KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA

COLLEGE OF SCIENCE

DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY

EFFECT OF WILDFIRE ON PLANT SPECIES COMPOSITION AND SOME SOIL PHYSICO-CHEMICAL PROPERTIES OF BOMFOBIRI WILDLIFE SANCTUARY, GHANA

A THESIS SUBMITTED TO THE DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ENVIRONMENTAL SCIENCE

BY

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DECLARATION

I hereby declare that this work is the result of my own research towards the MSc, and to the best of my knowledge no part of it has been presented for another degree in this University or elsewhere, or published by another person except where due acknowledgement has been made in the text.

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(HEAD OF DEPARTMENT) Signature Date

DEDICATION

To my parents, Mr. and Mrs. Anane Agyei, my lovely wife, Augusta Owusuaa Minse, my sons Ben, Nana and Junior, and all my siblings whose support and encouragement have made this work a success.

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ABSTRACT

Forest all over the world is dwindling at a faster rate due to several factors including wildfires. The effects of wildfire on soil physico-chemical properties and vegetation composition were evaluated in Bomfobiri Wildlife Sanctuary in the transitional vegetation zones of Ghana. Four forest types were analyzed; dry deciduous forest fire undisturbed (DDFFU), dry deciduous forest fire disturbed (DDFFD), savannah forest fire undisturbed (SFFU) and savannah forest fire disturbed (SFFD). Dry deciduous forest fire undisturbed and savannah forest fire undisturbed were used as control. Forty (40) sample plots of size 25 m × 25 m, ten (10) from each forest category were demarcated and laid randomly for the collection of plants and soil samples. Four composite soil samples from the dry deciduous (fire undisturbed and disturbed) and savannah (fire undisturbed and disturbed) were analyzed for nitrogen, phosphorus, potassium, organic matter, organic carbon, moisture content and pH. The results of soil analyses showed 0.075% nitrogen in DDFFD as compared to 0.120% in DDFFU and 0.045% in SFFD while SFFU recorded 0.065%. Phosphorus followed similar pattern with 0.017%, 0.027%, 0.013% and 0.014% in DDFFD, DDFFU, SFFD, SFFU, respectively. In terms of potassium, 0.040%, 0.107%, 0.019% and 0.067% were recorded in DDFFD, DDFFU, SFFD and SFFU, respectively. DDFFD, DDFFU, SFFD, and SFFU had moisture content of 12.58%, 21.62%, 11.87% and 10.95%, respectively. Organic matter had 3.73% in DDFFD as compared to 4.33% in DDFFU with 3.72% for SFFU and 1.50% in SFFD. The concentration of soil nutrients measured were significantly higher in the control sample plots as compared to fire disturbed sites. Generally, with plant species diversity, disturbed forest have higher as compared to undisturbed. In terms of plant species composition, trees have higher diversity followed by shrubs with herbs being the least in all the forest types. However with species distribution, trees were evenly disturbed (1.09) in deciduous undisturbed than all the other vegetation cover. It is recommended that there should be fire management plan for all protected areas in Ghana as well as educational campaign to educate the fringe communities on the need to manage the Bomfobiri wildlife sanctuary.

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LIST OF ABREVIATIONS

FAO	Food and Agricultural Organization
FORID	Forest Research Institute of Ghana
NPP	Net Primary Productivity
BWS	Bomfobiri Wildlife Sanctuary
pH	Hydrogen Ion Concentration
OC	Organic Carbon
MC	Moisture Content
OM	Organic Matter
P	Phosphorus
K	Potassium
N	Nitrogen
SOM	Soil organic matter
TOC	Total organic carbon
SOC	Soil organic carbon
SOM	Soil organic matter
F/R	Forest reserve
CO_2	Carbon dioxide
SO_2	Sulphur dioxide
DBH	Diameter at breast height
DDFFU	Dry deciduous forest fire undisturbed
DDFFD	Dry deciduous forest fire disturbed
SFFU	Savannah forest fire undisturbed
SFFD	Savannah Forest Fire Disturbed

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Wildfires are unrestrained fires occurring in wild areas that cause substantial destruction to natural and human resources. Apart from some wet evergreen type of forest, such fires are common to all other types of forests. Prescribed fires are controlled application of fires normally used as wild fuels. Prescribed fire can either be in its normal or changed state under specified environmental conditions. They are confined to a specific area to produce the intensity of heat and rate of spread required to achieve management objectives (Coates, 2017). For the purposes of destruction of forest for agriculture and grazing arranged fires are normally used (Coates, 2017). Wildfires eradicate forests and may cause high human death especially near cities. Fires are unavoidable friends in the management of forest across the globe. From the global standpoint, environmental degradation including global warming is attributed to wildfires (Zhengxi *et al.*, 2007). Fire is also a significant ecological factor in the management of forest. It contributes to shaping of the evolution of species (Certini, 2005).

Physical, chemical and biological properties of soil can be changed significantly by wildfires. (Sacchi *et al.*, 2015). Fire effects are mainly visible in the upper part of soil, where erosion processes are favoured (Gray and Dighton, 2006). It may also affect soil by reducing the quality and quantity of nutrient and change the structure of organic matter. (Sacchi *et al.*, 2015). Generally, fire increases nutrient availability on the surface of the soil due to the addition of ashes from burnt vegetation and burning of organic forms. The nutrient content of soil may also increase, decrease, or remain unaffected (Fernández-Férnandez, 2017). The wildfire effects on soil and vegetation is also determined by pre-burn changeability of the soil and vegetation, season of burning, frequency and fire behaviour.

In Ghana, especially in the transition vegetation zones, wildfires have mainly contributed to the ruin of forest and its resources, and have created permanent effects on flora, fauna, landscape and soil (Kusimi & Appati, 2012). Wildfires have directly caused significant damage to the environment in Ghana. Wildfires were comparatively uncommon before the 1983 fires in the country. From the 1982/83 severe drought, wildfires are now common in almost all vegetation forms especially around the dry seasons (Kusimi &Appati, 2012). In some parts of Ghana, land is degrading at a fast pace because of wildfires, which have forever ruined important, but delicate organic soil nutrients.

1.2 Problem Statement

In spite of the importance of wildfire in the management of forest resources in Bomfobiri Wildlife Sanctuary, wildfires have negative effects on forest biodiversity. They have contributed to the extinction of some plant species and change some soil physico-chemical properties. Wildfires also contribute to the destruction of ecological habitat and pollute the air thereby releasing chemicals, which are harmful to human health. Carbon dioxide, a key greenhouse gas, is one of these chemicals which are released into the atmosphere during wildfires. This ecological effect of wildfires on plant diversity and soil fertility have become a subject of intense discussions, particularly in the savannah and transitional vegetation zones of Ghana, where wildfires are common place.

Bomfobiri is one of the wildlife reserves located in the transitional vegetation zone where wildfire occurs annually, but there is lack of empirical evidence on the effects of wildfire on plant species and some properties of soil. This study addresses this research gap, by explaining the effects of wildfire on plant species and some soil physico-chemical properties of the Bomfobiri wildlife sanctuary, Ghana

1.3 Justification of Study

Presently, wildfires have been a main threat in the protection and managing of the forest resources and biodiversity in Ghana (Kusimi & Appati, 2012). Understanding wildfires effect on plant species and soil physico-chemical properties to all land managers is very crucial in the sustainability and conservation of forest resources (plant and animal species), and hence, the need to research into wildfire effects on plant species and some soil physico-chemical properties. The information generated will link the knowledge gap and could be valuable for (i) the effective information development on the prevention and controlling of wildfire in fire prone areas, and (ii) prevention and control of fires to rehabilitate forest to safeguard the economic and environmental benefits.

1.4 Objective of the Study

The main objective was to examine the effects of wildfire on plant species and some soil physico-chemical properties in Bomfobiri wildlife sanctuary in the Sekyere Kumawu and Sekyere Afram Plains Districts of the Ashanti Region, Ghana.

1.4.1 Specific objectives

The specific objectives were to:

1. Determine wildfires effect on plant species diversity and abundance at the different forest sites.
2. Determine soil physico-chemical characteristics (nitrogen, phosphorus, potassium, moisture content, organic carbon, organic matter and pH) at the different forest sites.
3. Determine whether vegetation type modulates the fire effect on the plant species and diversity.

1.5 Hypothesis

The following hypothesis were tested:

(i) Plant species diversity and abundance would be lower in frequently fire disturbed forest compared to fire undisturbed forest.

(ii) Soil physico-chemical properties (N, P, K, MC, OC, OM, and pH) levels would be higher in fire disturbed forest sites relative to fire undisturbed forest sites

(iii) Different vegetation types determines the effect of frequent fires on plant species diversity.

1.6 Organisation of the Study

This study is divided into six chapters. Chapter one focuses on background of the study, problem statement, justification of research, objectives, hypothesis and the organization of the study. Chapter two examines literature on the subject under study. The literature review focuses on relevant subjects like historic accounts of forest fires in Ghana, effect of wildfires on vegetation, soil physical properties like organic matter, moisture content, organic carbon and chemical properties of soil like nitrogen, potassium, phosphorus and pH. Effects of wildfires on soil microorganisms and chemical changes, and nutritional losses and availability of soil. Chapter three deals with location and general description of study area, legal status, socioeconomic settings, fauna and flora of the study area, geology& soil profile, climate, study design, vegetation sampling, soil sampling , sampling handling ,methods and procedure for analysis. Chapter four focuses on the results obtained from the field. Chapter five discusses the results obtained from the field. Chapter six presents the findings, conclusion and recommendations of the research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Wildfire and its Effects

Wildfires are paradox, it is the foundation of forest redevelopment and of nutrient reprocessing but can also destroy plants and animals, and cause extensive ecological damage (Sapkota, 2017). Effects of wildfire on plant species and subsequent productivity of soil are linked to both the major effects of combustion and soil heating, and minor effects of post-fire soil erosion. The amount of organic matter consumed and temperatures reached within the soil are determine by wildfires effect on physical, chemical and biological properties of soil. Plant available nitrogen is influence by speedy mineralization of organic matter during burning (Certini, 2005). However, with the increase in temperatures, nutrients are lost through the process of volatilization (Gray and Dighton, 2006). Effects of fire on vegetation is influenced by vegetation type, fire intensity and the season of burning. Whereas fire influence the rejuvenation of certain forest plant species, the maximum temperatures reached within the soil profile during fire determines regeneration potential of other species, which affects both recognised roots and soil seed bank. Wildfire effects on plant species and properties of soil varies. Fire intensity, temperature, type of vegetation and amount of soil moisture among other factors can be attributed to these variations (Kennard and Gholz, 2001).

2.2 Historical Accounts of Forest Fires in Ghana

The issue of wildfire seems to be an essential theme in forest management, because destructions cause by fires to forest is an interesting 'man versus environment' conflicts in Ghana. Management of forest ecosystems in the country is adversely affected by anthropogenic caused fires. Ecosystems are no more natural but biotically disturbed leading to irreparable damage as a result of alteration in fire regime. For instance in between 1982 and 1983, Ghana was hit by severe bushfires and an assessment by the Food and Agricultural Organisation (FAO) during

1982 and 1983 revealed that 50% of Ghana's vegetative cover and 35% of her standing crops were burnt by bushfires (Ampadu-Agyei, 1988). Beyond these periods, there has been series of reported cases of bushfires in Ghana especially around the transitional to savannah belt (Kusimi, & Appati, 2012; FORIG, 2003).

Fire controls the composition and structure of vegetation over most parts of Ghana. According to Hoffmann & Moreira (2002), the damage caused by fire in Ghana during the long drought of 1982-1983 has significantly changed the structure and composition of 30% of the semideciduous forest. Hoffmann & Moreira (2002) shared this view. Moreira (2000) stressed that without regular fires, large areas of savannah would have been forested and at least supported greater trees density than now. Fire is considered a major hindrance to the long term productivity, genetic wealth and general health of the semi-deciduous forest, which covers about half of the forest remaining in Ghana. Although wildfires have played some role in fasttracking environmental degradation particularly in the delicate savannah ecosystem, much attention has not be given in environmental discussions and decisions as likened to tropical deforestation and desertification which have received extensive attention in environmental discussions. This is not different from various occasional hazardous phenomena, issues of wildfires takes the centre stage in mass media reportage during the dry season and appear to be overlooked when the risk disappears with the start of the rains. Thus, very minute information and published data are obtainable regarding early detection, preventive measures, the frequency, intensity, duration and wildfire effect on the environment and human welfare in Ghana (Kusimi & Appati, 2012).

2.3 Effects of Wildfire on Vegetation

Globally fire destroys trees. In the year 2000 about 350,000 ha of forests were burned, equivalent to 6% of the global environmental zone (Flannigan *et al.*, 2009). The level of destruction hinge on the type of species, age, vegetation types and fire intensity. Fire enters forestlands by deliberate and accidental means (Kodandapani *et al.*, 2008). The gathering of non-timber forest products by numerous local societies normally leads to the introduction of fires to the forest by the community members (Saha, 2002). The degree of harm and reply of tree species to fire hinge on certain fire factors such as severity, soil heating and intensity, burning season, time since last fire was recorded and residence time. Furthermore, physical and climatic factors including weather, topography of the area, biological factors and fuel conditions determine subsequent effects of fire on plant communities (Narendran *et al*., 2001).

Periodically dry tropical forests are said to be the most vulnerable from natural fires, land use alteration and escaped fires subsequent to slash and burn agriculture practise in the dry season (Kauffman *et al.*, 2003). Fires also affect carbon accumulation and biomass by directly reducing their storage in dry tropical forests (Van der Werf *et al.*, 2003). There are substantial effects of wildfire on carbon storage pattern and biomass of tree species compared to shrubs. This is because shrubs produce more biomass in forests where there are frequent fires occurring as compared to protected sites (Jhariya *et al*., 2014).

Jhariya & Oraon (2012) attested to the fact that fire stimulate diversity and richness of tree seedling and it may kill root-crown sprouters. Decrease in species abundance over time shows that forest fires might be caused mostly by the removal of some initial species which were over topped and shaded out by rapidly growing fire hardy species. There was 44% decline in seedling population in high fire zones after fire season, which will have negative effect on the forest stratification in the near future. Native plant diversity is also affected by fires, with changing effects on species and ecosystems including the potential for localized extinction (Kittur *et al.*, 2014). According to Lange *et al.*, 2014, diversity of plant species is affected by fires positively. Reasearch conducted by Saha and Howe (2003) revealed that, diversity was higher among small plants in plots that are fire-excluded than those burnt.

Vulnerability of shrubs to fire is determined by certain morphological characteristics like height, branch density, crown size and shape, crown base location with respect to surface fuels and total crown. In general, plants with small buds and branches are more vulnerable to toxic heating than large ones. Thickness of bark, cracks, moisture and composition content of shrubs determine the extent of fire effects. Plant root mortality can be cause by fire. Sheuyange *et al.*, (2005) stressed that regular fires decrease shrub cover temporarily and promotes herbaceous cover. Regular fires influenced tree and herbaceous species positively. Forest canopies that are disturbed by surface fires by opening up and increase in sunlight can lead to understory layer development (Payette and Delwaide, 2003). Jhariya & Oraon (2012) counted shrubs and herbs in 4 sites namely, high, medium, low or non-fire zone, of tropical forest ecosystem of Chattisgarh and indicated that, the density of herbs and shrubs change from 1,120 to 2,480 individuals per ha in the pre-fire season with 1,920 to 3,360 persons a ha after fire season. A total of 11 species were recorded during the pre-fire season while there was an increase by 20 species after the fire. Wienk *et al.*, (2004) asserted that only burning can lead to an increase in abundance of forbs and under story species richness. Number, density and diversity of herbs increase after fire due to a reduction in number of tree species. According to Sahu *et al.* (2008), the potential of shrubs and herbs to rejuvenate naturally as a result of fire are common. Fire largely influences highest species diversity in relatively disturbed ecosystem than in an undisturbed ecosystem (Shafiei *et al.*, 2006).

2.4 Effects of Wildfire on Some Soil Physical Properties

2.4.1 Organic matter (OM)

Organic matter in soils can be classified into six simple components and it is normally found on, or near, the surface of the soil. The components are:

(i) The litter layer, containing the identifiable plant litter.
(ii) The duff layer, consisting of partly decayed, but identifiable plant litter.
(iii) The humus layer, composed of extensively decomposed and fragmented organic materials.
(iv) Decomposed wood, including the residual lignin matrix from decomposing woody material found on the soil surface.
(v) Charcoal, or largely charred wood that is homogenized into the mineral soil.
(vi) The top A horizon of the underlying mineral soil (Jurgensen *et al.*, 1997).

Soil organic matter (SOM) is a key component in the chemical, physical and biological properties of the soil hence enhancing the overall productivity of soil. The organic matter of the soil acts as the basic pool for the storage of many nutrients, hence, it is the source for the existing phosphorus (P), sulphur (S) and almost all of the existing nitrogen (N). The role of SOM in the storage of nitrogen is particularly significant in forests because their high productivity rest on, to a large degree, on more supplies of existing nitrogen. During the process of decomposition, nutrients present in organic matter are released gradually and providing a steady source of nutrients that keep losses of leaching at low rates. Humus and SOM also offer chemically active cation exchange sites that preserve most of the significant ions (NH_4^+, K^+, Ca^{2+}). It was projected that SOM can produce more than 50% of the CEC of some forest soils. In addition, it is an active agent in maintaining most metals. OMs function as a strong combining agent thus, plays an essential role in forming and retaining an aggregated soil. This property of the soil enhances the structure of the soil that forms macro pore space and increase the aeration ability of the soil. Non-aggregate soils containing less OM have less infiltration rate as likened to aggregate soils with more OM and higher infiltration rates. OM provides conducive environment and carbon compounds that serve as source of energy for soil microorganism. Both functions are essential for maintaining the nutritional quality and capillarity of forest soils (Lehmann *et al*., 2002).

2.4.2 Moisture content (MC)

Soil moisture content refers to amount of water that soil can hold for the plant usage. It is influence largely by soil texture. Porosity is high in silt loam and loam soil. Sandy loam (Coarse texture) have less microscopic surface area to hold water for plants as compared to fine textured soils (silty clay loam, clay, etc.). Pore space, soil structure, and aggregation are all soil physical properties that are affected adversely by heat during a fire. Wildfire also may have impacts on these soil nutrients, thereby damaging the soil texture, and reducing soil porosity. An important physical property affected by fire is water repellence. It regulates the hydrology of a soil (DeBano, 2000). The amount of water repellence formed hinge on the difference in temperature gradients near the surface of soil, soil water content and soil physical properties. Soils that are coarse-textured are most vulnerable to heat- induced water repellence as compared to finetextured clay soils. During the first rains after burning, there is increase in erosion and surface runoff due to the creation of water-repellent layer, in conjunction with protective plant cover loss. Infiltration is reduced by a water-repellent zone which can result in massive rill erosion on burnt watersheds (Doerr *et al*., 2009).

