KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF SCIENCE

DEPARTMENT OF ENVIRONMENTAL SCIENCE

THE IMPACT OF ILLEGAL FARMING ON BIODIVERSITY OF SUI RIVER FOREST RESERVE IN SEFWI WIAWSO FOREST DISTRICT, GHANA

BY

YEBOAH EMMANUEL

NOVEMBER, 2013

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

BY

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NOVEMBER, 2013

DECLARATION

"I hereby declare that I have wholly undertaken this study reported therein under the supervision of Dr. Ebenezer J. D. Belford and that except portions where references have been duly cited, this thesis is the outcome of my research".

Date: …….. ……

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Date: …….. ……

(Head of Department)

DEDICATION

I dedicate this work to my son Francis Opoku Yeboah.

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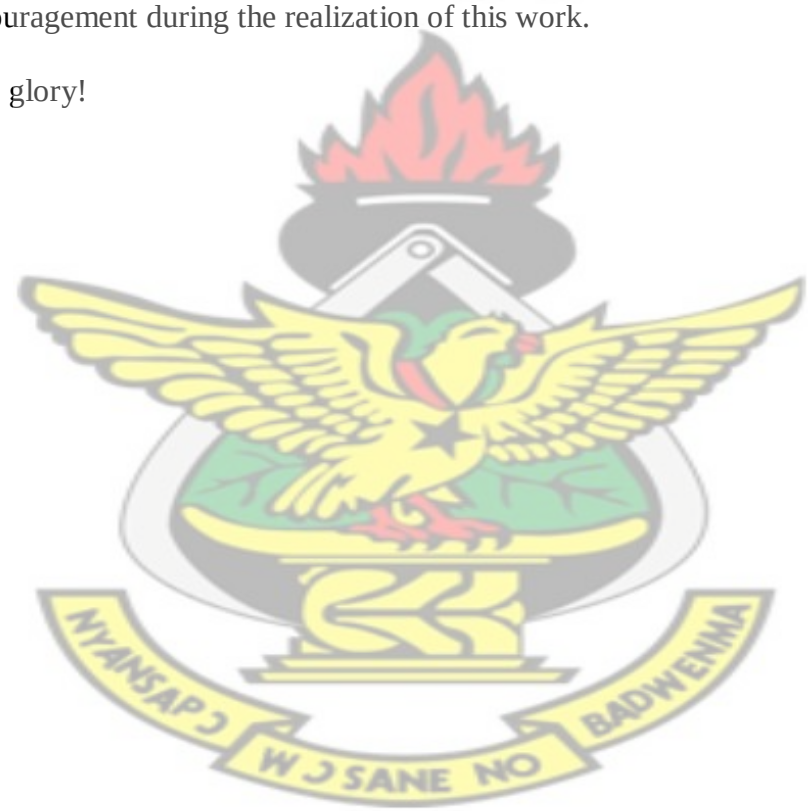
To God is all the glory!



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ABSTRACT

Despite substantial loss of natural forest in Sui River Forest Reserve by human disturbances, mainly illegal farming, little is known about the impact of the disturbances on biodiversity status of the forest reserve. To investigate the impact of illegal farming on biodiversity of Sui River Forest Reserve, flora and fauna were sampled in three forest compartments (163, 106 and 171) within the reserve. Compartment 163 was heterogeneous having two forest types, undisturbed forest (UF) and disturbed forest (DF) whilst compartments 106 and 171 were homogeneous. Compartments 106 was undisturbed forest and 171 was disturbed forest. The undisturbed forests (UF) served as control plots. In each forest block within the compartments, two 25m x 25m plots were randomly demarcated and these were subdivided into twenty-five 5m x 5m subplots. Fifteen (15) of the subplots accounting for 60% of the plot area were randomly sampled for tree species, regeneration of tree seedlings, herbs and fauna. Species diversity was determined using Shannon-Wiener Diversity Index (H^1). Species richness for flora and fauna in the undisturbed Forest (UF) was quantitatively higher than in the disturbed Forest (DF). *Celtis mildbraedii* was identified as the dominant and an indicator species for the undisturbed forest whilst *Musanga cecropioides* and *Trema orientalis* were identified as dominant and indicator species for the disturbed forest. Illegal farming had a direct impact on the regenerative capacity of the reserve resulting in colonisation by an invasive species *Chromolaena odorata* which displaced native species resulting in poor regeneration in the disturbed areas. The widespread loss and fragmentation of the original closed canopy of the moist semi-deciduous forest and the destruction of suitable habitat niches through the removal of forest vegetation in illegally farmed areas resulted in low fauna species and low diversity in the disturbed forest. The findings of the study revealed that illegal farming has negatively impacted on the biodiversity in Sui River Forest Reserve. Thus sustainable forest management is required to reduce the forest degradation process and biodiversity loss.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of study

Ghana covers a total land area of 23.9 million hectares. Approximately 30% (8.2 million hectares) of it constitutes the High Forest Zone. Two hundred and sixty-six (266) Forest Reserves with an area of 1.6 million hectares have been gazetted within the High Forest Zone with an estimated 400,000 hectares of closed canopy forests off-reserve (CFMP, 2009).

The existing 266 forest reserves within the High Forest Zone (HFZ) have been classified predominantly into Productive Reserves (47%), Permanent Protection Reserves (21%), Conversion Reserves (8%) and Convalescence Reserves (7%). The remaining 17% of the reserves are for a myriad of purposes (CFMP, 2009).

Ghana's forest and wildlife are a vital source of income for the country and livelihood for most people. Everyone in the country relies on sustainable healthy and well-managed forests. However, despite the public efforts by the Government and Forest Sector Agencies to protect forest and wildlife resources, the situation in Ghana seems degenerating and therefore demands increased attention. At present, forests in Ghana are considered among the most endangered in the world (TED, 2012).

Deforestation as a result of illegal farming has claimed an enormous toll through the ages in environmental damage, economic deterioration and human misery. Cash crop cultivation has rapidly and significantly decreased the rainforest in Ghana. Since 1981, the annual rate of deforestation in Ghana has been 2% per annum or 750 hectares each year. Ghana's tropical forest area is now just 25% of its original size (TED, 2012).

The majority of Ghanaians have always opted for herbal treatment over western medicine, however, more than 250 indigenous trees and plants with healing properties which have been catalogued are being lost (TED**,** 2012).

Located in the Western Region of Ghana, the Sefwi Wiawso District faces increasing deforestation due to its high population growth rate and the attendant negative anthropogenic impacts. The forests of the District are being encroached upon at alarming rate, resulting in the degradation of large sections of hitherto pristine forests (Vordzogbe *et al*., 2005).

The Sefwi area introduced cocoa production relatively late and only in the last couple of decades has it begun to witness the unequivocal signs of environmental degradation that have already invested most of southern Ghana. Apart from the economic downturn which is approaching, farmers in Sefwi as elsewhere in what used to be the forest belt, have witnessed a rapid degradation of the environment and are increasingly voicing their concerns (Boni, 2006).

Sui River Forest Reserve is unique because it falls within the Bia and Tano Basins and it is drained by the Sui River (Chemogo *et al*., 2013). However, in recent times the reserve is under serious threat by illegal farmers (FSD, 2012).

1.2 Problem Statement and Justification

Admitted farmers in Sui River Forest Reserve in Sefwi Wiawso Forest District in the Western Region of Ghana do not follow the prescribed forest laws, rules and regulations in their farming activities. In the quest for their basic necessities of life (food, clothing and shelter) they encroach the forest reserve without taking into account the harm or damage they cause to the biodiversity, wildlife habitat and the environment (FSD, 2012).

Illegal farming in the reserve has now become an annual phenomenon with about One-third ($^1/_3$ or 33.33%) of the forest reserve destroyed by illegal farmers (FSD, 2012). Consequently, biodiversity loss is now common in Sui River Forest Reserve. Growing public concern about biodiversity loss in Sui River Forest Reserve as a result of illegal farming is of grave concern to stakeholders in the Forestry sector and the local community members (Vordzogbe *et al*., 2005; FSD, 2012). Unfortunately, enough data on the impact of illegal farming on biodiversity in the forest reserve is lacking. This study was designed to elucidate the impact of illegal farming in Sui River Forest Reserve on biodiversity changes with the view to designing strategies for conservation.

1.3 Objectives of the Study

- **Main Objective**
  - To investigate the impact of illegal farming on biodiversity of Sui River Forest Reserve.
- **Specific Objectives**
  - To determine the impact of illegal farming on the tree composition of the forest vegetation of Sui River Forest Reserve.
  - To determine the impact of illegal farming on the fauna of the forest reserve.
  - To determine the impact of illegal farming on natural regeneration in Sui River Forest Reserve.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Concept of Forest

A forest is defined as land with more than 10% tree cover (of trees) which are more than 5metres tall usually within minimum size of 0.5 hectares. Forest is a plant community, predominantly of trees or other woody vegetation occupying an extensive area of land and in its natural state, a forest remains in a relatively fixed, self- regulated condition over a long period of time and that climate, soil and the topography of the region determine the characteristic of trees of a forest (Addai, 2011).

Regenerative processes, and the time scale in which they occur, define the ability for a forest to recover after disturbance and are strongly dependent on the scale and other aspect of the spatial distribution of the disrupted patches (Hawthorne and Abu-Juam, 1993).

Forest provides many social, economic and environmental benefits. In addition to timber and paper products, forest provides wildlife habitat and recreational opportunities, prevent soil erosion and flooding, help provide clean air and water and contain tremendous biodiversity. Forest is also an important defence against global climate change (Myers *et al*., 2000).

In spite of the enormous benefits obtained from forest and its resources, large areas of the richest forest in the world have been cleared for wood fuel, timber products, agriculture and livestock (Alonso *et al*., 2001). These forests are rapidly disappearing (Addai, 2011).

Tropical forest ecosystems host about two-thirds of the earth's terrestrial biodiversity (Gardner *et al*., 2009) and provide a variety of socioeconomic and conservation, hydrological and energy cycles, and stabilization of micro and macro-climate (Wright, 2005). Despite increasing concern

over the loss of tropical forests by local, regional and international efforts to find solutions to the problem, the rate of deforestation in the tropics continues unabated (Owusu *et al*., 2006; Meijaard *et al*., 2007).

