH**	**Conductivity**	**Salinity**	**Altitude**	**Aspect**	**Disturbance**
I	*7.9ab*	*6.79 a*	*241.5 a*	*0.10 a*	*1671 a*	*2.00 a*	*1.00 a*
II	*4.2a*	*7.22 a*	*340.85 a*	*0.15 ab*	*1675 a*	*1.33 a*	*9.75 b*
III	*10.3b*	*6.98 a*	*234.12 a*	*0.00 a*	*1508 a*	*1.67 a*	*7.33 ab*
IV	*8.41ab*	*6.69 a*	*293.93 a*	*0.14 a*	*1635 a*	*1.0 a*	*4.00 ab*
V	*10.9b*	*7.41 b*	*526.28 a*	*0.25 b*	*1683 a*	*2.0 a*	*14.5 a*
VI	*10.9bc*	*7.04 a*	*329.61 a*	*0.11 a*	*1650 a*	*2.1 a*	*7.00 b*
VII	*15.4c*	*7.11a*	*290.36 a*	*0.14 a*	*1650 a*	*2.7 a*	*9.00 b*
Neteli							
Community	**Moisture content**	**pH**	**Conductivity**	**Salinity**	**Altitude**	**Disturbance**	**Aspect**
1	*0.9 a*	*6.58 a*	*113.4 a*	*0.00³ a*	*1730 a*	*3.05 a*	*3.3a*
2	*1.4 b*	*6.68 a*	*161.5 ab*	*0.1 b*	*1722 a*	*2.74 a*	*3.3a*
3	*1.0 b*	*6.64 a*	*105.1 ab*	*0.00 a*	*1727 a*	*2.87 a*	*3.3a*
4	*5.1 a*	*6.51 a*	*194.3 a*	*0.00 a*	*1725 a*	*3.32 a*	*3.3a*
5	*1.0 b*	*6.72 a*	*253.5 b*	*0.10 b*	*1730 a*	*2.88 a*	*3.3a*
6	*2.6 b*	*6.51 a*	*297.5 b*	*0.15 b*	*1721 a*	*2.88 a*	*3.3a*

Alpha=0.05