2.4.3 Organic carbon

Soil organic matter (SOM) contains organic carbon (OC). Organic carbon (OC) enters soil by the decay of plant and animal remains, roots, exudates, living and dead microorganisms and soil biota. Non-decomposed plants and animals residues forms the organic fraction of soil organic matter. SOC serves as the core source of energy for microbes in soil. The speed and the easiness with which soil organic carbon becomes present are associated to the division of the SOM in which it exist. Soil organic carbon is a very vital constituent of the soil because of its ability to enhance plant growth by acting as source of energy and activate nutrients available through mineralization. Soil microorganisms takes their energy from the fraction of organic carbon present in the soil. Organic carbon compounds such as polysaccharides (sugars) contribute in aggregate stability, nutrient and water holding capacity and bind mineral particles together into micro aggregates. About 20% of soil carbon may be accounted for by glomalin, a soil organic matter substance which cements aggregates and stabilizes the structure of the soil making soil resistant to erosion but, more porous to enable water, plant roots and air to pass through the soil. Notwithstanding, poor SOC reduces microbial biomass activity and nutrient mineralization due to storage of energy source. (Six *et al.*, 2004)

2.5 Effects on Some Soil Chemical Properties

2.5.1 Nitrogen

Nitrogen is very important nutrient as a result of its ability to limit the growth of trees in forests as well as other wild land ecosystems (Britton *et al.*, 2001). Due to this, essential N losses in a fire could negatively affect productivity in a long term in most wild land ecosystems, especially if the replenishment systems of N are not made available during post fire management. Forest litter and soil that are unburnt contained nitrogen which is discharged exclusively by biological processes and is being controlled by "biogeochemical cycling" (Vincent *et al.*, 2010). Carbon(C) and nitrogen (N) have close relationship, C: N ratios play key function in maintaining the decay level of OM. Hence, regulating the level at which nitrogen and other nutrients are discharged and circulated.

2.5.1.1 Nitrogen fixation

The process by which atmospheric nitrogen are converted into nitrate which are usable by plant through symbiotic and non-symbiotic relationship between certain plants and microbes. Some tree species like nitrogenous plants, have the capacity to change or reduce the $N_{2.}O$ of the atmosphere. Chemoheterotrophic microorganisms such as *Clostridium*, *Azotobacter*, *Beijerinckia* and *Pastorianum* species have the ability of using nitrogen in the atmosphere to create their cell protein which is converted to ammonia to form part of the nitrogen available to plants upon the death of an organism. Other microbes like algae have the ability of fixing atmospheric nitrogen. Nitrogen is mainly found in organic forms in soil. It moves in the anionic form in plants and soil.

2.5.2 Phosphorus (P)

Phosphorus is known to be limiting in some forest ecosystems. The interrelationship between mycorrhizae and OM determines phosphorus availability and uptake to plants instead of being a meek absorption from the soil solution (Lynch *et al.*, 2001). Brady & Weil (2013) indicated that, phosphorus is a major component in agricultural and natural ecosystems. Naturally, phosphorus supply in soil is small with its availability being very low. Phosphorus from the atmosphere and rainfall into the soil are negligible. Phosphorus does not release gases into the atmosphere. As a result natural ecosystems that are undisturbed loose little of this nutrient, neither does it seep into the soil with drainage water. P is strictly associated with human and animal activity. For example, large amounts of this element are contain in human bones and teeth. High concentrations of phosphorus in soil are signs of activities of previous animals or humans in the area because they are normally scarce. Lack of adequate available phosphorus in extreme cases, contributes to land degradation in many developing nations of subtropical and tropical regions. Phosphorus deficiency restricts the growth of plants and may lead to failure of crops. Inadequate P could slow the natural vegetation regrowth on disturbed forest and savannah sites as well as reduce the prevention of erosion of the soil and depletion of organic matter (Brady & Weil, 2013).

2.5.3 Potassium (K)

Potassium is another essential elements, apart from nitrogen and phosphorus that limit plant productivity. Low levels of soil potassium also reduces crop quality and restricts plant growth. There are large quantity of this nutrient in most soils but they are tied up in the form of insoluble minerals and is unobtainable for plant use. Carefully management practices are necessary to make large amount of potassium available for plant growth. Also potassium is only available in the soil solution as a positively charged cation, K^+. Potassium do not form any gases that could be lost to the atmosphere. Its behaviour is influenced basically by soil cation exchange properties (Brady & Weil, 2013). The soil saturation is determine by the balance of these cations, which plays an important role in regulating pH levels in soils.

2.5.3.1 Role of potassium (K) in plant nutrition

Potassium activate more than 80 different enzymes responsible for the process of nitrate reduction, energy metabolism, starch synthesis, sugar degradation and photosynthesis in plant. Potassium is part of plant cytoplasmic solution and have a vital role in lowering cellular osmotic potentials, thereby reducing the loss of water from leaf stomata and increasing the capability of root cell water up take from the soil. These contributes to promoting and production of desirable grains and large tubers. Good potassium nutrition also leads to better drought tolerance, improved winter hardiness, healthier resistance to certain fungal diseases, and greater tolerance of insect pests. Again the quality of flowers, fruits and vegetables as well as increasing flavour and colour and strengthening stems are augments by good potassium levels (Brady & Weil, 2013). The favoured concentration of K for plant growth ranges between 100-200 mg/kg (Leigh & Wyn Jones, 1984).

2.5.4 Soil pH

Soil Acidity normally declines after fire as a result of damage of organic acids and their contribution, bases and oxides from ash (Granged *et al.*, 2011a). Soil organic matter decrease as a result of combustion and pH ranges between 4 and 5 units due to loss of OH- groups from clay minerals, the formation of oxides and release of cation or replacement of portion in the cation exchange complex, (Dikici & Yilmaz, 2006).Some writers indicate that, there is decreasing levels in pH of soils exposed to high laboratory temperature although soil heating experiment under laboratory condition usually do not consider the effect of ash (Terefe *et al.*, 2008). Generally the increase in pH is short-lived as a result of the formation of new humus and leaching of bases, although up to 50 years have been required to recuperate pre-fire soil pH in some cases. This period also hinge on buffer capacity of soil, but pH may sometimes recover very quickly after removal of ash by erosion processes (Zavala *et al.*, 2009).

2.6 Effects of Fire on Soil Microorganisms

Soil heating directly kills or alter the productive capabilities of microorganisms. OM (energy source) is indirectly alters by soil heating and improves availability of nutrients, hence having adverse effects on successive growth of microbes. The association between microbes found in soil and soil heating depends on heating duration, maximum temperature and water found in soil (Choromanska & Deluca, 2002). Microbial group's response differently to nitrifying bacteria and temperature appear to be significantly sensitive to heating of the soil. Population of microbes that are active in moist soil are extra irritated than populations in dry soil that are adamant. Endo- and ectomycorrhizae are important classes of soil microbes that are significantly sensitive to heating of soil during fire. Mostly ectomycorrhizae is found in the OM on or near the soil surface, the loss of shallow organic layers may be at least partly accountable for the reported fire-related decreases in ectomycorrhizal activity. For example, (Certini, 2005) reported that vesicular-arbuscular mycorrhizae [VAM](ectomycorrhizae) in woodlands were affected by soil heating .This decrease in VAM colonization may be key factor affecting the long-term productivity of forest ecosystems.

2.7 Soil Nutrient Losses & Availability

2.7.1 Nutrient losses

N, P, K and S, have low temperature standards and are simply volatilized It is significant to take their losses into consideration. Nitrogen which is likely to be restrictive in forest ecosystems would be used to demonstrate losses of nutrient by the process of volatilization. Choromanska & Deluca, (2002) reported that the amount of total N volatilized in burning has been reported to be related directly to the amount of OM burnt. Most of this volatilized N reverts to Nitrogen gas. Grogan *et al.,* (2000) also indicated that this link might not hold at lower temperatures due to OM decaying without volatilizing N. Loss of N is not relative to the OM loss (Giardina *et al.,* 2000). The N that is not volatilized stays on the site in highly available ammonium-N (NH_4-N) or un-combusted fuels in the soil (Giardina *et al.*, 2000). Reaction of phosphorus to fire is different. Only about 60% of the total P is destroyed by nonparticulate transfer when fuels are consumed entirely (Giardina *et al.*, 2000). In view of this, large amounts of highly available P can be found in the ash and on the soil surface directly following fire. Percentage loss of S by the process of volatilization is in between N, P and burning has been reported to remove 20 % to 40 % of the S in aboveground biomass (Barnett, 1989).

2.7.2 Nutrient availability

There are two different processes involve in nutrient availability changes:

(1) In situ changes

(2) Translocation of organic substances downward into the soil (DeBano *et al.,* 2000). Nutrients contained in soil OM are directly disturb by heating the underlying mineral soil. The reaction of the various nutrients to heating show that little change is likely to occur more than 4-5 cm below the surface of the soil, unless an extreme, long-duration fire occurs. Nutrients present especially N in soil can be enhanced by seeping nutrients into the soil downward during a fire. This is as a result of difference in temperature gradients produced in the upper soil layers during the combustion and humus on the surface of the soil. In the process of combustion, surface soil temperatures may surpass 1,000°C. Some of the vaporized OM and ammoniumrich nitrogenous compounds freed during combustion are transferred downward where they condense in the cooler underlying soil there by resulting in poor heat transmission (DeBano *et al.,* 2000).

During the combustion of plants and litter, large amounts of total N are lost ,accessible NH_4-N is usually higher in the underlying soil subsequent to fire because of the transfer mechanism(DeBano *et al*., 2000).The rise in N availability (as NH_4-N) observed instantly after fire appears related to the soil temperatures reached. For example, very hot fire mostly leads to soil N volatilized, mainly on or near the soil surface, and only minor amounts are transferred downward in the soil. On the contrary, under cooler soil-heating conditions, considerable amounts of NH_4-N can be located in the ash and underlying soil. Therefore, depending on the severity and length of the fire, concentrations of NH_4-N may rise, decline, or remain unaffected. Phosphorus does not look to be translocated downward in the soil profile as willingly as N compounds. As a result, P increases mainly in the ash and on, or near, the soil surface (Certini, 2005).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

3.1.1 General description of study area

Bomfobiri Wildlife Sanctuary (BWS) is one of the eighteen protected areas managed by the Wildlife Division of the Forestry Commission Ghana and situated within the transitional vegetation zone of the country. It has a total area of 53 km² and was carved out of the Boumfum Forest Reserve. BWS was gazetted by the Wildlife Reserves (Amendment) Regulations, L.I. 1022 in 1975. Its location is between 6° 54' to 6° 61' N latitude and 1° 07' to 1° 13' W longitude. It is situated in Ashanti Region specifically on the Kumawu Traditional Area. It is 67 km North-East of Kumasi. Bomfobiri is among three designated wildlife sanctuaries in Ghana and was established mainly for its diverse plants and animal species, and associated ecological values. Originally, about two-thirds of its vegetation was reputed to be semideciduous rainforest while the rest remained as typical savannah. However, the incidence of bushfires has downgraded the rainforest to a mosaic of remnant forests interspersed with savannah grasses and woodlands.

Its vegetation is typically semi-deciduous forest enclosing areas of more open savannah with sandstone outcrops. It can boast of over 141 species of birds; including the Great Blue Turaco, variety of hornbills, like the Yellow casqued hornbill. Also 26 species of mammals like red river hog, buffalo and species of duikers. There also five species of primates including Green and Mona monkeys and the three species of crocodiles. The sanctuary can also boost of two waterfalls.

3.1.2 Establishment and legal status

Bomfobiri Wildlife Sanctuary (BWS) had initial size of 16.8 km² within the Boumfum Forest Reserve. On 23rd day of March 1946 it was established under the Ashanti Authority Ordinance (Fig 3.1). During the gazetting, it was expanded and re-designated to present size as Bomfobiri Wildlife Sanctuary (BWS) by the Wildlife Reserves (Amendment) Regulation of 1975 L.I. 1022.

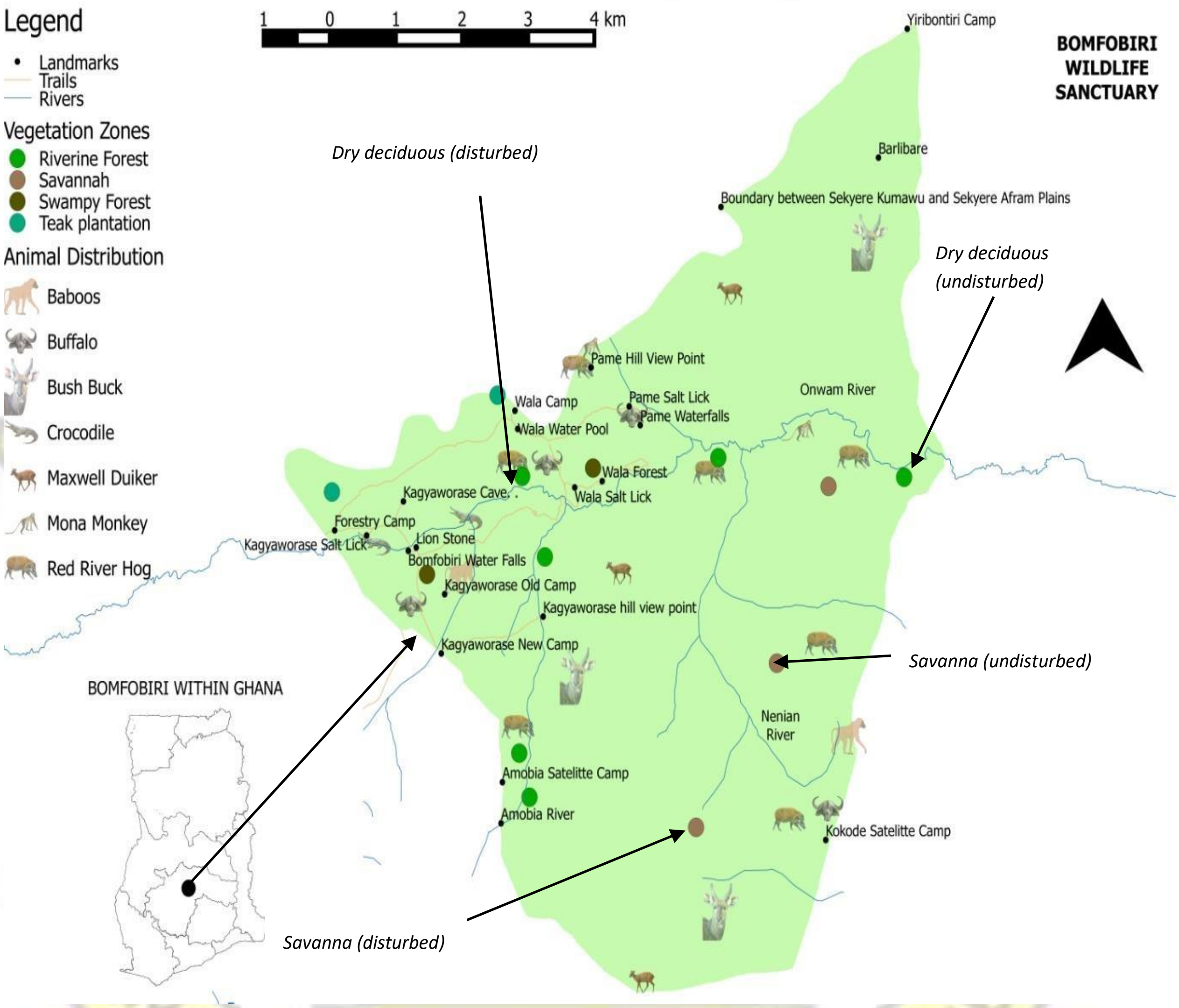

Figure 3.1: Map of Bomfobiri wildlife sanctuary

3.1.3 Flora

The forest within the Kumawu area has been classified as "Dry semi-deciduous fire zone" (Hall and Swaine, 1981) and according to the dominant species, "Moist semi-deciduous forest zone, *Antiaris-Chlorophora* association" and the vegetation on higher and rocky areas with shallow soils are Guinea savannah woodland (Taylor *et al.*, 2001). Five main plant communities have been identified; Remnant *Antiari-Chlorophora* forest, riverine and swampy forest, vegetation of rock outcrops, typical savannah vegetation and teak plantation. More than 50 % of BWS is covered by disturbed forest, which developed after the nationwide bushfires of 1983 and is now maintained by subsequent annual bushfires. This represents the remnants of the former semideciduous forest of *Antiaris-Chlorophora* association. Narrow bands of dense riverine forest are restricted mainly along the Ongwam and Amobia rivers and some of the seasonal streams.

However, only grass can grow on rock outcrops associated with shallow soils. The Guinea Savannah supports fire resistant trees, which seldom form a close canopy, associated with tall grasses of the *Andropogon* and *Panicum spp.* The north-western corner of the reserve is occupied by teak (*Tectona grandis)* plantation established in 1914 by the then Forestry Department.

3.1.4 Fauna

Based on field patrol reports, field surveys, direct observation, indirect methods of establishing the existence of species in the sanctuary and use of habitat and interviews conducted in fringe communities, BWS is found to still abound in several species of animals. They include 141 species of birds, mammals species of 26, 5 primates species, insects, reptiles, butterflies and reptiles, some of which are of special status and interest to the international community.

3.1.5 Geology and soils

The geology of the area belongs to the Voltaian system; sediments late Precambrian to Paleozoic age (300-1000 million years).The soils of the Sanctuary are consist of three soil associations, developed over course grained Voltaian sandstone:

i. The Bediesi-Sutawa-Bejua association, ii.
   The Yaya-Pimpimso-Bejua association iii.
   The Damango-Murugu-Tanoso association

The first two associations comprise shallow Leptosols on sandstone outcrops and steep upper slopes and forest Ochrosols which are red, fine sandy loam on upper to middle slopes and brownish yellow loamy sands on lower slopes. The Damango-Murugu-Tanoso association consist of savannah soils found only in the northern part of the sanctuary. The soils are good for the cultivation of food and cash crops.

3.1.6 Climate

There are no weather records for the sanctuary. However records obtained from Asante Mampong (25 km north-east of the sanctuary) indicate an average annual rainfall for the period 2001-2017 to be 1331.7mm. The area has two rainfall regimes; the major season is from AprilJune and minor season from September- October.

3.2 Study Design

The research takes the formula of a cross-sectional study where data were collected from dry deciduous (fire disturbed and fire undisturbed sites) and savannah forest (fire disturbed and fire undisturbed sites). Fire disturbed and undisturbed forest were selected by visually assessing the sites with the help of GPS and compasses. Forty (40) sampling plots of 25m x 25m were distributed randomly in the different forest types and their GPS coordinates recorded. Ten (10) plots in each forest type.