2.2 Forest Reservation and Management in Ghana

In 1906, the colonial administration enacted legislation to control the felling of commercial tree species. In 1909 the Forestry Department was established. Demarcation and reservation of the forest estate took place between 1928 and 1939, and the Forest Policy of 1948 was developed as a guiding instrument for the management of forests (Boakye and Affum, 2006).

According to Boakye and Affum (2006) at the beginning of the twentieth century the forest area of Ghana covered about 34 percent of the total land area and forest reservation started in 1927 by the colonial administration and ensured the reservation of 11 percent of the country's total land area. In all 282 forest reserves and 15 wildlife protected areas, occupying more than 38,000 km^2 or about 16 percent of the total land area, were established and gazetted in Ghana. There was an additional 4000 km^2 of forest outside this gazetted area.

The main aim of the reservation programme was to ensure the protection of substantial areas of forest, but the process of forest land reservation ignored the traditional tenure system, which led to a negative attitude to reserves among the population, especially in forest fringe communities. The situation was aggravated by a failure to inform forest communities of their usufruct rights and also by focusing of forest management mainly on forest protection activities by the central government (Boakye and Affum, 2006).

According to Boakye and Affum (2006) all forest lands in Ghana are held in trust by the government, which manages them for the stool landowners. However, the Forest and Wildlife Policy of 1948 stipulated that the government manage forest resources single-handedly, without the collaboration of Forest Fringe Communities. This system did not yield many positive results. The passage of the current Forest and Wildlife Policy of 1994 led to some progress regarding stakeholder collaboration. The Forest and Wildlife Policy of 1994 introduced a new set of principles for sustainable forest management and established priorities for development of the forest sector. This policy therefore contributed to the development of a national forest estate and a timber industry which provides the full range of benefits to society in a manner that is ecologically sustainable, while conserving Ghana's environmental and cultural heritage. The new policy promotes public participation in the sharing of forest management benefits and responsibilities, and encourages integrated and coordinated research in forest-related issues. It also provides for the conservation of all valuable wildlife habitats and communities (Boakye and Affum, 2006).

The 1994 Forest and Wildlife policy brought in participatory forest management and this time there is equity in benefit sharing. All stakeholders are consulted before decisions are taken with respect to management of Forest Reserves and revenues from forest reserves are disbursed to all stakeholders (Stool landowners, Traditional authorities, District /Municipal/Metropolitan Assemblies). All stakeholders benefit from forest revenues. Forest fringe communities also benefit from social responsibility commitments from timber companies operating in their areas. There is now good governance in environmental management and natural resource management (Asare, 2000; Boakye and Affum, 2006). The Forestry Commission is the agency responsible for the management of Forest and Wildlife resources on behalf of the government (Boakye and Affum, 2006).

2.3 Ownership Rights of Forest Reserve

Forest reserves are fully vested in the state through the Forest Ordinance of 1927 and all forest and timber resources are held in trust by the government on behalf of the stool land owners (Boakye and Affum, 2006). According to Boakye and Affum (2006) although landownership did not change at the time of reservation, traditional owners are denied rights of access to trees or land in forest reserves unless they have a permit from the Forest Services Division (FSD) of the Forestry Commission and since its outset, this law has created animosity between local communities and FSD because of foregone benefits and the view that reserves were created without consultation.

Ownership of forest is closely linked to the indigenous system of land ownership. Land is communally owned and held in trust on behalf of the people through the stools and skins (Asare, 2000). According to Asare (2000) landowners exert substantial control in deciding whether an area should be set aside for reservation. Asare (2000) indicated that although national law grants the government the authority to constitute a reserve on any land it deems appropriate, landowners must be consulted through an arbitration process that is under the jurisdiction of a reserve settlement commissioner, who must take landowner's concerns into consideration and that some proposed reserves have had to be abandoned because of strong opposition from landowners. Asare (2000) also reported that in some instances, such as wildlife reserves, the government purchased the land outright from the landowners, thereby becoming the property owner and enjoying the same rights as any other landowner. In effect landowners-whether stool, skins and government or individuals-wield immense power on the setting aside of an area as permanent forest estate, and always have rights to revenue from the exploitation of the resource (Asare, 2000).

2.3.1 Admitted Farms and Admitted Settlements

Admitted farms and admitted settlements are land legally granted to people during forest reservation by Reserve Settlement Commissioner. They are farms and settlements in existence prior to reservation. Under Section 23 of Cap 157, admitted farmers have admitted rights to cultivate or farm on their admitted farms within forest reserves (FSD, 2012). According to Chemogo *et al*. (2013) the claimants of admitted farms have unrestricted rights of access to farming on the admitted farms in forest reserves.

2.4 Deforestation of the Tropical High Forest in Africa

Deforestation is deliberate removal of natural forests by human activity (Hawthorne and Abu-Juam, 1993). According to Hawthorne and Abu-Juam (1993) most past deforestation has been legal, intentional and arguably necessary for the development of the country.

The highest rates of tropical deforestation yet recorded occurred during the 1980's and 1990's (Wright, 2005). By 1980, approximately 25% of the productive closed-canopy moist forest in tropical Africa, 10% in the Neotropics and 50% in tropical Asia had been logged (FAO, 2007).

The 1990 Global Forest Resource Assessment (FAO, 1993) indicated that the annual deforestation rate across tropical countries from 1981 to 1990 was approximately 0.8% or 15.4 million hectares (ha) per annum, as compared to 0.6% during 1976 to 1980. Between 2000 and 2005, the net forest loss was estimated to be about 4 million hectares per annum (FAO, 2007).

2.5 Deforestation in Ghana

Deforestation has for many years been the most serious problem inhibiting the sustainable management of the forest and its biota in Ghana. It is a serious issue because of its cumulative effect on the life supporting aspects of the biological environment, affecting weather and climate,

water supplies, soil quality and agricultural productions, and sustainability of timber and Non-Timber Forest Products (NTFPs) (Addai, 2011).

The current rates of deforestation in Ghana is about 1.3% per annum or on the average 22,000 ha/annum and it is one of the highest in Africa. The original high forest zone of the country extended over 145,000 km^2, however, the current area of the intact forest is now estimated to be between 10.9 and 11.8% of the original cover (Addai, 2011). The only remains of original forest are found in remote and inaccessible areas of the forest reserves established between 1919 and 1939 (Oates, 1999).

Hawthorne and Abu-Juam (1993) stated that the rate of deforestation in the country accelerated about a century ago because of demands for pit props in newly mechanised gold mines, development of communications, and a rapidly expanding area of farm, including cocoa. This increase continues and about one-third (1/3) of Ghana's forest is estimated to have disappeared in 17 years between 1955 and 1972 (Hall, 1987).

Some of the causes of deforestation include; rapid population growth, under developed and inappropriate agricultural technologies, weak law enforcement structure and poor legal system, bushfires, illegal activities of timber contractors and chainsaw operators, mining and social fabrics (Addai, 2011). Deforestation has led to forest degradation and a decline in economic, ecological or structural decline in forest quality (Addai, 2011). The factors that have led to a decline in forest quality in the country include; timber harvesting, fire, subsistence farming, mining and quarrying (Hawthorne and Abu-Juam, 1993).

Fuel wood remains the main source of energy in Africa and only few countries expand their forest through plantations. Consequently, the loss of biodiversity is expected to continue. West African forests are particularly vulnerable to human disturbances (FAO, 2001; Addai, 2011). Myers *et al*. (2000) designated West African forest as biodiversity hotspots because of the exceptional concentration of endemic species and exceptional loss of these endemic species and loss of habitat.

2.6 Problems and Causes of Deforestation in Ghana

Deforestation is deliberate removal of natural forest by human activity (Hawthorne and Abu-Juam, 1993). Most past deforestation has been legal, intentional and arguably necessary for the development of the country and even as far back as 1908, deforestation was alarming in the country (Hawthorne and Abu-Juam, 1993).

Shifting agriculture which contributes to deforestation must have occurred for centuries in Ghana but the rate of deforestation accelerated about a century ago because of demands for pit props in newly mechanised gold mines, development of communications, and a rapidly expanding area of farm, including cocoa (Hawthorne and Abu-Juam, 1993). About one-third (1/3) of Ghana's forest is estimated to have disappeared in 17 years between 1955 and 1972 (Hall, 1987).

The most serious problem inhibiting the sustainable management of the forest and its biota in Ghana is deforestation (Addo, 2003). Deforestation negatively affects water supplies, biological environment, weather and climate, soil quality, agricultural productions and sustainability of timber and Non-Timber Forest Products (NTFPs) (Addo, 2003).

The imminent role of tropical forest in the earth-atmosphere system means that the destruction of forest has serious environmental and socio-economic consequences (Boahene, 1997). Deforestation

has led to the decreased availability of Non-Timber Forest Products (NTFPs) (fire wood; mushroom; medicinal plants; pestles; wood and canes for craft) (Boni, 2006).

Boni (2006) stated that the exhaustion of the forest cover has led to widespread erosion on deforested land, especially within settlements and the lack of tree protection during thunderstorms provokes devastation of houses in villages and of crops on farms. Boahene (1997) stated that forest clearance for subsistence farming is the principal determinant of deforestation in Tropical Africa.

Rapid population growth, inappropriate agricultural technologies, weak law enforcement structure and poor legal systems, bushfires, illegal activities of timber contractors and chainsaw operators, mining are the various causes of deforestation (Green, 1996).

2.7 Forest Biodiversity in Ghana

Biodiversity is an attribute of an area and specifically refers to the variety within and among living organisms, assemblages of living organisms, biotic communities, and biotic processes, whether naturally occurring or modified by humans. Biodiversity can be measured in terms of genetic diversity and the identity and number of types of species, assemblages of species biotic communities, and biotic processes, and the amount (abundance, biomass, cover and rate) and structure of each. It can be observed and measured at any spatial scale ranging from microsites and habitat patches to the entire biosphere (DeLong, 1996). Biodiversity is the degree of nature's variety. It is the variety of life and its processes. Biodiversity is also the variety and variability among living organisms and the ecological complexes in which they occur (Cairns *et al*., 1992).

According to Delaat (2010) biodiversity is the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes

of which they are a part, this includes diversity within species, between species and of ecosystems. Biodiversity has now become a priority in the scientific community and in public policy and this includes issues of old-growth forests (Cairns *et al*., 1992).

Biodiversity is a very complex and multifaceted term and many scientists in various ways have defined the term and each definition reveals a new dimension and emphasizes a different aspect to suit the work at hand (Kpontsu, 2011). According to Kpontsu (2011) everyone, from farmers to different companies, relies on sustainable, healthy and well managed forests. This is because these natural resources are fundamental to Ghana's social and economic development and therefore must be protected and sustainably managed.

Ghana is part of the Upper Guinea forest ecosystem region of West Africa, which contains exceptionally diverse ecological communities of forest habitat providing refuge to numerous endemic species (Kpontsu, 2011). According to Kpontsu (2011) the Upper Guinea forest ecosystem region of West Africa is one of the world's 25 biological richest and most endangered terrestrial eco-regions but a variety of socio-economic factors have led to forest fragmentation which threatens the variability of biodiversity in the region.

Biodiversity is life and the world's ecosystems provide environmental services we simply cannot live without (Tim and Stahl, 2010). According to Tim and Stahl (2010) as an integral part of nature, our fate is tightly linked with biological diversity; that is the huge variety of animals, plants and microorganisms that live in mountains, forests, oceans, wetlands and other ecosystems and that we rely on this diversity of life to provide us with essentials such as water, food, fuel and medicine, yet each day an estimated 150 species disappear, many due to human activities, and the rate of loss is as much as 1000 times higher than the pre-human, or background, extinction rate. Forests are

particularly rich in biodiversity. They harbour an estimated two-thirds of all terrestrial species, as well as a fascinating array of ecological processes. Tropical forests, in particular, are among the most biologically diverse ecosystems on earth (Tim and Stahl, 2010).

Forests have both direct and indirect benefits to human beings and the direct benefits with associated market value include timber, fuel wood and non-timber forest products; indirectly, forests provide essential supporting services such as the maintenance of genetic diversity and the average value of these supporting services is estimated at US$ 900 per hectare per annum (Pavan, 2010).

2.7.1 Threats Facing Forest and Forest Biodiversity in Ghana

Forest of Africa are gravely threatened largely through anthropogenic influences like unsustainable farming practices, fuel wood over-exploitation, unauthorised logging, bushfire setting and pollution (Vordzogbe *et al*., 2005). Vordzogbe *et al*. (2005) reported that the forests of the Western Region of Ghana have, to a large extent, been subjected to increasing degradation over the years due to such unfavourable anthropogenic influences.

Unfavourable anthropogenic influences pose serious threat to the biodiversity of the Western Region of Ghana and its socio-economic and ecotourism potential (Vordzogbe *et al*., 2005). Vordzogbe *et al*. (2005) reported that located in the Western Region of Ghana, the Sefwi Wiawso District faces increasing deforestation due to its high population growth and the attendant negative anthropogenic impacts like unsustainable farming practices, fuel wood exploitation, unauthorised logging, bushfire setting and pollution and that the forests of the District are being encroached upon at alarming rates, resulting in the degradation of large sections of hitherto pristine forests and

according to Addai (2011) threats to biodiversity in Ghana include bush meat trade, agricultural expansion, commercial logging, mining and extraction of Non-Timber Forest Products (NTFPs).

The current rates of deforestation in Ghana is about 22,000ha/annum or about 1.3% on the average and this has negatively affected the Tropical moist forest of Ghana which at the beginning of the century covered an area of over 145,00 km^2 of Ghana. By the turn of the century it was estimated that 88,000km^2 forests remained, occupying 35% of the total land area and between 1938 and 1981 the area of closed forest in Ghana was reduced by 64% from 47,000km^2 to 17,200km^2 and by the mid 1970's more than 90% of the country's high forest had been logged. The current area of intact forest is now estimated between 10.9% and 11.8% of the original cover and 6.9% of the country's total area (Addai, 2011).

2.8 Strategies to Conserve Forest Biodiversity in Ghana

2.8.1 Identify Biodiversity "Hotspots" for Conservation Priorities

Biodiversity "hotspots" are areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat (Myers *et al.*, 2000). According to Myers *et al.* (2000) the number of species threatened with extinction far outstrips available conservation resources, and the situation looks set to become rapidly worse. A promising approach for biodiversity conservation is to identify biodiversity "hotspot" or areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat and protecting them (Myers *et al.*, 2000).

Mammals are excellent indicators of biodiversity and state of a habitat and represent an important biological and functional component of tropical forest ecosystems (Hunter, 1996; Davies and Hoffman, 2002; Damian *et al.*, 2012). Plant-mammal interactions are inevitable in ecosystems. Birds are important indicator species that exhibit characteristics that give insights in to a local environment without having to study the local environment itself (Damian *et al.*, 2012). The

suitability of habitat for birds is a good indicator of the ecosystem condition and its functioning. According to Johns (1997) indicator species are species whose abundance can predict some characteristics of the ecosystem. Flora determines the fauna species that are naturally associated with it (Harrington *et al.*, 1997; Vordzogbe *et al*., 2005).

2.8.2 Education and Awareness Creation to Preserve the Environment

Issues affecting the forest are many and complex (Addai, 2011). These issues have come about as a result of man's quest for the basic necessities of life (food, clothing and shelter). Man has tampered with the forest by farming, mining, logging, hunting and destroying rivers and streams and the forest ecosystem (Hawthorne and Abu-Juam, 1993).

According to Addai (2011) policy as a tool can be used to positively affect forest conservation, reforestation and management of the environment. Participation and communicating intelligently to the youth on the need to join in managing the environment and awareness creation as well as enforcing bye-laws vigorously can help conserve and preserve the environment.

2.8.3 Creating Sustainable system of Energy Use

Efficient use of resources and renewable energy for use is seen as an option in ending the threat to forest conservation (Addai, 2011).

According to Hawthrone and Abu-Juam (1995) the important step required for the development of a sustainable energy system is the installation of clean, renewable alternatives to wood and the most likely renewable alternatives include wind energy, hydro-power, solar energy, biomass and geothermal energy.

Another alternative source of energy is organic waste. About 14-19% of the world's energy demand is supplied by human waste, manure, crop and other forms of biomass (organic waste) (Oliver *et al*., 1998).

2.9 Land Use Types and Biodiversity loss

There is no doubt that primary rainforests are vanishing and that we are now living through the last decades of vegetation dating back as far as 300 million years (Bobo *et al*., 2005). The conversion of tropical primary forests into various land-use systems has serious impacts on distribution, community structure and population characteristics of flora and fauna. In general, forest modification and clearance have negative impacts on biodiversity and each 1% reduction of natural area will cost about 1% of steady-state diversity. To improve biodiversity conservation in tropical rainforest regions, it becomes crucial to redesign anthropogenic habitats so that their use is compatible with the use by a broad array of other species (Bobo *et al*., 2005).

2.10 The Structure of Forests, Floristic Composition of Moist Semi-Deciduous Forest and forest disturbance

The physical and temporal distribution of trees in a stand is known as the forest structure (Oliver and Larson, 1990; Kpontsu, 2011). Knowledge of floristic composition and structure of forest reserves is useful in identifying important elements of plant diversity, protecting threatened and economic species and monitoring the state of forest reserves among others (Tilman, 1988; Ssegawa and Nkuutu, 2006; Addo-Fordjour *et al*., 2009).

The study of forest disturbance (illegal farming) of Tropical High Forest of Ghana becomes more important in the face of ever increasing threat to forest biodiversity as a result of destruction of forest ecosystem and habitat. Studies have shown that species diversity, changes in floristic composition and loss of biodiversity of a forest is influenced by a number of factors (Hawthorne

and Abu-Juam, 1993; Vordzogbe *et al*., 2005; Anning *et al*., 2008; Addo-Fordjour *et al*., 2009; Addai, 2011; Kpontsu, 2011).

Prominent among these factors are disturbances which are thought to be key aspect and the cause of local species variation within forest based on their intensity, scale and frequency (Hill and Curran, 2003; Vordzogbe *et al*., 2005; LaidLaw *et al*., 2007; Addo-Fordjour *et al*., 2009; Addai, 2011; Kpontsu, 2011). Disturbances can alter the successional pattern and subsequent composition, diversity and structure of the forest (Doyle, 1981; Vordzogbe *et al*., 2005; Addo-Fordjour, *et al*., 2009; Addai, 2011; Kpontsu, 2011).

Farming which has more immediate and direct effects on diversity, composition and structure of forests also creates gaps (canopy openings) which may cause regeneration problems and other plant structural attributes such as density, height, canopy cover with increasing disturbance (Dumbrell *et al*., 2008; Lalfakawama *et al*., 2009; Addo-Fordjour *et al*., 2009; Kpontsu, 2011).

In exposed conditions where soils dry out rapidly, nutrient loss through run off (soil erosion) becomes common. Canopy openings and loss of forest vegetation as a result of forest disturbances readily support the growth of invasive weeds and other herbaceous plants which usually interfere with regeneration and impede recovery of trees and shrubs (Epp, 1987; Hawthorne and Abu-Juam, 1993; Madoffe, *et al*., 2006; Addo-Fordjour *et al*., 2009; Kpontsu, 2011).

Invasive weeds threaten biodiversity by displacing native species and disrupting community structure (Parker *et al*., 1999; Richardson *et al*., 2000; Sala *et al*., 2000; Stein *et al*., 2000; Addo-Fordjour *et al*., 2009; Kpontsu, 2011). Other studies carried out by Lieberman and Lieberman (1984) and Ceccon *et al*. (2002) revealed that soil water availability is also considered a key factor

for the regeneration, survival growth of seedling communities. Light conditions influence regeneration pathways strongly (Haugaasen *et al*., 2003) and ultimately affect the composition and structure of forest. Other work done by Tilman (1982) followed the same trend as reported by Haugaasen *et al*. (2003) on light availability to the survival of seedlings.