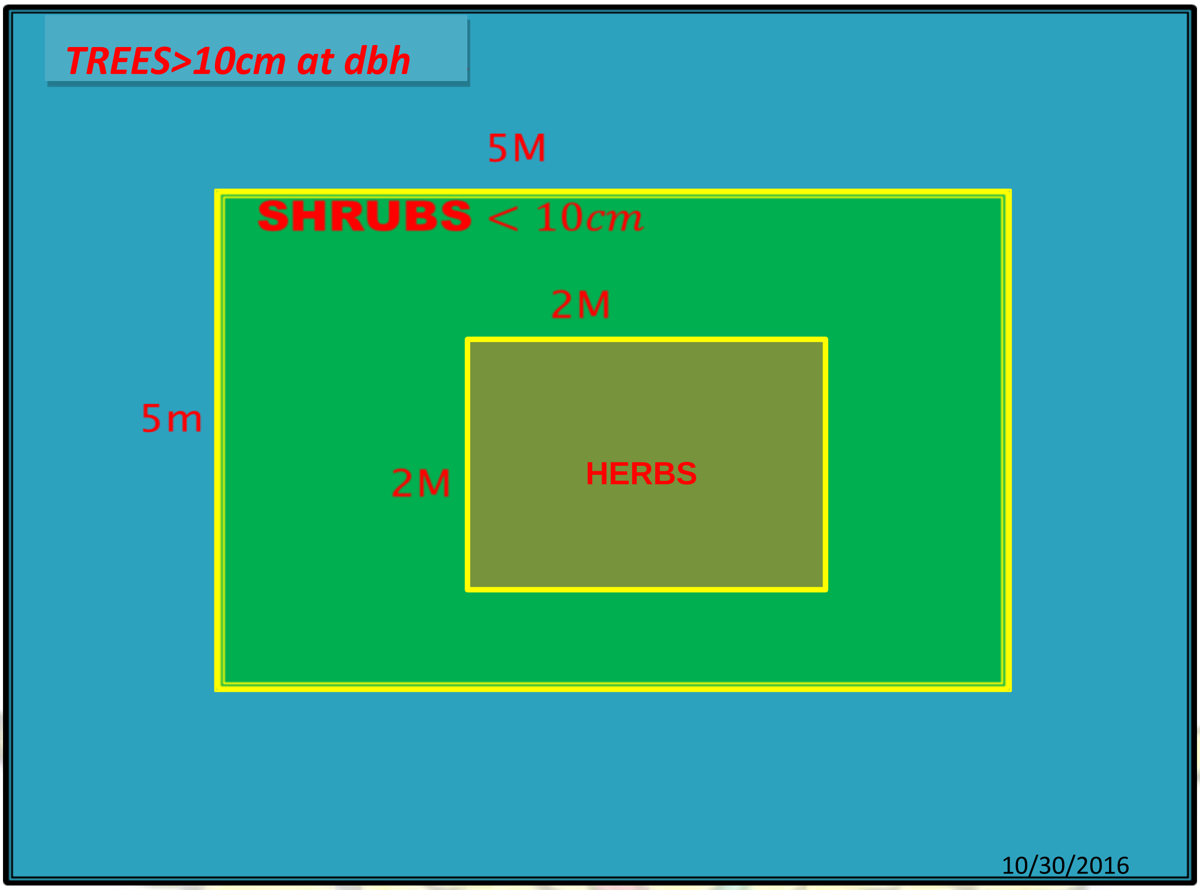

Figure 3.2: A typical sampling plot

3.3 Vegetation Sampling

All trees (≥10 cm of diameter at breast height) were enumerated in 25 m × 25 m plot (using diameter tape for measurement of diameters of species). Shrubs of <10 cm of diameter at breast height with 1.5 m in height were also identified and enumerated within a subplot of 5 m × 5 m in the larger plot. Herbs (seedlings) were also identified and enumerated within smaller subplot of 2 m × 2 m in the larger plot. Simple random sampling was used to enumerate plant species within these plots. The plant species composition identified and enumerated was presented in a tabular form for further analysis.

The plants species composition was examined using Shannon Wiener diversity species index to determine the species abundance and its diversity indices as described by Sugar *et al*. (2003). The Shannon-Weiner diversity index formula:

$$H' = -\sum_{i=1}^{s} Pi \ln Pi$$

Where s is the number of species, *pi* is the relative abundance of each species calculated as the proportion of individuals of a given species to the total number of individuals in the community (ni/N), where ni = the number of individuals in each species and N = the total number of all individuals, *Ln*pi is the sum of proportion times natural log of proportion of individual species. Relative frequency is calculated as the degree of dispersion of individual species in an area in relation to the number of all the species occurred (See in Anning *et al*., 2008)

Relative density deals with numerical strength of a species in relation to the total number of individuals of all the species (See in Anning *et al*., 2008)

Importance value index (IVI) of the species was computed as the average of the sum of the species relative density and relative frequency (See in Anning *et al.*, 2008).

3.4 Soil Sampling

A quadrat size of 1 m × 1 m was laid at each selected subplot for two times at two different spots. The spots were selected randomly within each demarcated plot. Soil samples were collected with the assistance of soil auger of depth 0-20cm of soil profile. Soil nutrient content can vary significantly by depth. Within the top 3-10 inches of the soil is the zone where most fertilizer and crop residue is located. It normally has much higher levels of organic matter, nitrogen (N), phosphorus (P), potassium (K) and micronutrients as compared to soil below. In light of the above, soil auger helps in the collection of soil samples of equal amount over the entire depth of soil. Field variability can also be an issue, especially in fields with variety of soil textures or parent materials. To cater for field variability, a composite sample was gathered, representing all areas of the field. Ten samples were taken from each forest type; dry deciduous forest (fire disturbed and undisturbed), Savannah (fire disturbed and undisturbed) making a total of forty (40) samples and then sent to the laboratory for analyses. Samples were bulked and sub-samples in forest type and bagged, labelled and send to laboratory for analyses. The 10 samples from each forest category were thoroughly mixed to form composite samples as stated below: Dry deciduous forest (disturbed) =DD, Dry deciduous (Undisturbed) =UD and Savannah disturbed=SD, Savannah undisturbed=SU.

Dry deciduous disturbed sites (DD1+DD2+DD3....DD10= D),

Dry forest undisturbed sites (UD1+UD2+UD3+.......UD10=UD),

Savannah disturbed sites (SD1+SD2+SD3........+SD10=SD),

Savannah Undisturbed (SU1+SU2+SU3+.........SU10=SU).

3.4.1. Sample handling

The way samples are handled from collection points to analysis can affect the results. For instance NO_3-N concentration is always in flux in moist soils due to the activity of soil microbes therefore it is imperative to handle samples well to avoid wrong results. Samples collected were put in air tight containers and were kept under room temperature until they were transferred to the laboratory for analysis.

3.5 Soil Chemical Analysis

3.5.1 Determination of total nitrogen

Soil nitrogen exist in both mineral (inorganic) and complex organic forms. The inorganic forms are accessible for plant uptake whiles organic forms are not readily accessible. Potassium chloride extraction is most systematic method commonly used in determining mineral N concentration in soils.

A "Kjeldahl" digestion approach as described by Bento,J.J, (1991) was used to determine the total nitrogen of soil samples.

3.5.2 Determination of phosphorus (P) in soil extracts

The "Olsen", or bicarbonate, extraction test is the most appropriate laboratory method for P determination in soils with pH greater than 6.2. During this test, weak solution of sodium bicarbonate is used to extract dry soil; to prevent the extraction of P that would not normally be available for plant in alkaline soil, the extracting solution is adjusted to pH of 8.5. For soils with pH < 6.2, the "Bray" extraction test is most appropriate. The Bray extraction solution is mildly acidic, and therefore similar to soil solution pH in these soils. Only small portion of total soil P are extracted using both Olsen and Bray techniques, and therefore should be considered as indexes of relative soil P availability rather than quantitative measures of soil P content.

3.5.2.1 Procedure

At temperature of 52^{o}C, soil samples collected were air – dried, grounded and passed through a 2mm mesh sieve. Two (2) grams of soil sample were put into a 50 ml shaking bottle with 20 ml of Bray P1 extracting mixture (extractant), shake it with a mechanical shaker for 1 minute and then filtered into a 100 ml conical flask. 10 ml of filtrate was pipetted into a 25 ml volumetric flask and 1.0 ml of molybdate reagent followed by 1.0 ml of the dilute reducing agent. The Solution develops blue colour solution was top up to the 25 ml mark and vigorously shaken and allowed the solution to settle for 15 minutes, the percent transmission at 600 nm wavelength on a colorimeter was measured and the recorded % transmittance values.

Thus:

$H_3\,PO_4 + 12\,H_2\,M_o\,O_4\,H_3\,P\,(Mo_3\,O_{10})_4 \longrightarrow + 12\,H_2O$

(Soluble P in Soil Extracts) (Molybdic acid) (Molybdo Phosphoric acid)

$H_3P(M_{03}O_{10})_4$ Reduction using → Blue colour

Amino – naphthol – sulphuric

Acid or stannous chloride

3.5.3 Determination of potassium (K)

The most common analytical technique for determination of soil K availability is the use of ammonium acetate extraction. In this technique dry soil was extracted with an ammonium acetate solution; the NH4-N ions in solution displace potassium on soil cation exchange sites; as a result this method is often called "exchangeable" K test. But extraction of K from "fixation sites" within the structural layers of some types of silt and clay particles can be done by this technique. Within soils derived from vermiculitic parent material, and having high silt and clay content, about 25% of "exchangeable" K can actually represent "fixed" K. Since in some soils the total amount of fixed K can be more than the amount of K on exchange sites, and much of the fixed K may become plant-available over time, the extractable K soil test should be considered to be an index of relative soil K availability rather than a quantitative measure of soil K content.

3.5.3.1 Preparation of soil extract containing potassium (K)

A 10 g of sample soil was weighed and put into extraction bottle, 1.0 NH_4OAc solution of quantity 100 ml was added and placed into a bottle with contents and shake for 2 hours with the help of mechanical shaker. The solution was filtered through No 42 white man filter paper. The flame photometer reading for soil using the meter reading standard curve determines the concentration of K in the soil extract. Calculations were done from the curve to determine the percentage of K.

3.5.4 Organic matter (OM)

Various methods are available for the estimating OM in soil. Loss of weight on ignition is one of the methods used as a direct measure of the OM contain in the soil. It is also equivalent to organic carbon(C) content in the soil. Normally it is assumed that, an average OM contains about 58 percent organic C. Volumetric and colorimetric procedure can also be used to estimate Organic matter / organic C. However, the use of potassium dichromate ($K_2Cr_2O_7$) in this is considered as a limitation due to its hazardous nature. N availability can also be determine by soil organic matter (SOM) content index (potential of a soil to supply N to plants) due to the fact that N content in SOM is comparatively constant.

3.5.4.1 Loss of weight on ignition

Ten (10) g of 2mm sieved soil sample into an ashing vessel (50-ml beaker or other suitable vessel). The soil was put in theashing vessel and placed in a drying oven with temperature 105 °C for a period of 4 hours. The ashing vessel was then removed from the drying oven and placed in a dry atmosphere. After cooling, the soil sample was weighed to the nearest 0.01 g. At a temperature of 400 °C for a period 4 hours theashing vessel with soil was placed in the muffle furnace. Then the percentage of organic matter was calculated as:

Organic matter (OM) % = $(W_1 - W_2)/W_1 \times 100$

Where:

-W_1 is the weight of soil at 105 °C;

-W_2 is the weight of soil at 400 °C.

The percentage of organic C is calculated as: % OM × 0.58.

3.5.5 Soil pH

Twenty (20) grams of soil was added to 50ml deionized water. The solution was stirred for ten minutes, allowed to settle for thirty minutes and then stirred again for two minutes. A calibrated pH meter with a buffer of pH 7.00 was immersed into the upper part of the soil solution and the pH value recorded (Rhoades, 1982).

3.5.6 Precautions

Nitrogen (IV) oxide fumes could cause choking and as a result soil samples were digestion in a fume chamber. To avoid contamination with pollutants and other gases in the atmosphere, digested samples were covered tightly in order to get accurate final results.

3.5.7 Limitations

Lack of funds and time did not allow the inclusion of all the other soil essential nutrients in this research.

3.5.8 Statistical Analysis of Data

Data obtained from the four composite soil samples from the four forest types (Dry deciduous (fire disturbed and undisturbed) and savanna (fire disturbed and undisturbed) were presented in tabular form. The mean comparisons test of the individual soil parameters or properties and the vegetation attributes were performed using analysis of variance (ANOVA), using MS Excel. All statistical analyses were performed at the 5 % significance level.

CHAPTER FOUR

RESULTS

4.1 Plants Species Abundance

The results indicated that undisturbed forest (deciduous and savannah) had higher tree numbers as compared to disturbed (Table 4.1). But shrubs have higher numbers in disturbed as related to undisturbed forest. Herbs also follows similar pattern like shrubs. For plant species diversity, trees in undisturbed forest are higher than disturbed. But Shrubs and herbs have higher diversity in disturbed than undisturbed. With species richness, trees in deciduous disturbed forest are higher than undisturbed. But trees in savannah have reverse.

From Table 4.1 the total number of plants (trees, shrubs and herbs) identified from all the four forest types; dry deciduous (fire disturbed and undisturbed) and savannah (fire disturbed and undisturbed) were 2,565. Out of this number, 802 (31.27%), 680 (26.51%), 634 (24.72%) and 449 (17.50%) were recorded for the dry deciduous (fire disturbed), dry deciduous (fire undisturbed), savannah (fire disturbed) and savannah (fire undisturbed), respectively. Trees were the most dominant growth form of plants encountered in the study area, accounting for 1,373 (53.53%) individuals, followed shrubs (775 or 30.21 % of individuals), whereas the herbs were the least abundant with 417 individuals (16.26%). With all the trees species identified, *Hymenocardia acida* had the highest count of 72 followed by *Syzygium guineense* with count of 62 whereas *Milicia excelsa* had the least count of one (1). With regards to the shrubs, *Momordica charantha* was the most abundant species with total number of 123 and *Calamus deeratus* had the least count of one (1). In terms of Herbs, *Imperata spp* recorded the highest number of 89 as indicated in Appendix IV.

Table 4.1: Plant species diversity, richness by growth type and vegetation

Parameters	Dry deciduous		Savannah	
	Disturbed	Undisturbed	Disturbed	Undisturbed
Trees(dbh≥10cm)				
Count of individuals	359	392	306	316
Number of families	21	25	13	19
Shannon diversity	2.52 ±0.42	3.30±0.74	1.45±0.52	2.37±0.54
Species richness	62	58	25	34
Species evenness	0.90±0.05	1.09±0.19	0.77±0.13	0.97±0.18

Shrubs				
Count of individuals	331	180	190	74
Number of families	21	15	15	11
Shannon diversity	2.00±0.78	1.59±0.15	1.55±0.17	1.13±0.40
Species richness	26	17	18	13
Species evenness	0.68±0.45	0.85±0.30	0.94±0.04	0.91±0.08
Herbs				
Count of individuals	112	108	138	59
Number of families	9	10	8	7
Species diversity	1.41±0.38	0.98±0.51	1.34±0.98	0.89±0.40
Species richness	9	10	8	7
Species evenness	0.94±0.09	0.80±0.30	0.90±0.15	0.96±0.04

From Table 4.1, plant species diversity in all the forest types in the study showed considerable variations. Trees had the highest diversity of 3.30 with standard deviation of ±0.74 for undisturbed deciduous with the least diversity in Savannah disturbed (1.45±0.52). Shrubs are a reverse of trees with highest diversity of 2.00 in deciduous disturbed and the least diversity in savannah undisturbed (1.13±0.40). For herbs follows a similar trend like shrubs.

Species richness varied across all the four forest types (Table 4.1). Species richness for trees species were high in DDFFD (62) as compared to 58 in DDFFU. But in savannah, undisturbed had 34 as compared to 25 in disturbed. With shrubs, disturbed deciduous had higher species richness (26) with the least being savannah undisturbed (13). However herbs have a different pattern as compared to shrubs. DDFFU (10) had higher species richness than DDFFD (9) with SFFD and SFFU having 8 and 7 respectively.

Species distribution for trees were high in DDFFU (1.09) than deciduous disturbed, savannah disturbed and undisturbed. For shrubs, deciduous disturbed were evenly distributed than all the other vegetation covers in the study (Table 4.1). Herbs followed a similar pattern like shrubs.

There were more families in the undisturbed forest in both deciduous and savannah. A total of 25 families were recorded in the deciduous undisturbed and 19 were recorded in the savannah undisturbed forest type. The dominant families in the undisturbed forest formation were leguminosae, Meliaceae, Euphorebiaceae, Sterculiaceae and Laminaceae. But the most dominant was luguminosae (Figure 4.1). For shrubs, disturbed forest had more families. Disturbed deciduous had 21 families and savannah had 15 as compared to 15 and 11 families for undisturbed deciduous and savannah respectively. From Figure 4.1 the most dominant families for shrubs were leguminosae and Euphorbiaceae in all forest types. However herbs had more families in deciduous undisturbed than disturbed but savannah disturbed had more families than undisturbed as indicated in Table 4.1.

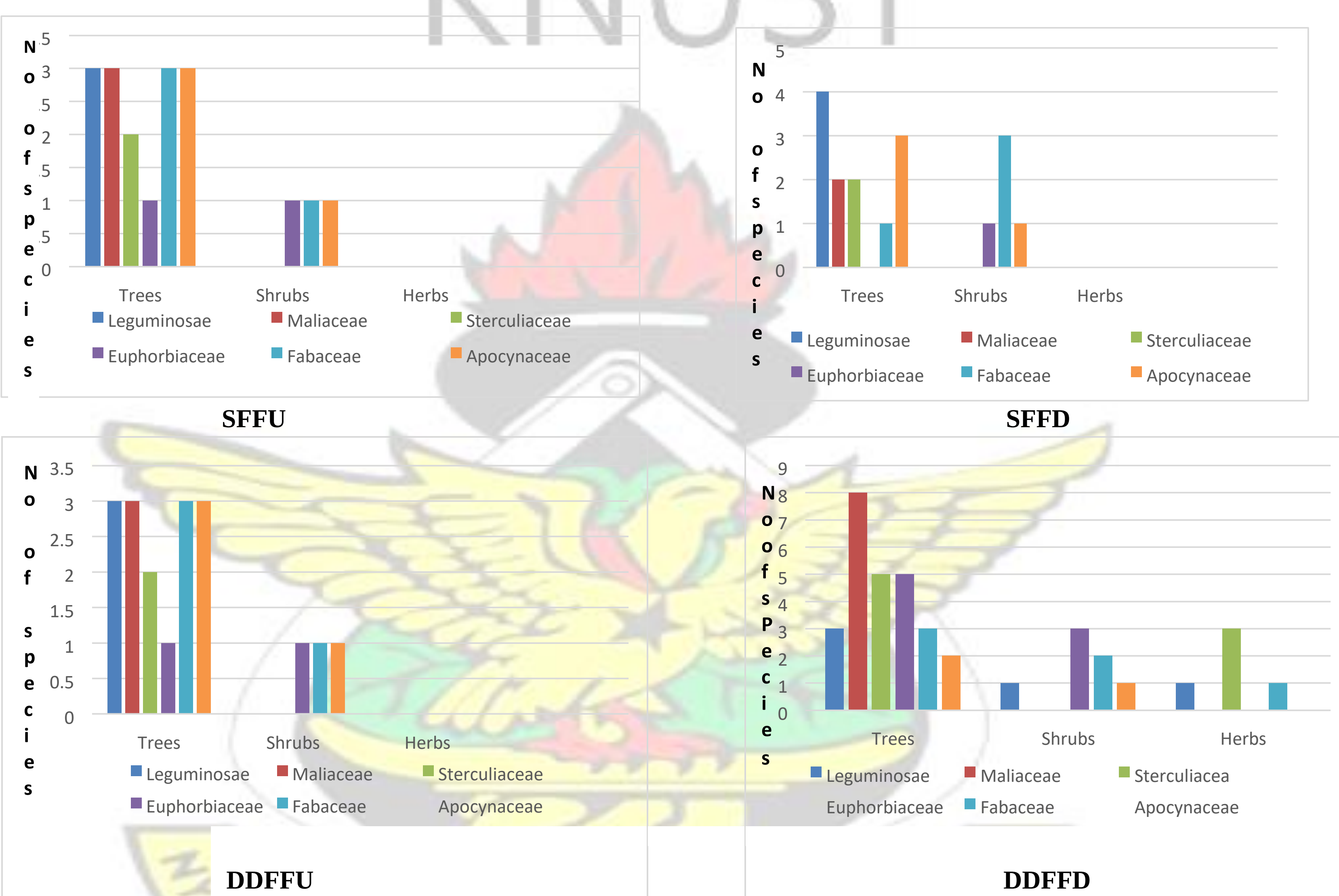

Figure 4.1: Dominant plant family in forest types.

SFFU**-*Savannah forest fire undisturbed* ***SFFD**-*Savannah forest fire disturbed* ***DDFFU**-*Dry deciduous forest fire undisturbed* ***DDFFD-Dry deciduous forest fire undisturbed*

The most dominant species of tree in dry deciduous (undisturbed and disturbed) was *Vitex doniana* with relative frequency (RF) of 5.56 and 7.87 and relative density (RD) of 4.37 and 5.72 and their corresponding important value index (IVI) of 4.96 and 6.80 respectively (Table 4.2). In terms of shrubs, *Momordica charantha* had RF of 18.18 and 8.93 for undisturbed and disturbed deciduous forest. *Momordica charantha* was also denser than all other species with RD of 13.20 and 6.90. IVI was 15.69 and 7.91in undisturbed and disturbed deciduous forest. With herbs deciduous forest had *imperata spp* with the highest RF of 34.48 in undisturbed with RD of 24.59 while *Acacia pentagyna* had highest RF of 14.89 and RD of 14.29 for disturbed forest.

Table 4.2: Dominant plant species for dry deciduous forest type

SPECIES	DRY DECIDUOUS					
Trees≥10cm dbh	Undisturbed			Disturbed		
	R.F	**R.D**	**IVI**	**R.F**	**R.D**	**IVI**
Vitex doniana	5.56	4.37	4.96	7.87	5.72	6.80
Drypetes aubrevillei	3.09	2.62	2.86	1.57	1.68	1.63
Trichilia preuriana	4.32	2.92	3.62	7.09	5.05	6.07
Carapa procera	3.09	2.33	2.71	1.57	2.69	2.13
Nesogordinia papaverifera	4.94	3.21	4.07	3.94	3.03	3.48
Triplochiton scleroxylon	4.94	3.79	4.36	3.15	2.69	2.92
Rhautia vomiteria	3.70	2.92	3.31	0.79	1.01	0.90
Macaranga barteri	3.09	2.33	2.71	3.15	2.69	2.92
Daniellia thurifera	3.09	2.33	2.71	0.00	0.00	0.00
Newtonia duparquetiana	4.32	3.79	4.06	0.00	0.00	0.00
Shrubs						
Momordica charantha	18.18	13.20	15.69	8.93 8.93	6.90 7.39	7.91 8.16
Hypselodelphys violaceae	14.55	12.26	13.40	0.89	1.97	1.43
Griffonia simplicifolia	14.55	11.32	12.93	8.93	7.39	8.16
Culcasia angolensis	10.91	8.49	9.70	2.68	3.45	3.06
Imperata spp	12.73	9.43	11.08			
Herbs				14.89	14.29	14.59
Acacia pentagyna	10.34	9.84	10.09	6.38	7.14	6.76
Aconitum colubianum	13.79	14.75	14.27	6.38	8.33	7.39
Imperata spp	34.48	24.59	29.54			

RF=Relative Frequency RD=Relative density IVI=Important Value Index

Table 4.3 shows the dominant plant species for savannah forest. It is indicated that, *Syzygium guineense* and *Pterecarpus erinaceuss* trees showed the highest RF of 7.50 with RD of 7.11 and IVI of 7.31 for undisturbed. For disturbed, *Hymenocardia acida* had the highest RF of 10.99 with RD of 10.11 and IVI of 10.55. In terms of shrubs, *Chromolea odorata* showed the highest RF, RD and IVI for both undisturbed and disturbed savannah. For herbs, *Dodonaea pedatum* recorded the highest RF of 25.00 with RD of 22.89 and IVI of 23.95 for undisturbed. But for disturbed savannah *Calamus deerant* had the RF of 21.28, 19.57 for RD and 20.42 for IVI

Table 4.3: Dominant plant species for savannah forest type

SPECIES	SAVANNAH					
Trees≥10cm dbh	**Undisturbed**			**Disturbed**		
	R.F	**R.D**	**IVI**	**R.F**	**R.D**	**IVI**
Syzygium guineense	7.50	7.11	7.31	10.99	10.11	10.55
Erythrophleum suaveolens	6.67	6.28	6.47	6.59	5.85	6.22
Parkia biglobosa	5.00	4.18	4.59	2.20	3.19	2.70
Sterculia oblonga	6.67	5.02	5.84	1.10	1.60	1.35
Pterocarpus erinaceuss	7.50	7.11	7.31	7.69	6.38	7.04
Lannea yelutina	6.67	6.28	6.47	3.30	3.19	3.24
Cleitopholis patens	6.67	6.28	6.47	10.99	9.57	10.28
Trichilia preuriana	5.00	4.60	4.80	1.10	1.60	1.35
Vitex doniana	4.17	4.18	4.18	3.30	3.19	3.24
Hymenocardia acida	3.33	3.35	3.34	10.99	10.11	10.55
Holarrhena floribunda	5.83	5.02	5.43	1.10	1.60	1.35
Shrubs						
Momordica charantha	20.69	17.57	19.13	15.38	13.10	14.24
Chromolena odorata	27.59	22.97	25.28	15.38	13.79	14.59
Culcasia angolensis	3.45	4.05	3.75	0.00	0.00	0.00
Aspilia Africana	17.24	14.86	16.05	15.38	13.10	14.24
Imperata cylindrical	6.90	6.76	6.83	1.54	2.07	1.80
Herbs						
Zingeba rofficinale	20.83	19.29	21.05	14.89	16.30	15.60
Dodonaea pedatum	25.00	22.89	23.95	12.77	11.96	12.36
Calamus deeratus	20.83	19.30	21.05	21.28	19.57	20.42

RF=Relative Frequency RD=Relative Density IVI=Important Value Index

4.2. Soil physico-chemical properties

Table 4.4 shows that nitrogen, potassium phosphorus, moisture content increase form deciduous disturbed to undisturbed. However in savannah forest, nitrogen and phosphorus decrease from disturbed to undisturbed while moisture content decrease from undisturbed to disturbed. Organic matter, organic carbon and pH levels increase from disturbed to undisturbed in deciduous forest whereas in savannah the same soil properties increase from undisturbed to disturbed.

Table 4.4: Mean soil physico-chemical properties for sampling plots.

Soil properties	**DDFFD (n=10)**		**DDFFU (n=10)**		**SFFD (n=10)**		**SFFU (n=10)**		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*p-value*
Nitrogen	0.075	0.0071	0.120	0.0141	0.065	0.0071	0.045	0.0071	0.006
Phosphorus	0.017	0.0007	0.027	0.0021	0.014	0.0014	0.013	0.0007	0.002
Potassium	0.040	0.0014	0.107	0.0007	0.019	0.0028	0.067	0.0014	0.000
Moisture content	12.58	1.2450	21.62	0.1480	10.95	1.2450	11.87	0.0780	0.000
Organic matter	3.730	0.0570	4.330	0.1910	3.720	0.1200	1.500	0.1630	0.000
Organic carbon	2.170	0.3500	2.510	0.1060	2.160	0.0640	0.870	0.9910	0.000
pH	5.360	0.1560	7.570	0.1480	6.690	0.1480	6.340	0.0571	0.000

SD=Standard deviation

4.2.1 Nitrogen (N)

The average overall nitrogen from the different forest site shows higher amount of nitrogen as expected in DDFFU which was used as control to DDFFD. Percentage of nitrogen decreased with decrease in vegetation. This is indicated in table 4.4 as the percentage of nitrogen decreases from deciduous forest to savannah. Thus, the mean nitrogen declined from 0.12% for DDFFU (with standard deviation of 0.0141), DDFFD (mean is 0.075% and standard deviation of 0.0071), SFFU (mean is 0.065% and standard deviation of 0.0071), to 0.045% (with standard deviation of 0.0071) for SFFD. The ANOVA test produced a *p*-value of 0.006, which is less than a significant level of 0.05 ($\alpha = .05$). This implies that there existed important differences in the means of nitrogen from the four sites, since F=23.00, df =7 and $p < .05$

4.2.2 Phosphorus (P)

Table 4.4 shows that DDFFU yielded the highest mean percentage of phosphorus of 0.027% (with standard deviation of 0.0021%), followed by DDFFD of 0.017% (SD = 0.007). The lowest mean percentage of phosphorus was noted in the SFFD (with mean of 0.013% and standard deviation of 0.0007%). Using the analysis of variance, it showed significant differences in relation to the mean phosphorous from the four forest categories (F=42.38, df =7 and $p < .05$).

4.2.3 Potassium (K)

The DDFFU have the highest mean percentage of potassium of 0.107% (with standard deviation of 0.0014%), followed by SFFU with 0.067% (SD=0.0028%), DDFFD with 0.040% (SD=0.0007) through to the SFFD with the least mean of 0.019% (SD=0.0014). Besides the virtual disparities between the mean percentages of potassium from the sites, the variance test was employed to exam for significant differences. The result produced F-value of 926.97, df

=7 and *p*-value of .000, indicating there were substantial differences between the mean percentages of potassium from the forestlands.

4.2.4 Moisture content

As indicated in Table 4.4, DDFFU had the highest moisture content of 21.62% (SD=0.148%), followed by DDFFD (12.58%; SD = 1.245%), and SFFD and SFFU having 11.87% (SD = 0.078%) and 10.95% (SD = 0.495), respectively. The ANOVA test showed that there were highly considerably differences among the mean moisture content with respect to the four forest categories. This is as a result of the *p*-value of 0.000, which is less than the 5% significance level ($\alpha = 0.05$).

4.2.5 Organic matter (OM)

The highest mean percentage of organic matter was obtained by DDFFU (4.33% with standard deviation of 0.191). This is followed by DDFFD with 3.73% (SD = 0.057). Also, SFFD had a mean and standard deviation of 3.72% and 0.120 respectively. The lowest mean of 1.50% (SD = 0.163) was shown in SFFU. The ANOVA test result points that the mean percentages of organic matter obtained for the treatment plots showed highly significant differences, since a $p < 0.05$

4.2.6 Organic carbon (OC)

Table 4.4 reveals that DDFFU (Dry Deciduous Fire Undisturbed) had the most percentage of organic carbon among the four forest categories sampled. It had 2.51% with variation of 0.106, followed by DDFFD with 2.17% (SD = 0.035), SFFU (2.16%; SD = 0.064) and SFFD (0.87%;

SD = 0.099). Once again the ANOVA test with p-value of .000 was obtained. This is less than $\alpha = 0.05$, hence it can be concluded that the mean organic carbons from the four forest sites were statistically different.

4.2.7 pH

The DDFFU recorded the highest pH of 7.57 (SD = 0.148), which is slightly acidic, followed by SFFU and SFFD which have acidic values of 6.69 (SD = 0.148) and 6.34 (SD = 0.057), respectively. DDFFD indicated the most acidic condition among the four forest types with the acidic level of 5.36 (SD = 0.156). The pH seemed to increase with decrease in flora cover among the forest types. Furthermore, the ANOVA test produced a $p = 0.000 < \alpha = 0.05$; indicating that there were important differences in the mean of pH for the four forest categories.

CHAPTER FIVE

DISCUSSION

5.1 Effect of Wildfires on Some Soil Physico-Chemical Properties

Nitrogen, phosphorus, potassium moisture content, organic matter and organic carbon were high in DDFFU as compared to DDFFD. However organic matter and organic carbon were higher in disturbed savannah forest than undisturbed. This could be as result of leaf litter fall with high decomposition which enhance soil fertility, increase humus level and organic material found at the underfloor of DDFFU. Generally DDFFU had higher species diversity and abundance for trees (Brady and Weil, 2013).

The low level of these soil physico-chemical properties in DDFFD and SFFD in relation to undisturbed in these forest types(deciduous and savannah) could be attributed to the opening forest canopies and exposure of soil microorganisms to bad weather condition like high temperatures which hinders microbial activities. The exposure of forest land bare leads to erosion and leaching of organic minerals which enhance destabilization of soil structure and decrease water holding capability and hence low levels of these soil properties. Generally tree species abundances were low in these type of forest which experience frequent fires. However shrubs and herbs have high diversity and abundance in the frequently disturbed vegetation. This could be attributed to open forest canopy which allows more sunlight penetration to enhance their growth (Jhariya & Oranon, 2012).

5.1.1 Nitrogen

Nitrogen level from the different sampling forest showed higher amount of N in DDFFU. This could be as result of leaf litter fall and higher decomposition which enhance soil fertility. The quantity of N and the abundance of plant species within DDFFU which recorded the highest value of N with plant species diversity (trees=3.30, shrubs=1.59 and herbs of 0.98) can be described as being normal value. Brady & Weil (2013) asserted that nitrogen content normally ranges from 0.02%-0.5% for surface mineral soil.

Though N levels in SFFU are significant, the change as likened to DDFFU might be attributed to amount of leaf litter in DDFFU, opening of forest canopy and exposure of soil microorganisms to bad weather condition in SFFU. This confirms the work by Buckley and Schmidt (2002). The small amount of nitrogen recorded in SFFD and DDFFD underlines the importance of leaf fall and it could also be attributed to releases of N from the debris to the atmosphere as ammonia and oxides of N as a result of high temperatures of fire. Though SFFD recorded the lowest mean N content of 0.045% but diversity of 1.45 for trees, 1.55(shrubs) and herbs had 1.34.

5.1.2 Phosphorus

Phosphorus followed similar pattern like nitrogen with DDFFU having the highest amount of phosphorus. Brady & Well (2013) asserted to a similar findings. The composite sample from DDFFU which compose mainly of forest cover soil provided higher amount of phosphorus than DDFFD, SFFU and SFFD. This may be ascribed to the increasing level of phosphorus in the humus and organic materials found at the under floor of the forest, Brady & Weil (2013). Phosphorus in organic material is released by process of mineralisation involving soil organism. It stimulate growth of young plants, giving them good and energetic start. Many plant species grow well in such areas. This is evident from Table 4.1 that DDFFU have high number of shrubs (180) and herbs (108) with diversity of 1.59 and 0.98.

The lower level of phosphorus in SFFD may be accredited to forest degradation brought about by the frequent wildfire in those sites of Bomfobiri Wildlife Sanctuary. These open-up the forest canopy for sun penetration resulting in the dry humus materials and also compacting the soil surfaces. During fires, material that may increase phosphorus concentration got burnt leaving the land bare and exposing it to erosion and mineral leaching. This situation in turn decreases the concentration of phosphorus in SFFD and DDFFD.

5.1.3 Potassium (K)

Potassium showed highly important differences in all the levels of soils of different forest types ($p < .000$). The statistical analysis indicated that, DDFFU area possessed the highest amount of potassium followed by DDFFD. The % level of potassium decrease with decrease in forest cover. The decline in the concentration of potassium could be as a result of the loss of falling litters and frequent fires which negatively affect microbial activities in the sites as well as decrease with amount of forest canopy which has no or little understory and falling material to decompose. However, high amount of K in the soil can unfavourably affect plants including trees, shrubs and herbs and also reducing calcium and magnesium uptake from soil (Brady & Weil, 2013).

5.1.4 Moisture content (MC)

DDFFU had the highest moisture content of 21.62% followed by DDFFD of 12.58% and SFFD and SFFU having 11.87% and 10.95 respectively. But the Shannon Wiener diversity index indicate that trees have diversity of 1.45,shurbs(1.55) and herbs(1.34)within SFFD as compared to trees(2.52),shrubs(2.00) and herbs of 1.41 in DDFFD. However in terms of species richness, DDFFD have the highest (62) followed by DDFFU of (58) but species were evenly distributed in DDFFU than DDFFD (Table 4.1). The regular fire within SFFD with little forest understory to prevent leaching and erosion may lead to destabilisation of soil structure, hinders percolations and cause change in soil structure. These could result in the decreasing water holding capability in the soils as stated by Melling *et al.*, (2007). This is an indication from the fraction of moisture content attained from the study.

5.1.5 Organic matter

The highest organic matter mean % of 4.33 was found in DDFFU with the least percentage of 1.50 in SFFD, DDFFD produced the second highest percentage of 3.72 with the plant diversity index of (trees 2.52, shrubs of 2.00 and herds 1.41). The reduction of organic matter and species abundance from undisturbed to disturbed forest might be ascribe to the type of organic matter layer over the parent material which is not incorporated into the soil in most cases, forest canopies opening, soil surface becoming bare facilitating erosion and leaching of organic materials which bind soil particles together in forestlands; BWS in context. Also high rate of plants species abundance in DDFFU gives indications of good soil condition for the support of forest biodiversity (Taylor *et al*., 2001).

5.1.6 Soil pH (acidity)

Fire affects the acidity of soil due to the huge amount of ash element from organic debris. The DDFFU recorded the most pH of 7.57(slightly acidic), followed by SFFU and SFFD which have acidic values of 6.69 and 6.34 respectively. The high acidity in DDFFD (5.36) may be credited to the low level of cations like calcium, magnesium, and potassium that were released during fires. The extent, duration and fire intensity, quantity of organic matter consumed and capacity of buffer of soil could all be cause for the high acidic in DDFFD.

These acidic values agrees with the data collected during the preparation of the management plan of the study area in 2012 (pH range of 5.0 – 8.00). Again the pH level of 5.3 – 7.6 for the study area is very much in line with the soil pH of 5.2 – 8.0 which offers optimum conditions for the growth of plants species (Lake, 2000). Most plants are affected by range of soil pHs', this is an evident of the values obtained from species abundance with the highest at DDFFU followed by the DDFFD and the least at the SFFU. Soil pH also affects the mineralization and solubility of soil nutrient like as N, P, K, OC and MO. Soil pH influences plant growth by its effects on the activities of beneficial microorganism.

5.1.7 Organic carbon

Organic carbon was high in DDFFU than all the other forest types. DDFFU had the highest OC of 2.51% followed by DDFFD with 2.17% and the least being SFFD (0.87%). The low percentage of OC shown in the SFFD may be due to low leaf litter and regular fires which have led to soil being bare and permitting more to more direct sunlight increasing soil temperatures and reducing decomposition of animal and plants residue. SOC is very important constituent of the soil because of its capabilities to influence plant growth by serving as source of energy as well as also activate nutrient availability through mineralisation.