Work done by Addo-Fordjour *et al.* (2009) showed that plant species diversity was quantitatively higher in undisturbed forest compared to the disturbed forest. In that study by Addo-Fordjour *et al*. (2009) the distribution of trees in the lower and higher diameter classes was highest in the undisturbed forest than in the disturbed forest and plant invasion impeded regeneration of native plant species in the disturbed invaded forest. There is therefore the need for proper management intervention to curb these anthropogenic activities and plant invasion so as to protect the integrity of such forest reserves.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was conducted in Sui River Forest Reserve, which falls under Sefwi Wiawso Municipal Area and Sefwi Akontombra District Area (Political administration) and Wiawso Forest District (Forestry administration) of the Western region of Ghana. The study was specifically carried out in compartments 106 (undisturbed forest (UF) Plot), 163 (disturbed forest (DF) and undisturbed forest (UF) and 171disturbed forest (DF) of the Forest Reserve (Figure 1). The sizes of compartment 106, 163 and 171 were 117.20 hectares, 124.25 hectares and 142.17 hectares respectively.

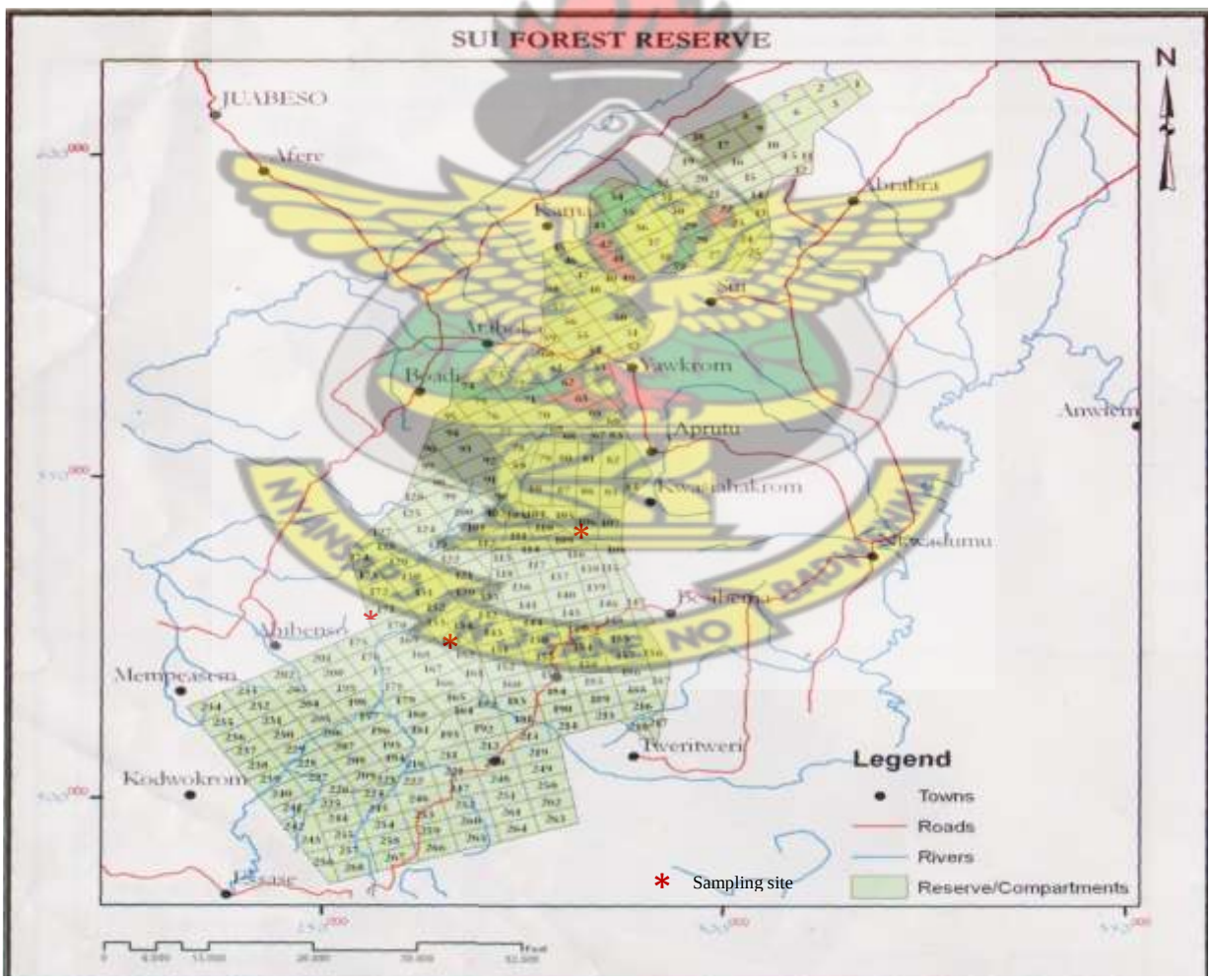

Fig. 1. Map of Study Area and Sampling Sites

Sui River Forest Reserve is unique because it falls within the Bia and Tano Basins and it is drained by the Sui River, Yoyo river and its numerous tributaries. It is one of the largest forest reserves in Ghana and covers 33,390 ha (333.90 km^2) of land (Chemogo *et al.*, 2013). The reserve is classified as a Moist Semi-Deciduous North-West (MSNW) vegetation zone (Hall and Swaine, 1981). The reserve corresponds to the *Celtis-Triplochiton* Association of the Tropical Moist Semi- Deciduous Forest (Chemogo *et al.*, 2013).

Sui River Forest Reserve has a typical three storey structure with the emergent trees attaining an average height of 40 metres. Most of the trees are deciduous (Chemogo *et al.*, 2013). The major soil type of the forest is the forest ochrosols and minor particles of granite are present in some areas. The forest reserve, keeps the soil in place so that it does not clog the waterways of its headwaters (Tano, Bia, Sui), absorbs rainfall, filters and slowly releases water into the rivers and streams for us and all of the animals to drink. It produces and cleans the air we breathe and provides wood and other products for our homes and forest fringe communities. It is a source of both traditional and modern medicines and provides a home to many plant and animal species.

The reserve falls within the Tropical Humid Climatic Zone and it influences the climate of the Sefwi Wiawso and Sefwi Akontonbra areas, including when the rain comes and how long the dry season will last. Sui River Forest Reserve is one of the important forest reserves in the country which serves as a water shed for four major rivers in the country (Sui, Tano, Bia, Yoyo) with large number of admitted farms (58 admitted farms) and large number of forest fringe communities influencing the local micro-climate (Chemogo *et al.*, 2013).

3.2 Data Collection

A total of four (4) main plots were laid in three forest reserve compartments. These plots were laid out in two forest types based on different levels of disturbance intensity. These were undisturbed forest (UF) and disturbed forest (DF). The undisturbed forest (UF) is categorised as primary forest because it was the part of the forest that has not undergone any major form of human disturbance and this served as the control plot for the study. The undisturbed forest type is due to effective protection and monitoring by the Forest Services Division field staff in the District. The disturbed forest has experienced past and recent degradation of illegal farming activities. Compartment 163 was heterogeneous having two forest types, undisturbed forest (UF) and disturbed forest (DF) whilst Compartment 106 and 171 were homogeneous. Compartment 106 was undisturbed forest and 171 was disturbed forest. The forest types; undisturbed forest (UF) and disturbed forest (DF) in Compartments 163, 106 and 171 were selected within areas with approximately equal topography and altitude so as to eliminate their effects on plant composition and structure as stated in (Addo-Fordjour *et al.*, 2009).

In each forest block within the compartments, 25 m x 25 m plots were randomly demarcated and these were subdivided into twenty-five 5 m x 5 m subplots using linear tapes, garden line, wooden beacons and Global Positioning System (GPS). Fifteen (15) of the subplots accounting for 60% of the plot area were randomly sampled for tree species, regeneration of tree seedlings, herbs and fauna. On each subplot, all tree species, seedlings, herbs, shrubs, mammals, reptiles, amphibians and birds were identified and their frequency of occurrence recorded. Plots and subplots that were close to each other were simultaneously counted to avoid a repetition of counting of fauna because of migration of fauna. Direct sightings, vocalizations, dung (scats and pellets) and tracks (trails), footprints for fauna were determined in the subplots. Identification was performed by a plant and animal taxonomist aided by manuals and floras (Hawthorne, 1990; Arbonnier, 2004; Poorter *et al.*,

2004; Hawthorne and Jongkind, 2006; Hawthorne and Gyakari, 2006). Identification of the flora species was confirmed at the Forestry Commission Herbarium, Kumasi. Field work was conducted from 5th November 2012 to 4th May 2013.

3.3 Data Analyses

The Diversity of plant and animal species in the forest types was quantified using the Shannon-Wiener species diversity index (Gimaret-Carpentier *et al*., 1998; Blanc *et al*., 2000; Parthasarathy, 2001; Addo-Fordjour *et al*., 2009).

Shannon-Wiener Diversity Index is given by:

$$H' = -\sum_{i=1}^{s} pi \ \mathbf{In}\ pi$$

Where: *Pi* = proportion of the *i*th species

In *pi* = natural log of *pi*

CHAPTER FOUR

4.0 RESULTS

4.1 Classification of tree species in Sui River Forest Reserve

4.1.1 Tree species identified in undisturbed and disturbed forests in Sui River Forest Reserve

The results of trees identified in the undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve are represented in Table 1. They were also classified according to their conservation status (Table 1). More species were identified in the UF than in the DF of the reserve. There were 54.5% of tree species in the UF in relation to the DF (Table 1).

A total number of 18 tree species belonging to 12 families were identified in the UF. Of the 12 families sampled in the UF, Leguminosae had 3 species followed by Ulmaceae, Meliaceae, Combretaceae and Sterculiaceae with 2 species each. *Celtis mildbraedii* (9) in the family Ulmaceae was the dominant tree species in the UF (Table 1). Of the 18 tree species, 7 were Pink stars, 5 Red stars, 3 Scarlet stars and 3 Non-star rating species (Logging Manual for Ghana: Ghana Forest Service (1998) (Table 1).

A total number of 5 tree species belonging to 5 families were identified in the DF (Table 1). Of the 5 species sampled, *Musanga cecropioides* (12) in the family Cecropiaceae was the most dominant species. With the exception of *Ceiba pentandra,* all the other four tree species were Non-star rating (Table 1).