5.2. Pattern of Species Diversity and Dominance of Plant in the Forest.

The higher diversity in undisturbed deciduous than disturbed is consistent with other studies (Kpontsu, 2011, Sang, 2009). According to Rao *et al* (1990), reported a peak diversity in undisturbed area and it was argued that the type of disturbance in the forest might be responsible for low diversity in disturbed forest. Sang (2009) and Muhanguzi *et al* (2007) also explained that, past harvesting and other factors like frequent fire were responsible for reducing diversity for trees in disturbed forest. However shrubs and herds showed high diversity in disturbed than undisturbed. Grime (2006) also reported the same trend of diversity in disturbed forest. This higher diversity in shrubs and herbs was also explained by Connel (1978) that intermediate; in terms of intensity and frequent, promotes higher species diversity. Also at intermediate level of disturbance, diversity is thus maximized because competitive and opportunistic species can co-exist. Again higher diversity in shrubs and herbs in disturbed forest in relation to undisturbed could also be attributed to the forest canopies opening giving way for more sunlight to the understorey (Payette and Delwaide, 2003). Deciduous disturbed have higher diversity than Savannah disturbed (Shafiei *et al*., 2006). In all the forest type, trees have higher diversity with the least being herbs. All these may be ascribed to a number of factors including soil type, species colonization, moisture and degree of disturbance as asserted by Addo-Fordjour *et al* (2009). Muhanguzi *et al* (2007), reported an increased in plant species diversity from an undisturbed to disturbed forests in a similar study in Uganda. Fire has helpful effect on the plant diversity (Jamshidi *et al.,* 2013). The component of plant species diversity that determined the expression of species traits are species richness, evenness, composition interaction among species etc. with species richness being the most extensively used index of biodiversity (Yang *et al.,* 2011). Species diversity of all plant species indicated high variation in study habitats.

Plant species dominance in different forest varied from each other. This pattern of species variation is supported by other related studies (Hall & Swaine, 2013) which opined that, a few plant species occurs naturally in both deciduous and savannah vegetation and the notably exceptions include *Afzelia africana* and *Diospyros mespiliforms*. Dominance of shrubs and herbs species for both vegetation was not different from tree species. Only *Momordica charantha* was found in both vegetation.

5.3. Pattern of Species Richness and Evenness of Plant in the Forest.

Species richness often varies from one forest to another depending on number of factors (Kpontsu, 2011). The high species richness in disturbed deciduous in relation to the undisturbed deciduous forest type is in line with studies by Sang (2009). But within savannah, undisturbed were higher than the disturbed as ascribed by Muhanguzi *et al* (2007). Whatever be the case, it is clear that species richness is affected negatively by intensive disturbance such as fire (Todaria *et al*., 2010). The pattern of species richness along a disturbed gradient may vary from one growth form to another (Kpontsu, 2011). Whereas tree and shrubs species peaked at disturbed deciduous, herds were peaked at undisturbed (Pitchairamu *et al*., 2008). Lalfakawma *et al* (2009), also documented shrubs and tree species richness in an undisturbed than disturbed Most researchers on herbs (seedlings) have investigated a surging species richness along a surging disturbance slop (Addo-Fordjour *et al.,* 2009). On the contrary, few studies have investigated relatively inflated species of lianas in undisturbed forest sites (Addo-Fordjour *et al.*, 2009). It also reported pattern of species richness are consequences of many interacting factors, such as plant productivity, competition, geographical area, historical or evolutionary development, environmental variables and anthropogenic disturbance (Erisksson, 1996, Muhanguzi *et al*., 2007). Species distribution (evenness) were reverse of species richness in all forest type study. Species were generally evenly distributed in undisturbed than disturbed. Tree species have the highest number of families during the study in all the forest type but the most predominance families were Leguminosae, Meliaceae, Euphorbiaceae, and Apocynaceae. This is in line with studies carried out by Anning *et al* (2008) and Addo-Fordjour *et al* (2009), which also indicate the prevalence of the families Apocynaceae, Euphorbiaceae, Meliaceae and Leguminosae, in some deciduous forests in Ghana.

Following frequent fires in DDFFD and SFFD, most of fire sensitive trees, shrubs and herbs were destroyed including seeds and seedlings. There was reduction in vegetation cover at disturbed site as compare to undisturbed site. This could be due to intensity, duration and frequency of fires as well as most of the species being fire sensitive (Hester *et al.*, 1997). Predominates plant species like Zingeba rofficinale, Chromolena odorata and Cleitopholis patens are some of the fire resistant species found and because of the peculiar nature of its roots which makes is difficult to be destroyed by fire since it is embedded in the soil.

Ellsworth *et al*., 2016 also made a similar observation in shift vegetation composition following burning which created initial dominance of fire resistant species, which were eventually eliminated by the constant killing of regeneration until replace by fire resistant shrubs, herbs and trees species that constituted the predominant vegetation.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

This study was conducted to determine wildfires effect on some plant species composition and soil properties in Bomfobiri wildlife sanctuary in the Sekyere Kumawu and Sekyere Afram Plains districts.

- ✓ Based on the results from the study, it can be established that the DDFFU and SFFU had suitable nutrient content, highest numbers of plants species.
- ✓ As the study indicated significant changes among the sampling means, it was observed that site with appreciable amount of forest cover, understory and mid-story (DDFFU and SFFU) showed a generally improved soil conditions for plant species abundance and diversity**.**
- ✓ The enhanced physico–chemical performance in terms of N, P, K, MC, OM, OC and pH in the DDFFU sites might be accredited to the fusion of falling litters, decomposition and appropriate percolation rate in the forest soil.
- ✓ The reserved indicated in the SFFD and DDFFD sampling plots where the above mentioned process were very poor which intern affected the plant species abundance .
- ✓ The poor vegetation cover shown in the SFFD sampling plots indicated why there is poor physico – chemical properties as likened to the DDFFU which have good vegetation cover.

6.2. Recommendations

There is prevalent of fire in the transitional vegetation zone of Ghana due to accidental and planned fires. In view of these findings, it is recommended that:

- All protected areas (Forest reserves) must have a management plan that will include methods and process of preventing and controlling wildfires by the Forestry Commission and other stakeholders.
- Education campaign must be high on the agenda of the government and all stakeholders especially among fringe communities of forest reserves on fire effects on the forest and the environment as a whole.
- More fire prevention methods like fire breaks, fire towers should be constructed in and around all forest reserves in Ghana to enhance enable early detection and prevent further degradation of our ecosystem of all ecological zones. Also existing fire towers and fire breaks must also be maintained and monitored regularly.
- There is the need for further research to examine the long term effects of fire on ecosystem dynamics in the transitional vegetation zone of Ghana.

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APPENDICES

Appendix I: Enumeration sheet for plant species composition

<u>Trees Species Enumeration Sheet (>10cm dbh)</u>

Forest Type:.. PLOT NO......... GPS Coordinates:.....................

S/N	Botanical Name	Local Name	Diameter(cm)	Remarks

<u>Shrubs Species Enumeration Sheet (<10cm)</u>

Forest Type:.. PLOT NO......... GPS Coordinates:.....................

S/N	Botanical Name	Local Name	Count of individuals

<u>Herbs Species Enumeration Sheet (1mx1m)</u>

Forest Type.............................. PLOT NO......... GPS Coordinates'.............................

S/N	Botanical Names	Local Names	Count of individuals

Appendix II: Total number and percentages of the plant species within the sampled plots.

Plants/Flora Parameters	DDFFU		DDFFD		SFFU		SFFD	
	Nos.	%	Nos.	%	Nos.	%	Nos.	%
Trees(dbh≥10cm)	392	15.28	359	14.01	316	12.32	306	11.93
Shrubs	180	7.02	331	12.90	74	2.88	190	7.41
Herbs	108	4.21	112	4.37	59	2.30	138	5.38
Total	**680**	**26.51**	**802**	**31.28**	**449**	**17.50**	**634**	**24.72**

Appendix III: Summary composite sample values of soil from the forty (40) sampled plots in forest types (DDFFD, DDFFU, SFFD, and SFFU).

Forest Type	pH	% N	%P	%K	%M.C	% O.M	% O.C
SFFD 1	6.38	0.05	0.012	0.020	11.92	1.38	0.80
SFFD 2	6.30	0.04	0.013	0.018	11.81	1.61	0.94
DDFFD 1	5.47	0.08	0.017	0.106	13.46	3.69	2.14
DDFFD 2	5.25	0.07	0.016	0.108	11.70	3.77	2.19
SFFU 1	6.58	0.07	0.013	0.069	10.60	3.80	2.20
SFFU 2	6.79	0.06	0.015	0.065	11.30	3.63	2.11
DDFFU 1	7.46	0.11	0.025	0.040	21.51	4.19	2.43
DDFFU 2	7.67	0.13	0.028	0.039	21.72	4.46	2.58

APPENDIX IV: Descriptive Statistics for physico-chemical properties in forest type.

Descriptive statistics on Nitrogen (%) from Four Sites Sites	Mean	Standard Deviation
Savannah (Fire Undisturbed) – SFFU	0.045	0.0071
Dry Deciduous (Fire Disturbed) – DDFFD	0.075	0.0071
Savannah (Fire Disturbed) – SFFD	0.065	0.0071
Dry Deciduous (Fire Undisturbed) – DDFFU	0.120	0.0141

From Figure 5 below, it appears that all the error bars did not overlap, hence pointing to differences in the mean percentages of nitrogen from the four sites.

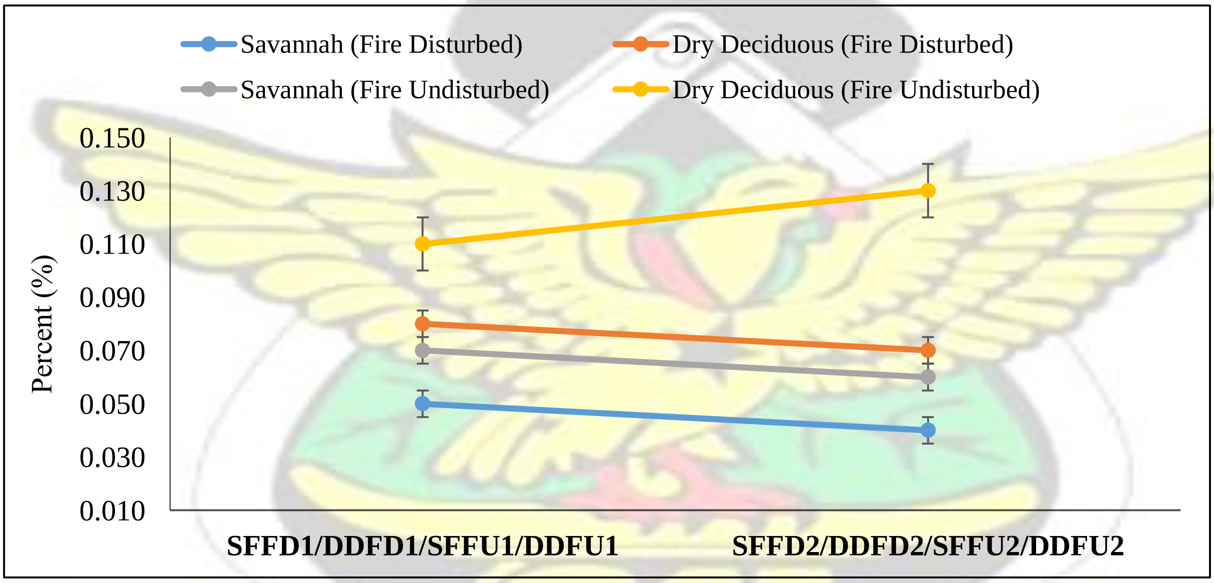


Figure 5: Error bars comparing samples of Nitrogen

Descriptive Statistics on Phosphorous (%) from Four Sites Sites	Mean	Standard Deviation
Savannah (Fire Undisturbed) – SFFU	0.013	0.0007
Dry Deciduous (Fire Disturbed) – DDFFD	0.017	0.0007
Savannah (Fire Disturbed) – SFFD	0.014	0.0014
Dry Deciduous (Fire Undisturbed) – DDFFU	0.027	0.0021

It can also be seen from Figure 6 that there were huge gaps in the error bars implying a possible statistically significant differences in the mean phosphorous from the four sites.

Appendix IV cont'd

Calculation

A calculation was done to convert % T values to 2 – Log T. A graph was plotted using P Standard solutions to obtain actual concentration of P. The concentration of P in the extract was obtained by comparing the results with a standard curve plotted.

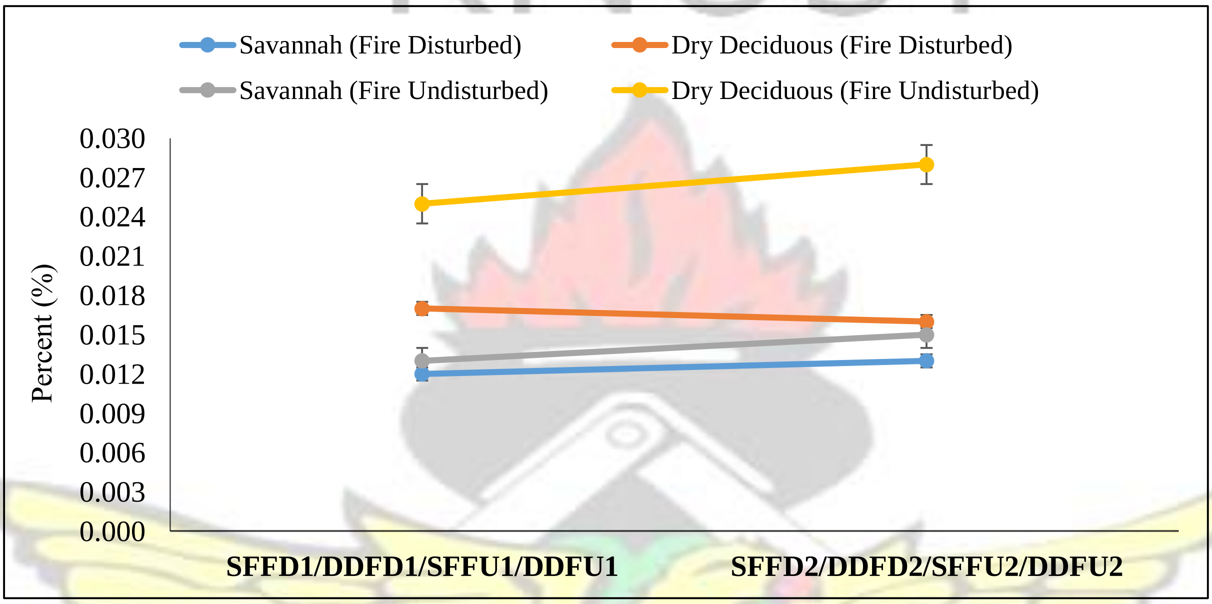


Figure 6: Error bars comparing samples of Phosphorous

Descriptive Statistics on Potassium (%) from Four Sites

Sites	Mean	Standard Deviation
Savannah (Fire Undisturbed) – SFFU	0.019	0.0014
Dry Deciduous (Fire Disturbed) – DDFFD	0.107	0.0014
Savannah (Fire Disturbed) – SFFD	0.067	0.0028
Dry Deciduous (Fire Undisturbed) – DDFFU	0.040	0.0007

The error bars further established wide differences among different forest sites as indicated in figure 7.

Appendix IV cont'd

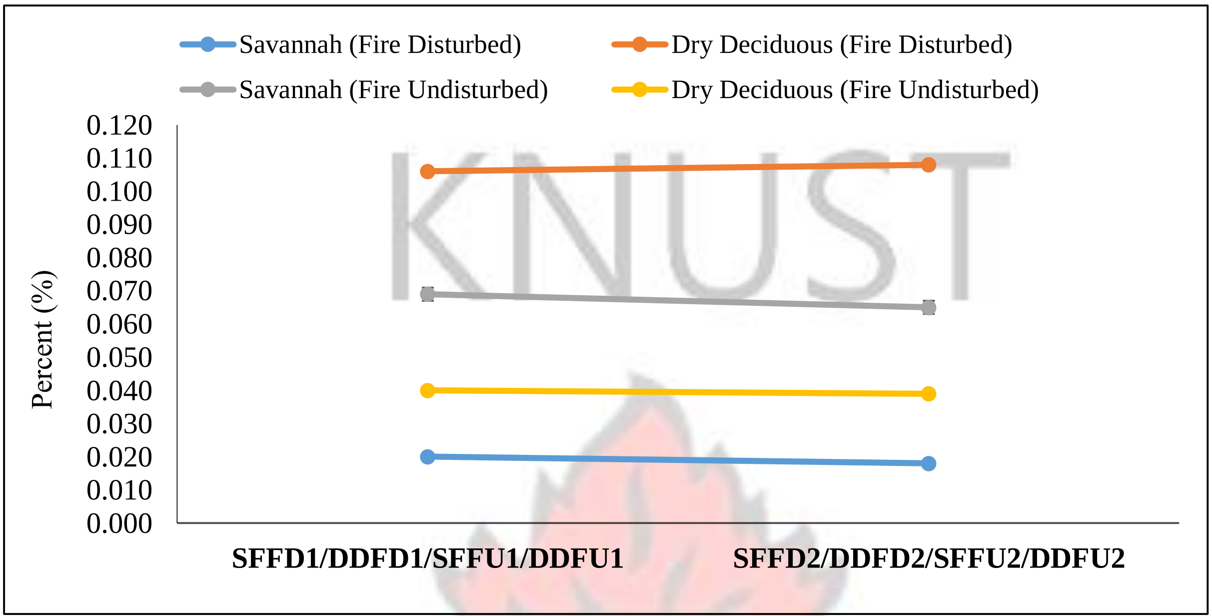
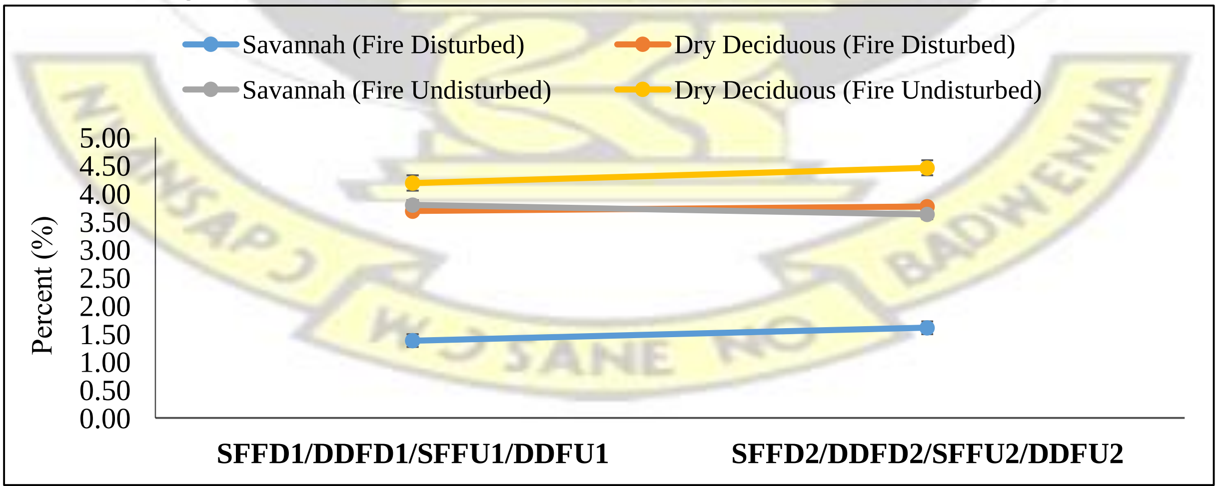


Figure 7: Error bars comparing samples of Potassium

Descriptive Statistics on Organic Matter (%) from Four Sites

Sites	**Mean**	**Standard Deviation**
Savannah (Fire Undisturbed) – SFFU	1.50	0.163
Dry Deciduous (Fire Disturbed) – DDFFD	3.73	0.057
Savannah (Fire Disturbed) – SFFD	3.72	0.120
Dry Deciduous (Fire Undisturbed) – DDFFU	4.33	0.191

Comparisons of the standard error bar for Organic matter value signified differences among all the treatments which gives an indication that there is significant difference between them as indicated in figure 8



Appendix IV cont’d

Figure 8: Error bars comparing samples of Organic matter

Descriptive Statistics on Moisture Content (%)	**from Four Sites**	**Sites Mean**
Standard Deviation		
Savannah (Fire Undisturbed) – SFFU	11.87	0.078
Dry Deciduous (Fire Disturbed) – DDFFD	12.58	1.245
Savannah (Fire Disturbed) – SFFD	10.95	0.495
Dry Deciduous (Fire Undisturbed) – DDFFU	21.62	0.148

Also Figure 9 shows error bars which did not entirely overlap; suggesting statistically significant differences in their mean percentages.