Apart from *Baphia nitida* which occurred in both UF and DF, the other four tree species, *Musanga cecropioides, Ficus exasperata, Trema orientalis and Ceiba pentandra* that were identified in the disturbed forest were not found in the undisturbed forest (Table 1).

Table 1. Tree Species identified in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

Scientific name	Family	Local name	Star rating	Freq. UF plots	Freq. DF plots
Funtumia elastica (Preuss) Stapf	Apocynaceae	Funtum	No rating	1	Nil
Musanga cecropioides R.Br. ex Tedlie	Cecropiaceae	Odwuma	No rating	Nil	12
Terminalia ivorensis A.Chev	Combretaceae	Emire	Scarlet	1	Nil
Terminalia superba Engl. & Diels	Combretaceae	Ofram	Red	2	Nil
Piptadeniastrum africanum Brenan	Fabaceae	Dahoma	Red	2	Nil
Klainedoxa gabonesis Engl	Irvingiaceae	kroma	Pink	1	Nil
Petersianthus macrocarpus Liben	Lecythidaceae	Esia	Pink	4	Nil
Baphia nitida Lodd	Leguminosae	Odwen	No rating	4	6
Baphia pubescens Hook.f	Leguminosae	Odwen Kobiri	No rating	1	Nil
Strombosia glaucescens Engl	Leguminosae	Afena	Pink	1	Nil
Ceiba pentandra (L.) Gaertn.	Malvaceae	Onyina	Red	Nil	2
Entandophragma cylindricum	Meliaceae	Sapele	Scarlet	2	Nil
Guarea cedrata (A.Chev.)	Meliaceae	Guarea	Red	1	Nil
Antiaris toxicaria Lesch	Moraceae	Kyenkyen	Red	2	Nil
Ficus exasperata Vahl	Moraceae	Nyankyerene	No rating	Nil	4
Pycnanthus angolensis (Welw.)	Myristicaceae	Otie	Pink	1	Nil
Chrysophyllum albidum G.Don	Sapotaceae	Akasaa	Red	1	Nil
Nesogordonia papaverifera (A. Chev.)	Sterculiaceae	Danta	Pink	5	Nil
Triplochiton scleroxylon K.Schum	Sterculiaceae	Wawa	Scarlet	2	Nil
Celtis mildbraedii Engl	Ulmaceae	Esa	Pink	9	Nil
Celtis zenkeri Engl	Ulmaceae	Esakokoo	Pink	2	Nil
Trema orientalis (L.) Blume	Ulmaceae	Sesea	No rating	Nil	11
TOTAL				**42**	**35**

Some tree species identified in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve are represented pictorially from Plate 1-20.

Plate 1. Wawa tree (*Triplochiton scleroxylon*)

Plate 2. Wawa leaf (*Triplochiton scleroxylon*)

Plate 3. Sinuro tree (*Alstonia boonei*)

Plate 4. Sinuro leaves (*Alstonia boonei*)

Plate 5. Esa tree (*Celtis mildbraedii*)

Plate 6. Esa leaves (*Celtis mildbraedii*)

Plate 7. Esia tree (*Petersianthus macrocarpus*)

Plate 8. Esia leaf (*Petersianthus macrocarpus*)

Plate 9. Otie tree (*Pycnanthus angolensis*)

Plate 10. Otie leaves (*Pycnanthus angolensis*)

Plate 11. Ofram tree (*Terminalia superba*)

Plate 12. Ofram leaves (*Terminalia superba*)

Plate 13. Ohaa tree (*Sterculia oblonga*)

Plate 14. Ohaa leaf (*Sterculia oblonga*)

Plate 15. Odwuma tree (*Musanga cecropioides*)

Plate 16. Odwuma leaf (*Musanga cecropioides*)

Plate 17. Sesea tree (*Trema orientalis*)

Plate 18. Sesea leaves (*Trema orientalis*)

Plate 19. Acheampong (*Chromolaena odorata*)

Plate 20. Leaves of *Chromolaena odorata*

4.2 Natural Regeneration of the forest in Sui River Forest Reserve

4.2.1 Seedlings identified in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

The results of seedlings identified in determining the regenerative capacity of the undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve are represented in Table 2. More species were identified in the UF than the DF of the reserve. A total number of 18 species belonging to 13 families were identified in the UF. Meliaceae had 3 species, Sterculiaceae and Ulmaceae had 2 species each. *Celtis mildbraedii* (15) in the family Ulmaceae was the dominant species in the UF in the reserve (Table 2). There were 59.6% of tree seedlings in the UF in relation to the DF (Table 2).

A total number of 8 species belonging to 8 families were identified in the DF in the reserve. *Musanga cecropioides* (11) in the family Cecropiaceae was the dominant species in the DF in the reserve (Table 2).

All the UF species identified in the reserve (*Alstonia boonei, Antiaris toxicaria, Celtis mildbraedii, Celtis zenkeri, Chrysophyllum albidum, Entandophragma angolense, Entandophragma cylindricum, Guarea cedrata, Klainedoxa gabonesis, Nesogordonia papaverifera, Petersianthus macrocarpus, Piptadeniastum africanum, Pycnanthus angolensis, Sterculia oblonga, Terminalia ivorensis, Terminalia superba, Tetrapleura tetraptera, Triplochiton scleroxylon*) were absent in the DF whilst all the DF species identified in the reserve (*Tabemaemontana, Musanga cecropioides, Trema orientalis, Zanthoxylum gilletii, Ficus exasperate, Discoglypremna caloneura, Solanum erianthum, Ceiba pentandra*) were also absent in the UF.

Table 2. Seedlings identified in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

Scientific name	Family	Local name	Freq. UF plots	Freq. DF plots
Alstonia boonei De Wild.	Apocynaceae	Sinuro	2	Nil
Tabemaemontana	Apocynaceae	Obonawa	Nil	2
Musanga cecropioides R.Br. ex Tedlie	Cecropiaceae	Odwuma	Nil	11
Terminalia ivorensis A.Chev.	Combretaceae	Emire	1	Nil
Terminalia superba Engl. & Diels	Combretaceae	Ofram	4	Nil
Discoglypremna caloneura (Pax) Prain	Euphorbiaceae	Fretefre	Nil	5
Piptadeniastum africanum (P.Beauv.) Liben	Fabaceae	Dahoma	4	Nil
Klainedoxa gabonesis Engl	Irvingiaceae	Kroma	1	Nil
Petersianthus macrocarpus Liben	Lecythidaceae	Esia	6	Nil
Tetrapleura tetraptera (Schum. & Thonn.) Taub	Leguminosae	Prekese	4	Nil
Ceiba pentandra (L.) Gaertn.	Malvaceae	Onyina	Nil	2
Sterculia oblonga Mast	Malvaceae	Ohaa	2	Nil
Entandophragma angolense	Meliaceae	Edinam	1	Nil
Entandophragma cylindricum	Meliaceae	Sapele	2	Nil
Guarea cedrata (A.Chev.)	Meliaceae	Guarea	1	Nil
Antiaris toxicaria Lesch	Moraceae	Kyenkyen	4	Nil
Ficus exasperata Vahl	Moraceae	Nyankyerene	Nil	5
Pycnanthus angolensis (Welw.) Warb	Myristicaceae	Otie	4	Nil
Zanthoxylum gilletii (De Wild.) P.G.Waterman	Rutaceae	Okuo	Nil	5
Chrysophyllum albidum G.Don	Sapotaceae	Akasaa	1	Nil
Solanum erianthum G.Don	Solanaceae	Pepediawuo	Nil	4
Nesogordonia papaverifera (A. Chev.)	Sterculiaceae	Danta	4	Nil
Triplochiton scleroxylon K.Schum	Sterculiaceae	Wawa	5	Nil
Celtis mildbraedii Engl	Ulmaceae	Esa	15	Nil
Celtis zenkeri Engl	Ulmaceae	Esakokoo	1	Nil
Trema orientalis (L.) Blume	Ulmaceae	Sesea	Nil	8
TOTAL			**62**	**42**

4.2.2 Other plant species (excluding trees and seedlings) identified in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

Shrubs (88.9%) were the dominant plant life form in the UF in the reserve (Table 3). Out of these, *Paullinia pinnata* (shrub) (Family Sapindaceae) was the most dominant (44.4%) followed by *Alchornia cordifolia* (shrub) (17.8%) (Family Euphorbiaceae) and *Mallotus oppositifolius* (shrub) (15.6%) (Family Euphorbiaceae). *Carpolobia lutea* (shrub) (Family Polygalaceae) and *Anchomanes difformis* (herb) (Family Araceae) were the least with 11.1% each (Table 3). With the exception of *Anchomanes difformis* (herb) (Family Araceae) all the other 4 species sampled in the UF in the reserve were shrubs (Table 3).

Chromolaena odorata (herb) (44.1%) (Family Asteraceae) was the most dominant species in the DF in the reserve followed by *Pteris* species (fern) (35.3%) (Family Pteridaceae) and *Centrocema pubecens* (herb) (14.7%) (Family Fabaceae). *Pennisetum purpureum* (herb) (Family Poaceae) was the least with 5.9% (Table 3). With the exception of *Pteris* species (fern) (Family Pteridaceae), all the other three plant species sampled in the DF in the reserve were herbs (Table 3).

Table 3. Other plant species (excluding trees and seedlings) identified in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

Scientific name	Family	Local name	Life Form	Freq. UF plots	%	Freq. DF plots	%
Anchomanes difformis	Araceae	Topie/Epe	Herb	5	11.1	Nil	Nil
Chromolaena odorata	Asteraceae	Acheampong	Herb	Nil	Nil	15	44.1
Alchornia cordifolia	Euphorbiaceae	Gyaka/Gyama	Shrub	8	17.8	Nil	Nil
Mallotus oppositifolius	Euphorbiaceae	Nyanyaforwa	Shrub	7	15.6	Nil	Nil
Centrocema pubecens	Fabaceae	Centrocema	Herb	Nil	Nil	5	14.7
Pennisetum purpureum	Poaceae	Elephant grass	Herb	Nil	Nil	2	5.9
Carpolobia lutea	Polygalaceae	Geseluwa	Shrub	5	11.1	Nil	Nil
Pteris species	Pteridaceae	Merya	Fern	Nil	Nil	12	35.3
Paullinia pinnata	Sapindaceae	Twentini	Shrub	20	44.4	Nil	Nil
Total				**45**	**100**	**34**	**100**

4.3 Classification of fauna (species) in Sui River Forest Reserve

4.3.1 Fauna Species identified in undisturbed and disturbed forests in Sui River Forest Reserve

The results of fauna identified in the undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve are presented in Table 4. They were also classified according to their families (Table 4). More fauna were encountered in the UF than in the DF of the reserve.

A total number of 18 species belonging to 17 families were identified in the UF. Of the 17 families sampled in the UF, only the family Bovidae had 2 mammalian species. Agama lizard (*Agama agama)* (12) (Family Agamidae) and Giant rat (*Cricetomys gambianus)* (12) (Family Nesomyidae) were the dominant species in the undisturbed forest (Table 4). Royal Antelope (*Neotragus pygmaeus*) was the next dominant species in the UF. There were 82.0% of fauna species in the UF in relation to the DF (Table 4).

A total number of 9 species belonging to 9 families were identified in the DF in the reserve (Table 4). Of the 9 species sampled, Giant rat (*Cricetomys gambianus)* (8) (Family Nesomyidae) was the most dominant species (Table 4). Giant rat (*Cricetomys gambianus)* was encountered in both the UF and DF (Table 4).

Table 4. Fauna Species identified in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

Scientific name	Family	Common name	Taxon	No. in UF plots	No. in DF plots
Agama agama	Agamidae	Agama Lizard	Reptile	12	3
Neotragus pygmaeus	Bovidae	Royal Antelope	Mammal	10	Nil
Tragelaphus scriptus	Bovidae	Bush Buck	Mammal	3	Nil
Tokus fasciatus	Bucerotidae	African Pied Hornbill (Akyenkyena)	Bird	6	Nil
Bufo marinus	Bufonidae	Toad	Amphibian	7	2
Cephalophus maxwelli	Cephalophinae	Maxwell Duiker (Otwe)	Mammal	8	Nil
Turtur tympanistria	Columbidae	Tambourine Dove (Abuburo Tawiah)	Bird	3	Nil
Centropus senegalensis	Cuculidae	Senegal Coucal (Brekuo)	Bird	2	Nil
Dendroaspis angusticeps	Elapidae	Green Mamba	Reptile	1	Nil
Naja naja	Elapidae	Black Cobra	Reptile	Nil	1
Antherurus africanus	Hystricidae	Brush Tail Porcupine	Mammal	4	Nil
Gymnobucco calvus	Lybiidae	Naked Faced Barbet (Asee)	Bird	4	2
Tauraco persa	Muscophagidae	Green Turaco (Brebe)	Bird	2	Nil
Cricetomys gambianus	Nesomyidae	Giant Rat (okusie)	Mammal	12	8
Perdix perdix	Phasianidae	Partridge	Bird	7	2
Xenopus laevis	Pipidae	Frog	Amphibian	9	1
Pycnonotus barbatus	Pycnonotidae	Common bulbul (Apatupre)	Bird	3	Nil
Geochelone sulcata	Testudinidae	Tortoise	Reptile	7	Nil
Thryonomys swinderianu	Thryonomyidae	Grasscutter	Mammal	Nil	2
Cyanomitra olivacea	Tyrannidae	Olive Sunbird (Aserewa)	Bird	9	3
TOTAL				**109**	**24**

4.4 Diversity of trees sampled in Sui River Forest Reserve

4.4.1 Diversity of trees in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

The results of tree diversity in the undisturbed and disturbed forests in Sui River Forest Reserve using Shannon-Wiener species diversity index (H^1) are represented in Table 5. More species (18) were identified in the undisturbed forest than in the disturbed forest (5) in the forest reserve.

The H^1 for undisturbed forest (UF) for the forest reserve was 2.6132 while that of the disturbed forest (DF) was 1.4445 (Table 5).

Table 5. Diversity of tree Species identified in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

Scientific name	No found		Proportion (Pi)		In(Pi)		Pi In(Pi)	
	UF	DF	UF	DF	UF	DF	UF	DF
Antiaris toxicaria	2	Nil	0.0476	Nil	-3.0450	Nil	-0.1450	Nil
Baphia nitida	4	6	0.0952	0.1714	-2.3518	-1.7637	-0.2239	-0.3023
Baphia pubescens	1	Nil	0.0238	Nil	-3.7381	Nil	-0.0890	Nil
Ceiba pentandra	Nil	2	Nil	0.0571	Nil	-2.8629	Nil	-0.1635
Celtis mildbraedii	9	Nil	0.2143	Nil	-1.5404	Nil	-0.3301	Nil
Celtis zenkeri	2	Nil	0.0476	Nil	-3.0450	Nil	-0.1450	Nil
Chrysophyllum albidum	1	Nil	0.0238	Nil	-3.7381	Nil	-0.0890	Nil
Entandophragma cylindricum	2	Nil	0.0476	Nil	-3.0450	Nil	-0.1450	Nil
Ficus exasperata	Nil	4	Nil	0.1143	Nil	-2.1689	Nil	-0.2479
Funtumia elastica	1	Nil	0.0238	Nil	-3.7381	Nil	-0.0890	Nil
Guarea cedrata	1	Nil	0.0238	Nil	-3.7381	Nil	-0.0890	Nil
Klainedoxa gabonesis	1	Nil	0.0238	Nil	-3.7381	Nil	-0.0890	Nil
Musanga cecropioides	Nil	12	Nil	0.3428	Nil	-1.0706	Nil	-0.3670
Nesogordonia papaverifera	5	Nil	0.1190	Nil	-2.1286	Nil	-0.2533	Nil
Petersianthus macrocarpus	4	Nil	0.0952	Nil	-2.3518	Nil	-0.2239	Nil
Piptadeniastrum africanum	2	Nil	0.0476	Nil	-3.0450	Nil	-0.1450	Nil
Pycnanthus angolensis	1	Nil	0.0238	Nil	-3.7381	Nil	-0.0890	Nil
Strombosia glaucescens	1	Nil	0.0238	Nil	-3.7381	Nil	-0.0890	Nil
Terminalia ivorensis	1	Nil	0.0238	Nil	-3.7381	Nil	-0.0890	Nil
Terminalia superba	2	Nil	0.0476	Nil	-3.0450	Nil	-0.1450	Nil
Trema orientalis	Nil	11	Nil	0.3143	Nil	-1.1574	Nil	-0.3638
Triplochiton scleroxylon	2	Nil	0.0476	Nil	-3.0450	Nil	-0.1450	Nil
TOTAL	42	35	1.0000	1.0000			-2.6132	-1.4445
H^1 = Shannon-Wiener species diversity Index							2.6132	1.4445

4.4.2 Diversity of seedlings in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest reserve

The results of seedling diversity in the undisturbed and disturbed forests in Sui River Forest Reserve using Shannon-Wiener species diversity index (H^1) are represented in Table 6. More species (18) were identified in the undisturbed forest than in the disturbed forest (8) in the forest reserve.

The H^1 for undisturbed forest (UF) for the forest reserve was 2.5639 while that of the disturbed forest (DF) was 1.9404 (Table 6).

Table 6. Diversity of seedling species in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

Scientific name	No found		Proportion (Pi)		In(Pi)		Pi In(Pi)	
	UF	DF	UF	DF	UF	DF	UF	DF
Alstonia boonei	2	Nil	0.0322	Nil	-3.4358	Nil	-0.1106	Nil
Antiaris toxicaria	4	Nil	0.0645	Nil	-2.7411	Nil	-0.1768	Nil
Ceiba pentandra	Nil	2	Nil	0.0476	Nil	-3.0450	Nil	-0.1449
Celtis mildbraedii	15	Nil	0.2419	Nil	-1.4192	Nil	-0.3433	Nil
Celtis zenkeri	1	Nil	0.0161	Nil	-4.1289	Nil	-0.0665	Nil
Chrysophyllum albidum	1	Nil	0.0161	Nil	-4.1289	Nil	-0.0665	Nil
Discoglypremna caloneura	Nil	5	Nil	0.1190	Nil	-2.1286	Nil	-0.2533
Entandophragma angolense	1	Nil	0.0161	Nil	-4.1289	Nil	-0.0665	Nil
Entandophragma cylindricum	2	Nil	0.0322	Nil	-3.4358	Nil	-0.1106	Nil
Ficus exasperata	Nil	5	Nil	0.1190	Nil	-2.1286	Nil	-0.2533
Guarea cedrata	1	Nil	0.0161	Nil	-4.1289	Nil	-0.0665	Nil
Klainedoxa gabonesis	1	Nil	0.0161	Nil	-4.1289	Nil	-0.0665	Nil
Musanga cecropioides	Nil	11	Nil	0.2619	Nil	-1.3398	Nil	-0.3509
Nesogordonia papaverifera	4	Nil	0.0645	Nil	-2.7411	Nil	-0.1768	Nil
Petersianthus macrocarpus	6	Nil	0.0968	Nil	-2.3351	Nil	-0.2260	Nil
Piptadeniastum africanum	4	Nil	0.0645	Nil	-2.7411	Nil	-0.1768	Nil
Pycnanthus angolensis	4	Nil	0.0645	Nil	-2.7411	Nil	-0.1768	Nil
Solanum erianthum	Nil	4	Nil	0.0952	Nil	-2.3518	Nil	-0.2239
Sterculia oblonga	2	Nil	0.0322	Nil	-3.4358	Nil	-0.1106	Nil
Tabemaemontana	Nil	2	Nil	0.0476	Nil	-3.0450	Nil	-0.1449
Terminalia ivorensis	1	Nil	0.0161	Nil	-4.1289	Nil	-0.0665	Nil
Terminalia superba	4	Nil	0.0645	Nil	-2.7411	Nil	-0.1768	Nil
Tetrapleura tetraptera	4	Nil	0.0645	Nil	-2.7411	Nil	-0.1768	Nil
Trema orientalis	Nil	8	Nil	0.1905	Nil	-1.6581	Nil	-0.3159
Triplochiton scleroxylon	5	Nil	0.0806	Nil	-2.5182	Nil	-0.2030	Nil
Zanthoxylum gilletii	Nil	5	Nil	0.1190	Nil	-2.1286	Nil	-0.2533
Total	**62**	**42**					-2.5639	-1.9404
H^1 = Shannon-Wiener species diversity Index							2.5639	1.9404

4.4.3 Diversity of other plant forms (excluding trees and seedlings) identified in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

The results of other plant forms (excluding trees and seedlings) diversity in the undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve using Shannon-Wiener species diversity index (H^1) are represented in Table 7. More species were identified in the UF than in the DF.