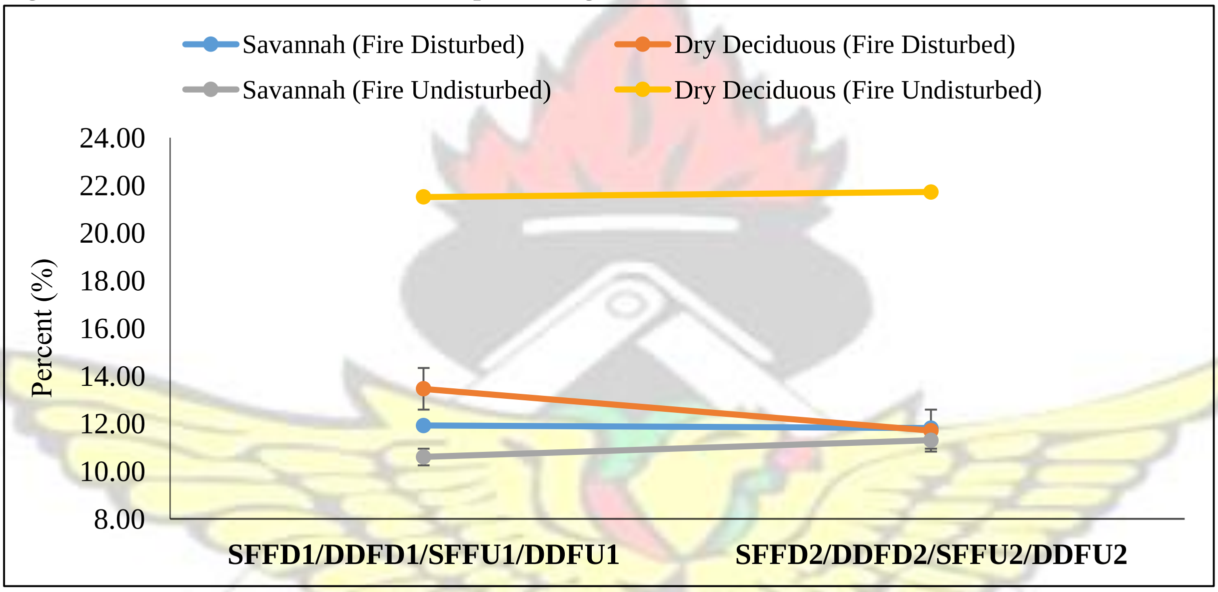


Figure 9: Error bars comparing samples of moisture content

Descriptive Statistics on Organic Carbon (%) from Four Sites

Sites	**Mean**	**Standard Deviation**
Savannah (Fire Undisturbed) – SFFU	0.87	0.099
Dry Deciduous (Fire Disturbed) – DDFFD	2.17	0.035
Savannah (Fire Disturbed) – SFFD	2.16	0.064
Dry Deciduous (Fire Undisturbed) – DDFFU	2.51	0.106

Figure 10 portrays that the error bars were not overlapping; implying there may be significant differences in their mean percentages among the forest types.

Appendix IV cont'd

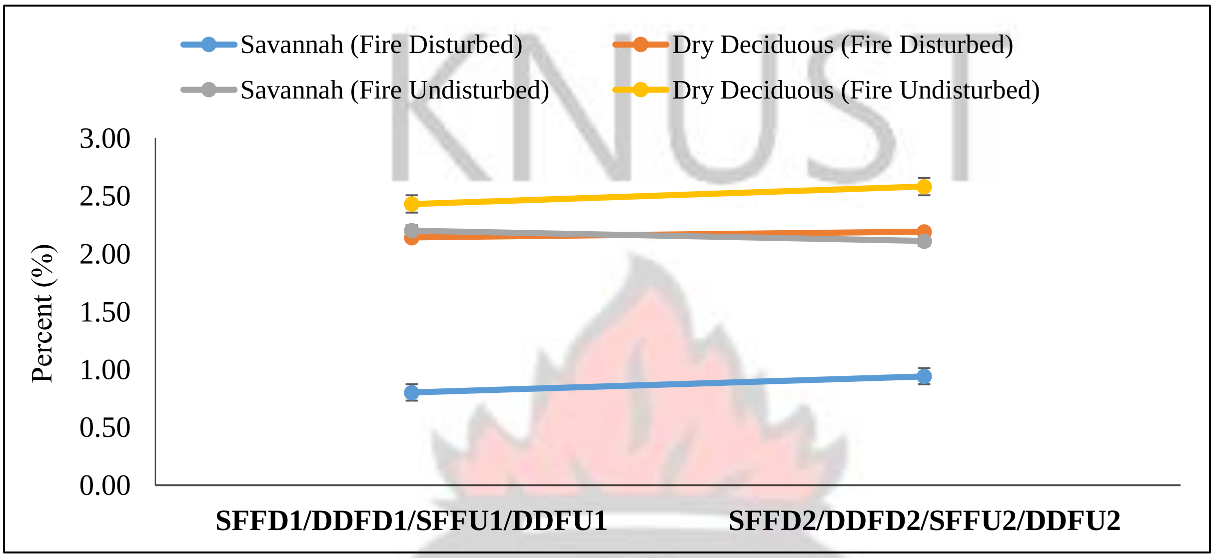


Figure 10: Error bars comparing samples of organic carbon

Descriptive Statistics on pH (%) from Four Sites

Sites	**Mean**	**Standard Deviation**
Savannah (Fire Undisturbed) – SFFU	6.34	0.057
Dry Deciduous (Fire Disturbed) – DDFFD	5.36	0.156
Savannah (Fire Disturbed) – SFFD	6.69	0.148
Dry Deciduous (Fire Undisturbed) – DDFFU	7.57	0.148

For pH, the comparison shows that the standard error bars of the four forest sites showed large disparities in their mean values among them. This is an indication that there is a significant difference in their nutrients content in the soil as in the figure 11 below.

Appendix IV cont'd

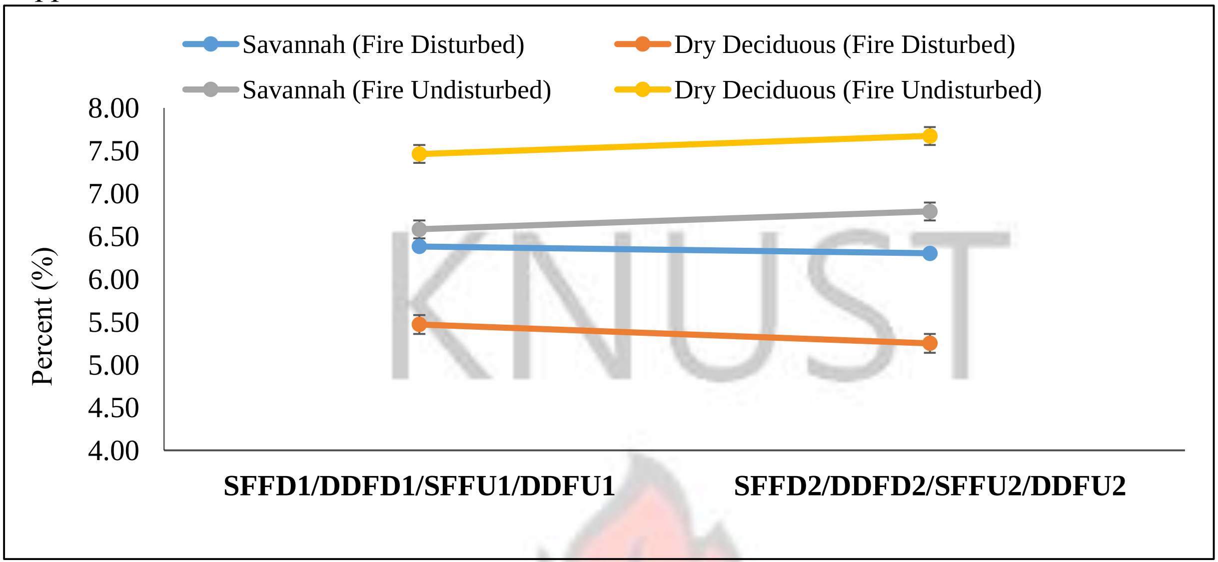


Figure 11: Error bars comparing samples of

APPENDIX V: ANOVA test result of soil physico chemical properties of forest type.

Nitrogen

Sources	**df**	**SSS**	**MSS**	***F*-value**	***p*-value**
Between samples	3	0.006037	0.002013	23.00	.006
Within samples	4	0.000350	0.000087		
Total	**7**	**0.006387**			

Phosphorous

Sources	**df**	**SSS**	**MSS**	***F*-value**	***p*-value**
Between samples	3	0.000238	0.000079	42.38	.002
Within samples	4	0.000007	0.000002		
Total	**7**	**0.000246**			

Potassium

Sources	**df**	**SSS**	**MSS**	***F*-value**	***p*-value**
Between samples	3	0.008690	0.002897	926.97	.000
Within samples	4	0.000013	0.000003		
Total	**7**	**0.008703**			

Moisture content

Sources	**df**	**SSS**	**MSS**	***F*-value**	***p*-value**
Between samples	3	147.221	49.0735	107.74	.000
Within samples	4	1.822	0.4555		
Total	**7**	**149.043**			

Organic matter

Sources	**df**	**SSS**	**MSS**	***F*-value**	***p*-value**
Between samples	3	9.32944	3.10981	154.43	.000
Within samples	4	0.08055	0.02014		
Total	**7**	**9.40999**			

Appendix V cont'd Organic carbon

Sources	**df**	**SSS**	**MSS**	***F*-value**	***p*-value**
Between samples	3	3.11984	1.03995	157.87	.000
Within samples	4	0.02635	0.00659		

Total	**7**	**3.14619**			

pH

Sources	**df**	**SSS**	**MSS**	***F*-value**	***p*-value**
Between samples	3	4.98605	1.66202	92.98	.000
Within samples	4	0.07150	0.01787		
Total	**7**	5.05755			

APPENDIX VI: Dominance of plant species composition in Dry Deciduous forest type

DRY DECIDUOUS

SPECIES(TREES)		Undisturbed			Disturbed	
	R.F in DDFFU	R.D in DDFFU	IVI for DDFFU	R.F in DDFFD	R.D in DDFFD	IVI for DDFFD
Vitex doniana	5.555556	4.37318	4.96437	7.8740157	5.72391	6.79896
Drypetes aubrevillei	3.08642	2.62391	2.85516	1.5748031	1.6835	1.62915
Manilkara obovata	0.617284	0.87464	0.74596	5.511811	3.367	4.43941
Anogeissus leiocarpus	0	0	0	1.5748031	1.6835	1.62915
Malacantha alnifolia	1.851852	1.45773	1.65479	7.8740157	4.7138	6.29391
Khaya anthotheca	0	0	0	0.7874016	1.3468	1.0671
Gmelina aborea	0.617284	0.87464	0.74596	0.7874016	1.3468	1.0671
Trichilia preuriana	4.320988	2.91545	3.61822	7.0866142	5.05051	6.06856
Alstonie boonie	1.851852	1.45773	1.65479	1.5748031	2.3569	1.96585
Gluema ivorensis	0.617284	0.87464	0.74596	0.7874016	1.0101	0.89875
Zanthoxylum leprieurii	0	0	0	1.5748031	1.6835	1.62915
Ricinodendron heudelotii	0.617284	0.87464	0.74596	0.7874016	1.3468	1.0671
Carapa procera	3.08642	2.33236	2.70939	1.5748031	2.6936	2.1342
Macaranga heudelotii	0	0	0	0.7874016	1.0101	0.89875
Strombosia pustulata	0	0	0	0.7874016	1.3468	1.0671
Pseudospondias microcarpa	2.469136	2.33236	2.40075	2.3622047	2.6936	2.5279
Cola gigantean	1.851852	2.04082	1.94633	5.511811	3.7037	4.60776
Coula edulis	0.617284	1.16618	0.89173	0.7874016	1.0101	0.89875
Nesogordinia papaverifera	4.938272	3.207	4.07263	3.9370079	3.0303	3.48366
Triplochiton scleroxylon	4.938272	3.79009	4.36418	3.1496063	2.6936	2.9216
Rhautia vomiteria	3.703704	2.91545	.30958	0.7874016	1.0101	0.89875
Macaranga barteri	3.08642	2.33236	2.70939	3.1496063	2.6936	2.9216
Cieba pentandra	2.469136	2.04082	2.25498	2.3622047	2.3569	2.35955
Funtumia elastic	1.851852	1.45773	1.65479	2.3622047	2.3569	2.35955
Pentaclethra macrophylla	0	0	0	0.7874016	1.0101	0.89875
Afrostyrax lepidophyllus	0	0	0	0.7874016	1.3468	1.0671
Cleitopholis patens	0.617284	0.87464	0.74596	0	0	0
Morinda lucida	0.617284	1.16618	0.89173	0.7874016	1.0101	0.89875
Antiaris toxicaria	2.469136	2.04082	2.25498	0.7874016	1.3468	1.0671
Baphia nitida	0	0	0	0.7874016	1.3468	1.0671
Dacryodes klaineana	0	0	0	0.7874016	1.0101	0.89875
Celtis mildbraedii	1.851852	1.74927	1.80056	1.5748031	1.6835	1.62915
Pynanthus angolensis	2.469136	2.33236	2.40075	0.7874016	1.0101	0.89875
Blighia unijugata	0	0	0	0.7874016	1.3468	1.0671

Trichilia monadelpha	0.617284	0.87464	0.74596	0.7874016	1.0101	0.89875
Vitex grandifolia	0.617284	1.16618	0.89173	0.7874016	1.0101	0.89875

RF=Relative Frequency *RD=Relative density* *IVI=Important* Value index

Appendix VI Cont'd

Mammea Africana	0.617284	1.45773	1.0375	0.7874016	1.0101	0.89875
Hallea stipulosa	0	0	0	0.7874016	1.3468	1.0671
Blighia welwitschii	0	0	0	1.5748031	2.0202	1.7975
Xylopia rubescens	0	0	0	0.7874016	1.0101	0.89875
Antrocaryon mycraster	0	0	0	0.7874016	1.3468	1.0671
Khaya ivorensis	0	0	0	0.7874016	1.0101	0.89875
Sterculia tragacantha	0	0	0	0.7874016	1.0101	0.89875
Elaeis guineensis	1.234568	1.45773	1.34615	0.7874016	1.3468	1.0671
Protomegabaria stapfiana	0	0	0	0.7874016	0.6734	0.7304
Pterygota bequaertii	0	0	0	1.5748031	1.6835	1.62915
Napoleonaea vogelii	1.851852	1.45773	1.65479	0.7874016	1.0101	0.89875
Macaranga hurifolia	0	0	0	0.7874016	0.6734	0.7304
Ficus sur	0	0	0	0.7874016	1.0101	0.89875
Newbouldia laevis	0	0	0	0.7874016	1.0101	0.89875
Guarea thompsonii	0	0	0	0.7874016	1.3468	1.0671
Bridelia micrantha	0	0	0	3.1496063	0.6734	1.9115
Anthonotha vignei	0	0	0	0.7874016	1.3468	1.0671
Cathormion altissimum	1.851852	1.74927	1.80056	0.7874016	1.0101	0.89875
Guarea cedrata	0	0	0	0.7874016	0.6734	0.7304
Sterculia rhinopetala	0	0	0	0.7874016	1.3468	1.0671
Sterculia tragagantha	2.469136	2.33236	2.40075	0.7874016	1.0101	0.89875
Khaya grandifoliola	0.617284	0.87464	0.74596	0.7874016	0.6734	0.7304
Lannea yelutina	0	0	0	0.7874016	1.0101	0.89875
Mansonia altissima	1.851852	1.74927	1.80056	0.7874016	0.6734	0.7304
Margaritaria discoidea	1.851852	2.04082	1.94633	0.7874016	1.0101	0.89875
Pterocarpus erinaceuss	0	0	0	0.7874016	1.0101	0.89875
Albizia zygia	2.469136	2.62391	2.54652	0.7874016	1.0101	0.89875
Hymenocardia acida	2.469136	2.33236	2.40075	0	0	0
Dialium dinklagei	3.08642	3.207	3.14671	0	0	0
Daniella ogea	0.617284	0.87464	0.74596	0	0	0
Tetrapleura tetraptera	0.617284	0.87464	0.74596	0	0	0
Bussea occidentalis	0.617284	1.16618	0.89173	0	0	0
Daniellia thurifera	3.08642	2.33236	2.70939	0	0	0
Duguetia staudtii	1.851852	2.04082	1.94633	0	0	0
Newtonia duparquetiana	4.320988	3.79009	4.05554	0	0	0

Anthocleista spp	0.617284	0.87464	0.74596	0	0	0
Vitex ferruginea	0.617284	1.16618	0.89173	0	0	0
Lannea welwitschii	0.617284	0.87464	0.74596	0	0	0
Distemonanthus benthamianus	0.617284	1.16618	0.89173	0	0	0
Rhadophyllum calophyllum	0.617284	0.87464	0.74596	0	0	0
Albizia ferruginea	0.617284	1.16618	0.89173	0	0	0

Appendix VI Cont'd

Holarrhena floribunda	2.469136	2.62391	2.54652	0	0	0
Khaya grandifoliolia	0.617284	0.87464	0.74596	0	0	0
Musanga cecropiodes	0.617284	1.16618	0.89173	0	0	0
Gilbertiodendron spl	0.617284	0.87464	0.74596	0	0	0
Drypetes gilgiana	0.617284	1.16618	0.89173	0	0	0
Morus mesozygia	0.617284	1.16618	0.89173	0	0	0
Christiana Africana	0.617284	0.87464	0.74596	0	0	0
Discogly premna	0.617284	1.45773	1.0375	0	0	0
Trichilia tessmannii	0.617284	1.16618	0.89173	0	0	0
Erythrophleum suaveolens	0	0	0	0	0	0
Syzygium guineense	0	0	0	0	0	0
Parkia biglobosa	0	0	0	0	0	0
Daniellia oliveria	0	0	0	0	0	0
Cynometra ananta	0	0	0	0	0	0
Blighia unijugata	0	0	0	0	0	0
Sterculia oblonga	0	0	0	0	0	0
Terminalia ivorensis	0	0	0	0	0	0
Dialium guineensis	0	0	0	0	0	0
Kigelia African	0	0	0	0	0	0
	100	100	100	100	100	100