The H^1 for UF was 1.4451 while that of the DF was 1.1770 (Table 7).

Table 7. Diversity of other plant forms (excluding trees and seedlings) identified in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

Scientific name	No found		Proportion (Pi)		In(Pi)		Pi In(Pi)	
	UF	DF	UF	DF	UF	DF	UF	DF
Alchornia cordifolia	8	Nil	0.1778	Nil	-1.7271	Nil	-0.3071	Nil
Anchomanes difformis	5	Nil	0.1111	Nil	-2.1973	Nil	-0.2441	Nil
Carpolobia lutea	5	Nil	0.1111	Nil	-2.1973	Nil	-0.2441	Nil
Centrocema pubecens	Nil	5	Nil	0.1470	Nil	-1.9173	Nil	-0.2818
Chromolaena odorata	Nil	15	Nil	0.4412	Nil	-0.8182	Nil	-0.3610
Mallotus oppositifolius	7	Nil	0.1555	Nil	-1.8611	Nil	-0.2894	Nil
Paullinia pinnata	20	Nil	0.4444	Nil	-0.8110	Nil	-0.3604	Nil
Pennisetum purpureum	Nil	2	Nil	0.0588	Nil	-2.8336	Nil	-0.1666
Pteris species	Nil	12	Nil	0.3529	Nil	-1.0416	Nil	-0.3676
TOTAL	**45**	**34**					**-1.4451**	**-1.1770**
H^1 = Shannon-Wiener species diversity Index							**1.4451**	**1.1770**

4.4.4 Diversity of fauna in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

The results of fauna diversity in the undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve using Shannon-Wiener species diversity index (H^1) are represented in Table 8. More species were identified in the UF (18) than in the DF (9). The H^1 for UF for Sui River Forest Reserve was 2.7245 while H^1 for DF was 1.9790 (Table 8).

Table 8. Diversity of fauna species in undisturbed forest (UF) and disturbed forest (DF) in Sui River Forest Reserve

Scientific name	No found		Proportion (Pi)		In(Pi)		Pi In(Pi)	
	UF	DF	UF	DF	UF	DF	UF	DF
Agama agama	12	3	0.1101	0.1250	-2.2064	-2.0794	-0.2429	-0.2599
Antherurus africanus	4	Nil	0.0367	Nil	-3.3050	Nil	-0.1213	Nil
Bufo marinus	7	2	0.0642	0.0833	-2.7457	-2.4853	-0.1763	-0.2070
Centropus senegalensis	2	Nil	0.0183	Nil	-4.0008	Nil	-0.0732	Nil
Cephalophus maxwelli	8	Nil	0.0734	Nil	-2.6118	Nil	-0.1917	Nil
Cricetomys gambianus	12	8	0.1101	0.3333	-2.2064	-1.0987	-0.2429	-0.3662
Cyanomitra olivacea	9	3	0.0826	0.1250	-2.4937	-2.0794	-0.2060	-0.2599
Dendroaspis angusticeps	1	Nil	0.0091	Nil	-4.6995	Nil	-0.0428	Nil
Geochelone sulcata	7	Nil	0.0642	Nil	-2.7457	Nil	-0.1763	Nil
Gymnobucco calvus	4	2	0.0367	0.0833	-3.3050	-2.4853	-0.1213	-0.2070
Naja naja	Nil	1	Nil	0.0417	Nil	-3.1772	Nil	-0.1325
Neotragus pygmaeus	10	Nil	0.0917	Nil	-2.3892	Nil	-0.2184	Nil
Perdix perdix	7	2	0.0642	0.0833	-2.7457	-2.4853	-0.1763	-0.2070
Pycnonotus barbatus	3	Nil	0.0275	Nil	-3.5936	Nil	0.0988	Nil
Tauraco persa	2	Nil	0.0183	Nil	-4.0008	Nil	-0.0732	Nil
Thryonomys swinderianu	Nil	2	Nil	0.0833	Nil	-2.4853	Nil	-0.2070
Tokus fasciatus	6	Nil	0.0550	Nil	-2.9004	Nil	-0.1595	Nil
Tragelaphus scriptus	3	Nil	0.0275	Nil	-3.5936	Nil	0.0988	Nil
Turtur tympanistria	3	Nil	0.0275	Nil	-3.5936	Nil	0.0988	Nil
Xenopus laevis	9	1	0.0826	0.0417	-2.4937	-3.1772	-0.2060	-0.1325
Total	**109**	**24**	**1.000**	**1.000**			**-2.7245**	**-1.9790**
H^1 = Shannon-Wiener species diversity Index							**2.7245**	**1.9790**

CHAPTER FIVE

5.0 DISCUSSION

5.1 Tree species richness and diversity

Generally tree species richness within the undisturbed forest was higher as compared to the disturbed forest. Tree species diversity was also quantitatively higher in the undisturbed forest compared to the disturbed forest. The higher number of tree species and higher diversity in the undisturbed forest is attributed to the intact nature of the undisturbed forest vegetation while the lower number of tree species and the lower diversity in the disturbed forest could be attributed to the anthropogenic disturbances which has impacted negatively on the number of tree species and diversity in the disturbed forest. This pattern of species distribution has been reported by other works (Doyle 1981; Vordzogbe *et al*., 2005; Addo-Fordjour *et al.*, 2009; Addai, 2011; Kpontsu, 2011). All these studies have related the differences observed to the influence of human disturbances.

The number of tree species and plant families in the undisturbed forest were more than those in the disturbed forest. While there were eighteen (18) tree species belonging to 12 families in the undisturbed forest in the reserve, there were only five (5) tree species belonging to 5 families in the disturbed forest of the reserve (Table 1).

Celtis mildbraedii (Family Ulmaceae) was the most dominant species in the undisturbed forest. The dominance of *Celtis mildbraedii* in the flora of the undisturbed forest in Sui River Forest Reserve is considered as a major characteristic of a semi-deciduous forests (Hall and Swaine, 1981; Vordzogbe *et al.,* 2005; Addo-Fordjour *et al.,* 2009) and an indicator that the forest is a virgin forest. The predominance of *Celtis mildbraedii* in the undisturbed forest is also attributed to its shade-bearing ability and a characteristic which makes it compete favourably with other species and overcome

them. The dominance of the family Ulmaceae in some primary semi-deciduous forests has been reported (Vordzogbe *et al.,* 2005; Anning *et al.,* 2008; Addo-Fordjour *et al.,* 2009).

The presence of *Baphia nitida* (Family Leguminosae) in both the undisturbed and disturbed forests in Sui River Forest Reserve may indicate its wider range of ecological adaptation, hence its presence in the disturbed forest. The semi-deciduous forest is known for its high diversity of various economic tree species (Vordzogbe *et al.,* 2005; Anning *et al.,* 2008; Addo-Fordjour *et al.,* 2009, Kpontsu, 2011). Thus, the high diversity of tree species confirms the semi-deciduous characteristic of the Sui River Forest Reserve.

Musanga cecropioides (Family Cecropiaceae) and *Trema orientalis* (Family Ulmaceae) were the most dominant species in the disturbed forest of the reserve. Their dominance in the flora of the disturbed forest is considered a major characteristic and an indicator of a disrupted community structure of a tropical forest whose native species have been displaced following anthropogenic disturbances (Ambika, 1996; Parker *et al*., 1999; Richardson *et al*., 2000; Sala *et al*., 2000; Stein *et al*., 2000, Madoffe *et al*., 2006; Kpontsu, 2011). The conservation status of the economic tree species in the undisturbed forest are threatened by various degrees of exploitation whilst the conservation status of flora in the disturbed forest are not threatened since they are not exploited. *Musanga cecropioides* and *Trema orientalis* predominant in the disturbed forest are common distinctive medium sized trees of secondary forest which are of less economic value. All the species distribution in the disturbed forest are attributed to the anthropogenic disturbances in the reserve which has resulted in the removal of the forest vegetation leading to changes in the composition and structure of the forest reserve (Hawthorne and Abu-Juam, 1993; Vordzogbe *et al*., 2005; Anning *et al*., 2008; Addo-Fordjour *et al*., 2009; Addai, 2011; Kpontsu, 2011).

5.1.1 Impact of illegal farming on tree species diversity in the Sui River Forest Reserve

Anthropogenic disturbances (Illegal farming) have influenced the tree composition of the Sui River Forest Reserve. Illegal farming activities in the reserve have affected plant diversity through the removal of tree species and consequently a reduction in the number of tree species and their diversity in the disturbed forest.

On the basis of only trees, the number of species recorded in this study (18 tree species/hectare) in the undisturbed forest and (5 tree species/hectare) in the disturbed forest in Sui River Forest Reserve was relatively lower in comparison with similar studies in other tropical forests. Campbell *et al*. (1986) and Riswan (1987) recorded 189 tree species/hectare and 160 tree species/hectare in Brazilian Amazon and Lempake Indonesia respectively. Vordzogbe *et al*. (2005) reported of much higher values (80 tree species/hectare) in a moist semi-deciduous forest (Muro forest reserve) and other moist semi-deciduous off-reserve forest zone in the Sefwi Wiawso District of the Western Region of Ghana. Anning, *et al*. (2008) recorded species richness (37 tree species/hectare) in Kwame Nkrumah University of Science and Technology Botanic Garden-Kumasi, Ghana (another disturbed semi-deciduous forest). Addo-Fordjour *et al*. (2009) recorded species richness (48 tree species/hectare) in Tinte Bepo Forest Reserve in Ahafo Ano South District, Ashanti Region, Ghana (another moist semi-deciduous forest). These are however, much lower than many other tropical forests. Other researchers have also recorded lower species per hectare. Pappoe, *et al*. (2010) reported 73 tree species/2.25hectares in the Kakum National Park, Central Region, Ghana.