SPECIES(SHRUBS)	R.F in DDFFU	R.D in DDFFU	IVI in DDFFU	R.F in DDFFD	R.D in DDFFD	IVI in DDFFD
Momordica charantha	18.18182	13.2075	15.6947	8.9285714	6.89655	7.91256
Hypselodelphys violaceae	14.54545	12.2642	13.4048	8.9285714	7.38916	8.15887
Griffonia simplicifolia	14.54545	11.3208	12.9331	0.8928571	1.97044	1.43165
Chromolena odorata	1.818182	2.83019	2.32419	8.9285714	6.89655	7.91256
Napoleona vogelii	1.818182	3.77358	2.79588	2.6785714	2.95567	2.81712
Culcasia angolensis	10.90909	8.49057	9.69983	8.9285714	7.38916	8.15887
Baphia nitida	3.636364	4.71698	4.17667	3.5714286	3.44828	3.50985

Combretum smeathmanii	1.818182	2.83019	2.32419	4.4642857	4.4335	4.44889
Xylopi aaethiopica	0	0	0	7.1428571	5.41872	6.28079
Spenocentrum jollyanum	0	0	0	0.8928571	1.47783	1.18534
Thaumatococcus danielli	1.818182	3.77358	2.79588	2.6785714	3.44828	3.06342
Hymenostegia afzelii	0	0	0	7.1428571	6.40394	6.7734
Paulinia pinnita	1.818182	2.83019	2.32419	7.1428571	5.91133	6.52709
Rinorea oblongifolia	5.454545	6.60377	6.02916	3.5714286	3.94089	3.75616
Alchornea cordifolia	1.818182	2.83019	2.32419	1.7857143	3.44828	2.617
Gongronema spp	1.818182	3.77358	2.79588	0.8928571	1.47783	1.18534
Adiantum pedatum	1.818182	2.83019	2.32419	3.5714286	3.44828	3.50985

Appendix VI Cont'd

Mranthocloa leucantha	3.636364	5.66038	4.64837	4.4642857	4.4335	4.44889
Imperata spp	12.72727	9.43396	11.0806	2.6785714	3.44828	3.06342
Calamus deeratus	1.818182	2.83019	2.32419	1.7857143	2.46305	2.12438
Piper guinnense	0	0	0	1.7857143	2.95567	2.37069
Aspilia Africana	0	0	0	2.6785714	3.44828	3.06342
Heteropogon contortus	0	0	0	1.7857143	2.46305	2.12438
Alchorenea cordifolia	0	0	0	0.8928571	1.97044	1.43165
Landolphia owariensis	0	0	0	1.7857143	2.46305	2.12438
Cleidion gabonicum	0	0	0	0	0	0
Adiantum pedatum	0	0	0	0	0	0
Imperata cylindrical	0	0	0	0	0	0
Mimosa pigra	0	0	0	0	0	0
Smilax krussiana	0	0	0	0	0	0
Ageratum conyzoides	0	0	0	0	0	0
Calycobolusafricanus	0	0	0	0	0	0
Aconitum colubianum	0	0	0	0	0	0
SUM	100	100	100	100	100	100

SPECIES(HERBS)	R.F DDFFU	Undisturbed R.D in DDFFU	IVI in DDFFU	R.F DDFFD	Disturbed R.D in DDFFD	IVI in DDFFD
Adenia cissampeloides	6.896552	8.19672	7.54664	6.3829787	8.33333	7.35816
Millettia pinnita	3.448276	4.91803	4.18315	17.021277	15.4762	16.2487
Acacia pentagyna	10.34483	9.83607	10.0904	14.893617	14.2857	14.5897
Zingebarofficinale	3.448276	4.91803	4.18315	6.3829787	7.14286	6.76292
Imperata spp	34.48276	24.5902	29.5365	6.3829787	8.33333	7.35816
Dracaeana aborea	10.34483	9.83607	10.0904	21.276596	19.0476	20.1621
Dodonaea pedatum	10.34483	11.4754	10.9101	10.638298	9.52381	10.0811

Calamus deeratus	3.448276	4.91803	4.18315	10.638298	10.7143	10.6763
Aconitum colubianum	13.7931	14.7541	14.2736	6.3829787	7.14286	6.76292
Appendix VI Cont'd						
Imperata cylindrical	3.448276	6.55738	5.00283	0	0	0
Mezoneuron benthamianus	0	0	0	0	0	0
SUM	100	100	100	100	100	100

APPENDIX VII: Dominance of plant species composition in savannah forest type

SAVANNAH

	Undisturbed			Disturbed		
SPECIES(TREES)	R.F SFFU	R.D in SFFU	IVI in SFFU	R.F SFFD	R.D in SFFD	IVI in SFFD
Vitex doniana	4.16667	4.1841	4.17538	3.2967	3.19149	3.2441
Drypetes aubrevillei	0.83333	1.25523	1.04428	0	0	0
Manilkara obovata	0.83333	1.25523	1.04428	1.0989	1.59574	1.34732
Anogeissus leiocarpus	1.66667	2.09205	1.87936	5.49451	4.25532	4.87491
Malacantha alnifolia	0	0	0	0	0	0
Khaya anthotheca	0	0	0	1.0989	2.12766	1.61328
Gmelina aborea	0.83333	1.25523	1.04428	0	0	0
Trichilia preuriana	5	4.60251	4.80126	1.0989	1.59574	1.34732
Alstonie boonie	3.33333	1.67364	2.50349	1.0989	2.12766	1.61328
Gluema ivorensis	1.66667	1.67364	1.67015	1.0989	1.06383	1.08137
Zanthoxylum leprieurii	0	0	0	0	0	0
Ricinodendron heudelotii	0	0	0	0	0	0
Carapa procera	0	0	0	0	0	0
Macaranga heudelotii	0	0	0	0	0	0
Strombosia pustulata	0	0	0	0	0	0
Pseudospondias microcarpa	0	0	0	0	0	0
Cola gigantean	0	0	0	0	0	0
Coula edulis	0	0	0	0	0	0
Nesogordinia papaverifera	2.5	2.09205	2.29603	0	0	0

Triplochiton scleroxylon	0.83333	1.25523	1.04428	0	0	0
Rhautia vomiteria	0	0	0	0	0	0
Macaranga barteri	0	0	0	0	0	0
Cieba pentandra	.83333	1.67364	1.25349	0	0	0
Funtumia elastic	1.66667	2.09205	1.87936	1.0989	2.12766	1.61328
Pentaclethra macrophylla	0	0	0	0	0	0
Afrostyrax lepidophyllus	0	0	0	0	0	0
Cleitopholis patens	6.66667	6.27615	6.47141	10.989	9.57447	10.2817
Morinda lucida	0.83333	1.25523	1.04428	0	0	0
Antiaris toxicaria	0	0	0	0	0	0
Baphia nitida	0	0	0	0	0	0
Dacryodes klaineana	0	0	0	0	0	0
Celtis mildbraedii	0	0	0	0	0	0
Pynanthus angolensis	0.83333	1.25523	1.04428	0	0	0
Blighia unijugata	0	0	0	0	0	0
Trichilia monadelpha	1.66667	2.09205	1.87936	0	0	0
Vitex grandifolia	0	0	0	0	0	0
Mammea Africana	0.83333	1.67364	1.25349	0	0	0
Appendix VII Cont'd						
Hallea stipulosa	0	0	0	0	0	0
Blighia welwitschii	0	0	0	0	0	0
Xylopia rubescens	0	0	0	0	0	0
Antrocaryon mycraster	0	0	0	0	0	0
Khaya ivorensis	0	0	0	0	0	0
Sterculia tragacantha	3.33333	2.92887	3.1311	1.0989	1.59574	1.34732
Elaeis guineensis	0	0	0	0	0	0
Protomegabaria stapfiana	0	0	0	0	0	0
Pterygota bequaertii	0	0	0	0	0	0
Napoleonaea vogelii	0	0	0	0	0	0
Macaranga hurifolia	0	0	0	0	0	0
Ficus sur	0	0	0	0	0	0
Newbouldia laevis	0	0	0	0	0	0
Guarea thompsonii	0	0	0	0	0	0
Bridelia micrantha	0	0	0	0	0	0
Anthonotha vignei	0.83333	1.67364	1.25349	0	0	0
Cathormion altissimum	0	0	0	0	0	0
Guarea cedrata	0	0	0	0	0	0
Sterculia rhinopetala	0	0	0	0	0	0
Sterculia tragagantha	0	0	0	0	0	0

Khaya grandifoliola	0	0	0	0	0	0
Lannea yelutina	6.66667	6.27615	6.47141	3.2967	3.19149	3.2441
Mansonia altissima	0	0	0	0	0	0
Margaritaria discoidea	0	0	0	0	0	0
Pterocarpus erinaceuss	7.5	7.11297	7.30649	7.69231	6.38298	7.03764
Albizia zygia	0	0	0	0	0	0
Hymenocardia acida	3.33333	3.34728	3.34031	10.989	10.1064	10.5477
Dialium dinklagei	0	0	0	0	0	0
Daniella ogea	0	0	0	0	0	0
Tetrapleura tetraptera	0	0	0	0	0	0
Bussea occidentalis	0	0	0	0	0	0
Daniellia thurifera	0	0	0	0	0	0
Duguetia staudtii	0	0	0	0	0	0
Newtonia duparquetiana	0	0	0	0	0	0
Anthocleista spp	0.83333	1.25523	1.04428	0	0	0
Vitex ferruginea	0	0	0	0	0	0
Lannea welwitschii	0	0	0	0	0	0
Distemonanthus benthamianus	0	0	0	0	0	0
Rhadophyllum calophyllum	0	0	0	0	0	0
Albizia ferruginea	0	0	0	0	0	0
Holarrhena floribunda	5.83333	5.02092	5.42713	1.0989	1.59574	1.34732

Appendix VII Cont'd

Khaya grandifoliolia	2.5	2.92887	2.71444	0	0	0
Musanga cecropiodes	0	0	0	0	0	0
Gilbertiodendron spl	0.83333	1.67364	1.25349	0	0	0
Drypetes gilgiana	0	0	0	0	0	0
Morus mesozygia	0	0	0	0	0	0
Christiana Africana	0	0	0	0	0	0
Discogly premna	0	0	0	0	0	0
Trichilia tessmannii	0	0	0	0	0	0
Erythrophleum suaveolens	6.66667	6.27615	6.47141	6.59341	5.85106	6.22224
Syzygium guineense	7.5	7.11297	7.30649	10.989	10.1064	10.5477
Parkia biglobosa	5	4.1841	4.59205	2.1978	3.19149	2.69465
Daniellia oliveria	3.33333	2.92887	3.1311	10.989	9.57447	10.2817
Cynometra ananta	2.5	2.51046	2.50523	1.0989	1.59574	1.34732
Blighia unijugata	1.66667	2.09205	1.87936	1.0989	2.12766	1.61328
Sterculia oblonga	6.66667	5.02092	5.84379	1.0989	1.59574	1.34732
Terminalia ivorensis	0	0	0	10.989	10.1064	10.5477

Dialium guineensis	0	0	0	3.2967	3.7234	3.51005
Kigelia African	0	0	0	1.0989	1.59574	1.34732
	100	**100**	100			**100**
SUM				**100**	**100**	

SPECIES(**SHURBS)**	R.F. SFFU	R.D in SFFU	IVI in SFFU	R.F. SFFD	R.D in SFFD	IVI in SFFD
Momordica charantha	20.6897	17.5676	19.1286	15.3846	13.1034	14.244
Hypselodelphys violaceae	0	0	0	1.53846	2.75862	2.14854
Griffonia simplicifolia	0	0	0	4.61538	4.13793	4.37666
Chromolena odorata	27.5862	22.973	25.2796	15.3846	13.7931	14.5889
Napoleona vogelii	3.44828	5.40541	4.42684	7.69231	7.58621	7.63926
Culcasia angolensis	3.44828	4.05405	3.75116	0	0	0
Baphia nitida	0	0	0	1.53846	2.06897	1.80371
Combretum smeathmanii	0	0	0	0	0	0
Xylopia aethiopica	0	0	0	0	0	0
Spenocentrum jollyanum	0	0	0	0	0	0
Thaumatococcus danielli	0	0	0	0	0	0
Hymenostegia afzelii	0	0	0	0	0	0
Paulinia pinnita	0	0	0	0	0	0
Rinorea oblongifolia	0	0	0	0	0	0
Alchornea cordifolia	0	0	0	0	0	0
Gongronema spp	0	0	0	3.07692	3.44828	3.2626
Adiantum pedatum	0	0	0	0	0	0
Mranthocloa leucantha	0	0	0	0	0	0
Imperata spp	0	0	0	0	0	0

APPENDIX VII Cont'd

Calamus deeratus	3.44828	5.40541	4.42684	1.53846	2.75862	2.14854
Piper guinnense	0	0	0	0	0	0
Aspilia Africana	17.2414	14.8649	16.0531	15.3846	13.1034	14.244
Heteropogon contortus	0	0	0	0	0	0
Alchorenea cordifolia	0	0	0	0	0	0
Landolphia owariensis	3.44828	4.05405	3.75116	12.3077	11.7241	12.0159
Cleidion gabonicum	3.44828	4.05405	3.75116	0	0	0
Adiantum pedatum	3.44828	5.40541	4.42684	7.69231	8.27586	7.98408

Imperata cylindrical	6.89655	6.75676	6.82665	1.53846	2.06897	1.80371
Mimosa pigra	0	0	0	3.07692	3.44828	3.2626
Smilax krussiana	3.44828	4.05405	3.75116	1.53846	2.06897	1.80371
Ageratum conyzoides	0	0	0	1.53846	2.75862	2.14854
Calycobolus africanus	3.44828	5.40541	4.42684	4.61538	4.82759	4.72149
Aconitum colubianum						0
SUM	**100**	**100**	**100**		**100**	

SPECIES(**HERBS**)	R.F. SFFU	Undisturbed R.D. in SFFU	IVI of SFFU	R.F. SFFD	Disturbed R.D in SFFD	IVI of SFFD
	0	0 **100**	1.53846	2.06897	**100**	1.80371
Adenia cissampeloides	0	0	0	0	0	0
Millettia pinnita	0	0	3.19149	6.38298	7.6087	6.99584
Acacia pentagyna	0	0	0	0	0	0
Zingeba rofficinale	20.8333	21.0526	17.8635	14.8936	16.3043	15.599
Imperata spp	20.8333	19.2982	21.055	21.2766	20.6522	20.9644
Dracaeana aborea	4.16667	5.26316	5.27482	6.38298	7.6087	6.99584
Dodonaea pedatum	25	22.807	18.883	12.766	11.9565	12.3612
Calamus deeratus	20.8333	19.2982	21.055	21.2766	19.5652	20.4209
Aconitum colubianum	4.16667	5.26316	7.40248	10.6383	9.78261	10.2105
Imperata cylindrical	0	0	0	0	0	0
Mezoneuron benthamianus	4.16667	7.01754	5.27482	6.38298	6.52174	6.45236
SUM	**100**	**100**	**100**	**100**	**100**	**100**

RF=Relative Frequency *RD=Relative density* *IVI=Important* Value index

APPENDIX VIII: Plant species density, richness, diversity and evenness for forest types**.**

SUMMARY: TREE

Plot	Density	Species richness	Shannon diversity index	Shannon evenness
Plot 1 DDFFD	41	10	1.938274533	0.84178193
Plot 2 DDFFD	36	21	2.899810593	0.95246813
Plot 3 DDFFD	40	24	3.017308429	0.94942018
Plot 4 DDFFD	41	21	2.926945958	0.96138098
Plot 5 DDFFD	47	23	2.964702221	0.94552948
Plot 6 DDFFD	35	19	2.517461179	0.8549884
Plot 7 DDFFD	27	14	2.374867534	0.89989236
Plot 8 DDFFD	33	14	2.33109729	0.8833068
Plot 9 DDFFD	29	10	1.894725189	0.82286869
Plot 10 DDFFD	30	13	2.349698307	0.91607981
Plot 11 DDFFU	22	12	1.922252064	0.77357114
Plot 12 DDFFU	50	25	4.059111764	1.26103397
Plot 13 DDFFU	60	23	4.513443655	1.43946802
Plot 14 DDFFU	48	18	3.454153962	1.19505526
Plot 15 DDFFU	43	21	3.452535243	1.13401537

Plot 16 DDFFU	34	23	3.26298203	1.04065956
Plot 17 DDFFU	29	19	2.762074598	0.93806481
Plot 18 DDFFU	32	17	2.67460946	0.94401979
Plot 19 DDFFU	34	20	3.106910989	1.03711237
Plot 20 DDFFU	40	26	3.778131245	1.15961304
Plot 21 SFFD	15	8	1.249827173	0.60103982
Plot 22 SFFD	12	8	1.092239301	0.52525607
Plot 23 SFFD	34	5	1.295334954	0.80483686
Plot 24 SFFD	41	10	2.072039508	0.89987532

Appendix VIII cont'd

Plot 25 SFFD	13	2	0.54841412	0.79119433
Plot 26 SFFD	23	7	1.424167987	0.73187757
Plot 27 SFFD	38	6	1.22618047	0.68434435
Plot 28 SFFD	54	6	1.491445472	0.83239157
Plot 29 SFFD	44	7	1.716171247	0.88193756
Plot 30 SFFD	32	14	2.425585359	0.91911052
Plot 31 SFFU	39	13	2.847212202	1.11004617
Plot 32 SFFU	29	10	2.100599843	0.91227892
Plot 33 SFFU	48	11	3.003218973	1.25243959

Plot 34 SFFU	18	12	1.746017952	0.70264931
Plot 35 SFFU	46	16	3.44525591	1.2426134
Plot 36 SFFU	27	12	2.269395837	0.91327207
Plot 37 SFFU	30	10	2.191319884	0.95167813
Plot 38 SFFU	29	10	2.113426683	0.91784955
Plot 39 SFFU	27	10	2.045058614	0.88815767
Plot 40 SFFU	23	11	1.983300496	0.82710055

SUMMARY: SHRUB LAYER

Plot	Density	Species richness	Shannon diversity index	Shannon evenness
Plot 1 DDFFD	38	5	0.77896523	0
Plot 2 DDFFD	47	16	0.30997036	0.111798174
Plot 3 DDFFD	62	11	2.32412001	0.969233327
Plot 4 DDFFD	59	16	2.59975111	0.937662008
Plot 5 DDFFD	48	12	2.37119726	0.954239974
Plot 6 DDFFD	45	11	2.3139336	0

Appendix VIII cont'd

Plot 7 DDFFD	24	12	2.38354037	0.959207209
Plot 8 DDFFD	29	11	2.29758121	0.958165785
Plot 9 DDFFD	27	11	2.31350194	0.964805248
Plot 10 DDFFD	27	11	2.32608706	0.970053648
Plot 11 DDFFU	20	5	1.29456058	0.804355715
Plot 12 DDFFU	15	5	1.5641315	0.971849545
Plot 13 DDFFU	32	7	1.8894564	0.970988512
Plot 14 DDFFU	23	5	1.54213674	0
Plot 15 DDFFU	9	5	1.52295507	0.946265187
Plot 16 DDFFU	13	6	1.69773359	0.947523158
Plot 17 DDFFU	10	19	1.69574253	0.946411928
Plot 18 DDFFU	9	5	1.58109375	0.982388782
Plot 19 DDFFU	8	5	1.55958116	0.969022256
Plot 20 DDFFU	11	5	1.54659869	0.960955793
Plot 21 SFFD	65	7	1.62880204	0.837038667
Plot 22 SFFD	32	5	1.44640036	0.898699075
Plot 23 SFFD	22	5	1.55443283	0.965823419
Plot 24 SFFD	10	4	1.36615885	0.985475297
Plot 25 SFFD	16	6	1.70016494	0.948880121
Plot 26 SFFD	12	5	1.5171064	0.942631204
Plot 27 SFFD	11	5	1.54659869	0.960955793
Plot 28 SFFD	11	4	1.29454517	0.933816945
Plot 29 SFFD	17	7	1.89462886	0.973646632

Plot 30 SFFD	14	5	1.53177808	0.951747232
Plot 31 SFFU	10	4	1.22060726	0.880482024
Plot 32 SFFU	2	2	0.69314718	1

Appendix VIII cont'd

Plot 33 SFFU	8	3	1.08219553	0.985056822
Plot 34 SFFU	6	4	1.32966135	0.959147917
Plot 35 SFFU	14	7	1.80951426	0.929906377
Plot 36 SFFU	6	3	1.01140426	0.920619836
Plot 37 SFFU	12	6	1.67623494	0.935524532
Plot 38 SFFU	7	3	1.00424247	0.914100892
Plot 39 SFFU	5	2	0.50040242	0.721928095
Plot 40 SFFU	7	3	0.95569989	0.86991553

Herbs layer

Plot	Density	Species richness	Shannon diversity index	Shannon evenness
Plot 1 DDFFD	10	2	0.48300092	0.69682303
Plot 2 DDFFD	11	3	1.09861229	1
Plot 3 DDFFD	16	5	1.54378919	0.95921015
Plot 4 DDFFD	11	4	1.34211318	0.96813001
Plot 5 DDFFD	9	5	1.58109375	0.98238878
Plot 6 DDFFD	9	4	1.36892236	0.98746875
Plot 7 DDFFD	10	6	1.69574253	0.94641193

Plot 8 DDFFD	8	5	1.55958116	0.96902226
Plot 9 DDFFD	12	5	1.56071041	0.9697239
Plot 10 DDFFD	16	7	1.84074873	0.94595772
Plot 11 DDFFU	39	3	0.72861186	0.66321109
Plot 12 DDFFU	5	2	0.67301167	0.97095059
Plot 13 DDFFU	12	4	1.26500138	0.91250561
Plot 14 DDFFU	13	3	0	0
Plot 15 DDFFU	4	3	1.03972077	0.94639463
Plot 16 DDFFU	4	3	0.68257716	0.94639463

Appendix VIII cont'd

Plot 17 DDFFU	4	3	0.7824046	0.71217536
Plot 18 DDFFU	11	5	1.51570795	0.9417623
Plot 19 DDFFU	7	4	1.35178399	0.97510603
Plot 20 DDFFU	9	6	1.73512646	0.96839251
Plot 21 SFFD	34	4	0.82592164	0.59577653
Plot 22 SFFD	20	5	1.00976271	0.62740085
Plot 23 SFFD	15	3	1.08518861	0.98778124
Plot 24 SFFD	19	5	1.55908699	0.96871521

Plot 25 SFFD	14	4	4	0.89422523
Plot 26 SFFD	5	3	1.05492017	0.96022972
Plot 27 SFFD	5	2	0.67301167	0.97095059
Plot 28 SFFD	9	3	1.09861229	1
Plot 29 SFFD	7	2	0.6829081	0.98522814
Plot 30 SFFD	10	4	1.36615885	0.9854753
Plot 31 SFFU	7	3	1.07899221	0.98214103
Plot 32 SFFU	11	3	0	0.85086423
Plot 33 SFFU	5	2	0.67301167	0.97095059
Plot 34 SFFU	8	3	1.00271826	0.96902226
Plot 35 SFFU	6	4	1.32966135	0.95914792
Plot 36 SFFU	7	4	1.35178399	0.97510603
Plot 37 SFFU	3	3	1.09861229	1
Plot 38 SFFU	3	2	0.63651417	0.91829583
Plot 39 SFFU	4	2	0.69314718	1
Plot 40 SFFU	5	3	1.05492017	0.96022972

APPENDIX IX: List of plant species identified in the forest types and number of individual.

S/N	TREES Species Name	Family Name	Local Name	NUNMBER OF INDIVIDUALS			
				Dry Deciduous Forest		Savannah Forest	
				Fire Undisturbed	*Fire Disturbed*	*Fire Undisturbed*	*Fire Disturbed*
1	*Vitex doniana*	*Lamiaceae*	*Adodowa*	21	38	13	10
2	*Drypetes aubrevillei*	*Euphorbiaceae*	*Duamako*	11	6	4	-
3	*Manilkara obovata*	*Sapotaceae*	*Berekankum*	2	16	2	2
4	*Anogeissus leiocarpus*	*Combretaceae*	*Kanie*	-	8	8	13
5	*Malacantha alnifolia*	*Sapotaceae*	*Frafraraha*	8	35	-	-
6	*Khaya anthotheca*	*Meliaceae*	*Krunben*	-	3	-	1
7	*Gmelina aborea*	*Lamiaceae*	*Gmelina*	5	1	3	-
8	*Trichilia preuriana*	*Meliaceae*	*Kakadukro*	16	22	14	3
9	*Alstonie boonie*	*Apocynaceae*	*Sinuro*	8	7	11	2
10	*Gluema ivorensis*	*Sapotaceae*	*Nsudua*	3	3	6	1
11	*Zanthoxylum leprieurii*	*Rutaceae*	*Oyaa*	-	7	-	-
12	*Ricinodendron heudelotii*	*Euphorbiaceae*	*Wama*	4	2	-	-
13	*Carapa procera*	*Meliaceae*	*Kwakubese*	12	8	-	-
14	*Macaranga heudelotii*	*Euphorbiaceae*	*Awora – Opam*	-	5	-	-
15	*Strombosia pustulata*	*Olacaceae*	*Afena*	-	3	-	-
16	*Pseudospondia smicrocarpa*	*Anacardiaceae*	*Akatawani*	9	11	-	-
18	*Cola gigantean*	*Sterculiaceae*	*Watapuo*	7	15	-	-
19	*Coula edulis*	*Olacaceae*	*Bodwue*	5	4	-	-
20	*Nesogordinia papaverifera*	*Sterculiaceae*	*Apuro*	15	14	8	-
21	*Triplochiton scleroxylon*	*Malvaceae*	*Wawa*	15	10	2	-

22	*Rhautia vomiteria*	------------- ---	*Kakapenpen*	10	3	-	-
23	*Macaranga barteri*	*Euphorbi ıceae*	*Opam*	10	8	-	-
24	*Cieba pentandra*	*Malvaceae*	*Cieba/Onyina*	9	6	4	-
25	*Funtumia elastic*	*Apocynac ae*	*Funtum*	8	8	7	1
26	*Pentaclethra macrophylla*	*Fabaceae*	*Ataa*	-	2	-	-
28	*Afrostyrax lepidophyllus*	*Huaceae*	*Duagyenne*	-	5	-	-
29	*Cleitopholis patens*	*Annonaceae*	*Ngo Ne Nkyene*	5	-	19	24
30	*Morinda lucida*	*Rubiaceae*	*Konkroma*	1	2	3	1
31	*Antiaris toxicaria*	*Moraceae*	*Kyenkyen*	8	3	-	-
32	*Baphia nitida*	*Fabaceae.*	*Odwen*	-	1	-	-
33	*Dacryodes klaineana*	*Burseraceae*	*Adwea*	-	2	-	-
34	*Celtis mildbraedii*	*Ulmaceae*	*Esa*	8	8	-	-
35	*Pynanthus angolensis*	*Myristicaceae*	*Otie*	8	3	5	-
36	*Blighia unijugata*	*Sapindaceae,*	*Akye-Nini*	-	3	-	-
37	*Trichilia monadelpha*	*Meliaceae*	*Tanuro*	4	2	7	-
38	*Vitex grandifolia*	*Lamiaceae*	*Supowa*	2	3	-	-
39	*Mammea Africana*	*Guttiferae*	*Bompagya*	3	2	2	-
40	*Hallea stipulosa*	*Rubiaceae*	*Subaha*	-	2	-	-
41	*Blighia welwitschii*	*Sapindaceae*	*Akye – Kobiri*	-	6	-	-
42	*Xylopia rubescens*	*Annonaceae*	*Dua – Kokoo*	-	1	-	-
43	*Antrocaryon mycraster*	*Anacardiaceae*	*Aprokuma*	-	5	-	-
44	*Khaya ivorensis*	*Meliaceae*	*Dubin*	-	2	-	-
45	*Sterculia tragacantha*	*Sterculiaceae*	*Sofo*	-	2	10	1
46	*Elaeis guineensis*	*Palmae*	*Palm Tree*	6	1	1	-
47	*Protomega bariastapfiana*	*Phyllanthaceae*	*Agyahere*	-	1	-	-
48	*Pterygota bequaertii*	*Malvaceae*	*Kyere-bere*	-	6	-	-
49	*Napoleonae avogelii*	*Lecythidaceae*	*Obua*	7	3	-	-
50	*Macaranga hurifolia*	*Euphorbiaceae*	*Opam – Fufuo*	-	2	-	-
51	*Ficus sur*	*Moraceae*	*Domini*	-	3	-	-

52	*Newbouldia laevis*	*Bignoniaceae*	*Sesemasa*	-	5	-	-
53	*Guarea thompsonii*	*Meliaceae*	*Kwadwuma*	-	1	-	-
54	*Bridelia micrantha*	*Phyllanthaceae*	*Bawea*	-	13	-	-
55	*Anthonotha vignei*	*Fabaceae*	*Tufuabo*	-	1	5	-
56	*Cathormion altissimum*	*Leguminosae*	*Abobonkayere*	6	1	-	-
57	*Guarea cedrata*	*Meliaceae*	*Kwabohoro*	-	1	-	-
58	*Sterculia rhinopetala*	*Sterculiaceae*	*Wamabima*	-	1	-	-
59	*Sterculia tragagantha*	*Sterculiaceae*	*Foto*	8	3	-	-
60	*Khaya grandifoliola*	*Meliaceae*	*Mahogany*	3	5	-	-
61	*Lannea yelutina*	*Anacardiaceae*	*Kuntunikuni*	-	3	17	7
62	*Mansonia altissima*	*Sterculiaceae*	*Oprono*	7	2	-	-
63	*Margaritaria discoidea*	*Euphorbiaceae*	*Papea*	8	1	-	-
64	*Pterocar puserinaceuss*	*Leguminosae*	*Rosewood*	-	2	20	15
65	*Albizia zygia*	*Leguminosae*	*Okoro*	8	1	-	-
66	*Hymeno cardiaacida*	*Phyllanthaceae*	*Sabrakyie*	7	-	8	72
67	*Dialium dinklagei*	*Leguminosae*	*Awendade*	10	-	-	-
68	*Daniella ogea*	*Leguminosae*	*Hyedua*	1	-	-	-
69	*Tetrapleura tetraptera*	*Leguminosae*	*Prekese*	1	-	-	-
70	*Busseaoc cidentalis*	*Leguminosae*	*Kotoprepre*	2	-	-	-
71	*Daniellia thurifera*	*Leguminosae*	*Sopi*	11	-	-	-
72	*Duguetia staudtii*	*Annonaceae*	*Duawisa*	8	-	-	-
73	*Newtoniaduparquetiana*	*Leguminosae*	*Adadaba*	15	-	-	-
74	*Anthocleista spp*	*Loganiaceae*	*Bontodee*	4	-	1	-
75	*Vitexferruginea*	*Lamiaceae*	*Otwentorowa*	3	-	-	-
76	*Lanneawelwitschii*	*Anacardiaceae*	*Kumanini*	1	-	-	-
77	*Distemonanthusbenthamianus*	*Leguminosae*	*Bonsamdua*	2	-	-	-
78	*Rhadophyllumcalophyllum*	*Ochnaceae*	*Opunini*	2	-	-	-
79	*Albiziaferruginea*	*Leguminosae*	*AwienfoSamina*	3	-	-	-

80	*Holarrhena floribunda*	*Apocynaceae*	*Sese*	13	-	15	1
81	*Khayagrandifoliolia*	*Meliaceae*	*Kruba*	5	-	8	-
82	*Musangacecropiodes*	*Urticaceae*	*Oduma*	4	-	-	-
83	*Gilbertio dendronspl*	*Fabaceae*	*Agyamera*	3		1	-
84	*Drypetesgilgiana*	*Euphorbiaceae*	*Katrika*	2	-	-	-
85	*Morusmesozygia*	*Moraceae*	*Wonton*	2	-	-	-
86	*Christiana Africana*	*Tiliaceae*	*Suprono*	2	-	-	-
87	*Discoglypremna*	*Lamiaceae*	*Fetefre*	5	-	-	-
88	*Trichiliatessmannii*	*Meliaceae*	*Tanuro – Nini*	2	-	-	-
89	*Erythrophleumsuaveolens*	*Leguminosae*	*Protodom*	-	-	17	15
90	*Syzygiumguineense*	*Myrtaceae*	*Asibenyanya*	-	-	20	62
91	*Parkiabiglobosa*	*Fabaceae*	*Dawadawa*	-	-	15	6
92	*Danielliaoliveria*	*Leguminosae*	*Sanya*	-	-	9	20
93	*Cynometraananta*	*Caesalpiniaceae*	*Ananta*	-	-	10	1
94	*Blighiaunijugata*	*Sapindaceae*	*Akyeberi*	-	-	7	3
95	*Sterculiaoblonga*	*Sterculiaceae*	*ohaa*	-	-	15	1
96	*Terminaliaivorensis*	*Combretaceae*	*Emire*	-	-	-	31
97	*Dialiumguineensis*	*Leguminosae*	*Asenaa*	-	-	-	9
98	*Kigelia African*	*Bignoniaceae*	*Nufutin*	-	-	-	1
	Total	---------------------	-------------------	**379**	**348**	**313**	**303**

SHRUBS

	SHRUBS			**NUMBER OF INDIVIDUALS**			
				Dry Deciduous Forest		**Savannah Forest**	
S/N	***Species Name***	***Family Name***	***Local Name***	***Fire Undisturbed***	***Fire Disturbed***	***Fire Undisturbed***	***Fire Disturbed***
1	*Momordica charantha*	*Cucurbitaceae*	*Nya- Nya*	43	51	14	45
2	*Hypselodelphysviolaceae*	*Marantaceae*	*Babadua*	19	26	-	3

3	*Griffoniasimplicifolia*	*Fabaceae*	*Kaja*	20	5	-	7
4	*Chromolenaodorata*	*Asteraceae*	*Acheampong*	5	37	17	24
5	*Napoleonavogelii*	*Myrtaceae*	*Obuaa*	3	9	3	11
6	*Culcasiaangolensis*	*Araceae*	*Konkrohahan*	14	26	1	-
7	*Baphianitida*	*Fabaceae*	*Odwene*	6	11	3	3
8	*Combretumsmeathmanii*	*Combretaceae*	*Hyeremoo*	4	12	-	-
9	*Xylopiaaethiopica*	*Annonaceae*	*Hwento-ohenti*	-	17	-	-
10	Spenocentrumjollyanum	*Menispermaceae*	*Karamankote*	-	2	-	-
11	Thaumatococcusdanielli	*Marantaceae*	*Aworommo*	3	7	-	-
12	Hymenostegiaafzelii	*Leguminosae*	*Takorowa*	-	17	-	-
13	*Pauliniapinnita*	*Sapindaceae*	*Ntowentini*	4	17	-	-
14	*Rinorea oblongifolia*	*Pittosporaceae*	*Mpawuotumtum*	10	11	-	-
15	*Alchorneacordifolia*	*Euphorbiaceae*	*Ogyama*	5	7	-	-
16	*Gongronemaspp*	*Asclepiadaceae*	*Ansurogya*	3	3	-	6
17	*Adiantumpedatum*	*Pteridaceae*	*Fern*	4	10	-	-
18	*Mranthocloaleucantha*	*Lamiaceae.*	*Sibire*	6	13	-	-
19	*Imperataspp*	*Poaceae*	*Droben*	15	9	-	-
20	*Calamus deeratus*	*Palmae*	*Damere*	3	7	1	1
21	*Piper guinnense*	*Piperaceae*	*Sorowusa*	-	8	--	-
22	*Aspilia Africana*	*Compositae*	*Mfonfoa*	-	10	10	45
23	*Heteropogoncontortus*	*Poaceae*	*Spear grasses*	-	6	-	-
24	*Alchoreneacordifolia*	*Euphorbiaceae*	*Jama*	-	4	-	-
25	*Landolphiaowariensis*	*Apocynaceae*	*Kentankrate*	-	6	5	19
26	*Cleidiongabonicum*	*Euphorbiaceae*	*Mpawuofuofuo*	-	3	9	3
27	*Adiantumpedatum*	*Pteridaceae*	*Aye*	-	-	3	10
28	*Imperata cylindrical*	*Poaceae*	*Aponkyeabogyese*	-	-	6	5
29	*Mimosa pigra*	*Fabaceae*	*Abrewekatawoho*	-	-	-	7
30	*Smilax krussiana*	*Smilacaceae*	*kokraa*	-		1	2
31	*Ageratum conyzoides*	*Compositae*	*Adwokro*	-	-	-	3
32	*Calycobolus africanus*	*Convolvulaceae*	*Motuo*	-	-	2	8

33	Aconitum colubianum	*Ranunculaceae*	*Akokra-notansa*	-	-	-	4
	Total	**--------------------**	**-----------------------**	**180**	**331**	**74**	**190**

HERBS

S/N	***Species Name***	***Plant Family***	***Local Name***	**NUMBER OF INDIVIDUALS**			
				Dry Deciduous Forest		**Savannah Forest**	
				Fire Undisturbed	***Fire Disturbed***	***Fire Undisturbed***	***Fire Disturbed***
1	*Adeniacissampeloides*	*Passifloraceae*	Kusietoma	6	8	-	-
2	*Millettiapinnita*	*Leguminosae*	Sahoma	4	17	-	6
3	*Acacia pentagyna*	*Fabaceae*	Sapowie	9	15	-	-
4	*Zingeba rofficinale*	*Zingiberaceae*	Sensam	4	9	13	15
5	*Imperata spp*	*Poaceae*	Tretwe	35	9	13	45
6	*Dracaeanaaborea*	*Dracaenaceae*	Ntuo-ntuo	9	32	2	6
7	*Dodonaeapedatum*	*Sapindaceae*	Okum-ankani	9	10	14	14
8	*Calamusdeeratus*	*Palmae*	Nfiaa	5	10	12	28
9	*Aconitum colubianum*	*Ranunculaceae*	Aboakro	12	7	5	11
10	*Imperata cylindrical*		*Esree*	1	-	-	-
11	*Mezoneuron benthamianus*	*Rubiaceae*	*Akoobowere*	-	-	2	6
	Total	**--------------------**	**----------------**	**97**	**102**	**62**	**131**