Although the tree species/hectare in Sui River Forest Reserve was low in both the undisturbed and disturbed forest, that of the undisturbed (18 tree species/hectare) was higher than the disturbed forest (5 tree species/hectare). The felling of mature trees for farming in the disturbed forest and their attendant invasion of the disturbed forest by invasive weed species might have had effects on

the species composition of the disturbed forest in the reserve. This pattern of species distribution is supported by other related studies (Terborgh, 1992; Addo-Fordjour *et al.*, 2009; Addai, 2011; Kpontsu, 2011).

Tree species diversity in the undisturbed forest in the reserve was higher than that of the disturbed forest. Shannon-Wiener species diversity index (H^1) for the undisturbed forest was 2.6132 and that of the disturbed forest was 1.4445. Thus, anthropogenic tampering of the tropical primary forest of Sui River Forest Reserve by illegal farming has serious impacts on the distribution, community structure and population characteristic of flora in the reserve.

5.2 Natural Regeneration

Natural regeneration within the undisturbed forest was higher in relation to the disturbed forest as a result of invasion of the disturbed forest by invasive weed species. The most dominant regeneration species in the undisturbed forest was *Celtis mildbraedii*. None of the regeneration species within the undisturbed forest was found in the disturbed forest. The predominance of *Celtis mildbraedii* in the undisturbed forest indicate that they are the native plant species in the forest reserve implying that they can thrive very well in the moist semi-deciduous forest of the tropics. Many of the regeneration flora in the undisturbed forest were made up of very important economic tree species.

Odwuma (*Musanga cecropioides*) was the most dominant species within the disturbed forest. This is attributed to its ability to tolerate light, hence its absence in the undisturbed forest which is conducive for shade-bearing trees. As light demanders their presence in the disturbed forest indicates an open canopy of the disturbed forest. The regeneration flora in the disturbed forest was made up of species of less economic importance such as Sesea (*Trema orientalis*), Okuo (*Zanthoxylum gilletii*), Obonawa (*Tabemaemontana*), Fretefre (*Discoglypremna caloneura*).

Shrubs were generally more prominent in the undisturbed forest of the reserve with *Paullinia pinnata* (Family Sapindaceae) being the most dominant species. Herbs were generally more prominent in the disturbed forest of the reserve with *Chromolaena odorata* (Family Asteraceae) and *Pteris* species (Family Pteridaceae) being the most prominent. The presence of these species serve as an indicator of greater anthropogenic disturbances in the disturbed forest (Mishra *et al*., 2008; Addo-Fordjour *et al*., 2009).

Invasion of the disturbed forest by *Chromolaena odorata* partly contributed to the poor regeneration of the disturbed forest of the reserve. Seedling diversity decreased with increasing cover of *Chromolaena odorata* until there was no seedling of the native species in the disturbed forest (Table 2 and Table 3). Seedling diversity was high in the undisturbed forest but relatively poor in the disturbed forest with only seedlings of less economic importance in the disturbed forest. This is attributed to the presence of *Chromolaena odorata* and *Pteris* species which impeded the regeneration of native seedling species in the disturbed forest of the reserve.

5.2.1 Impact of illegal farming on natural regeneration in Sui River Forest Reserve

Illegal farming had a direct and immediate impact on the regenerative capacity of the disturbed forest in Sui River Forest Reserve. The undisturbed forest had a higher number of seedlings and other plant species than the disturbed forest (Table 2). Seedling diversity was quantitatively higher H^1 (2.5639) in the undisturbed forest in relation to the disturbed forest H^1 (1.9404) in the reserve.

Illegal farming activities in disturbed forest have affected plant diversity through the removal of plant species and consequently a reduction of number of the regenerative flora in the disturbed forest. The illegal farming have favoured the growing of invasive species among native species with

Chromolaena odorata which has been identified as notorious invasive weed in Ghana (CSIR, 2002; Addo-Fordjour *et al*., 2009) being the most dominant (44.1%) (Table 3). Invasion of the disturbed forest partly contributed to the poor regeneration of the disturbed forest. Seedling diversity therefore decreased with increasing cover of *Chromolaena odorata* until there were no seedlings of the native species in the disturbed forest (Addo-Fordjour *et al*., 2009). The diversity of other plant forms in the undisturbed forest (UF) was higher H^1 (1.4451) than the disturbed forest (DF) H^1 (1.1770) (Table 7).

The dominance of herbs in the disturbed forest (Table 7) could be attributed to the illegal farming in the disturbed forest. This is also attributed to the creation of canopy gaps and rapid run off exposing the forest floor to high light intensity. This favoured light demanding and invasive species like *Chromolaena odorata, Pteris* species and *Centrocema pubecens* immediately colonizing the illegally farmed areas (Table 7).

5.3 Fauna Diversity

The results of the present survey in Sui River Forest Reserve indicate that the undisturbed forest in the reserve supports diverse large mammalian fauna, avifauna (birds), reptiles and amphibians whilst the disturbed forest did not (Table 8). The greater fauna diversity and higher species richness occurred in the undisturbed forest where suitable habitat niches still occur. The greatest threat to the survival of the fauna is habitat destruction. Similar pattern of fauna distribution has also been recorded by Vordzogbe *et al.* (2005) and Addai (2011).

The disturbed forest harboured very low fauna species as a result of widespread loss and fragmentation of the original closed-canopy moist forest which has resulted in fauna species becoming rare (Vordzogbe *et al*., 2005; Addai, 2011; Yeboah *et al*., 2012). The large mammals

were dominant in the undisturbed forest because of availability of habitat and food source but have not been able to adapt to the conditions in the disturbed forest, hence their absence. The fragmentation of the forest vegetation as seen in the disturbed forest is attributed to habitat loss and a threat to wildlife.

The ground dwelling species (*Cricetomys gambianus*-giant rat) were found both in the undisturbed forest and the disturbed forest. They were distributed within the patches of fragmented forests located in the disturbed forest. They are rather favoured by opening of mature forests and an increase in secondary growth and invasive plant species. They have been able to adapt to the conditions in the disturbed forest type which provide them with alternative food source (maize, cocoyam, cassava and yam) as a result of illegal farming. Ground dwelling species do not appear to suffer to the same extent as large mammals in the disturbed forest in the event of their habitat destruction (Vordzorgbe *et al*., 2005; Yeboah *et al*., 2012).

The presence of *Agama agama*, *Cricetomys gambianus* and *Cyanomitra olivacea* in both the undisturbed and disturbed forests in the reserve indicate their ability to adapt to degraded environments. There were 82.0% of fauna species in the undisturbed forest in relation to the disturbed forest (18.0%). According to Vordzogbe *et al.* (2005) the fragmentation of their habitats makes it impossible for the immigration of new species into such fragmented habitats. Though frog (1) and toads (2) were identified in the disturbed forest, their numbers were not as high as those recorded in the undisturbed forest (9 and 7 respectively). This may be attributed to the poor environmental conditions in the disturbed forest.

The diverse fauna species dominance in the undisturbed forest in Sui River Forest Reserve in relation to the disturbed forest indicates that the flora determines the fauna species that are naturally associated with it. Similar observation was made by Vordzogbe *et al*. (2005).

5.3.1 Impact of illegal farming on the fauna of the forest reserve

Illegal farming has impacted negatively on the number of fauna species and their families in the disturbed forest. Quantitatively, the number of fauna species and their diversity was higher in the undisturbed forest compared to the disturbed forest of the reserve. This is attributed to the widespread loss and fragmentation of the original closed-canopy moist forest and the destruction of suitable habitat niches through the removal of forest vegetation by illegal farming. Source of food for fauna species is therefore threatened in the disturbed forest.

The low number of fauna species recorded in the disturbed forest is an indication of illegal farming which removes forest cover that serves as shelter and food resource for most of the fauna species.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Illegal farming is a threat to species diversity. Findings from this study indicate that the biodiversity of plant and animal species in the Sui River Forest Reserve a moist semi-deciduous forest was greatly affected by encroachment as a result of illegal farming. In general there were about 54.5% tree species, 59.6% seedlings and 82.0% fauna in the undisturbed forest compared to the disturbed forest.

The undisturbed forest has a higher community complexity than the disturbed forest because there was no disturbance, thus making this forest more diverse and species rich. The composition and species identified in both undisturbed and disturbed forests serve as an indicator and confirms the effect of illegal farming activities in the Sui River Forest Reserve. *Celtis mildbraedii* is characteristic and dominant in the undisturbed forest whilst *Musanga cecropioides* and *Trema orientalis* are characteristic and dominant tree species in the disturbed forest.

Regeneration of species in the undisturbed forest was higher than in the disturbed forest. The seedling species identified gives us an indication of the nature of forest type and the extent of illegal farming. *Celtis mildbraedii* was the dominant seedling species in the undisturbed forest whilst *Musanga cecropioides* was the dominant tree seedling species in the disturbed forest.

Invasion of the disturbed forest by *Chromolaena odorata* affected regeneration of native plant species in the disturbed forest. It is a dominant colonising species following the impact of farming. All other plant species identified in the undisturbed forest were mainly shrubs whilst the other plant species identified in disturbed forest were herbs.

The forest habitat serves as shelter and food resource for the fauna species. The undisturbed forest has a higher number of fauna species than the disturbed forest. The species identified in both undisturbed and disturbed forests serve as an indicator and confirms the effect of illegal farming activities in the Sui River Forest Reserve. *Neotragus pygmaeus* (Family Bovidae), *Cephalophus maxwelli* (Family Cephalophinae) and *Geochelone sulcata* (Family Testudinidae), *Agama Agama* (Family Agamidae) and *Xenopus laevis* (Family Pipidae), are characteristic species in the undisturbed forest whilst *Thryonomys swinderianu* (Family Thryonomyidae) is a characteristic species in the disturbed forest.

The effects of illegal farming in the Sui River Forest Reserve has been investigated and have provided some information on the loss of biodiversity as a result of encroachment through unauthorized farming. The findings of the study revealed that illegal farming has negatively impacted on the biodiversity in Sui River Forest Reserve.

This study is very unique since it is the first of its kind in investigating the impact of illegal farming on biodiversity in the Sui River Forest Reserve. This novel findings present us with information on the current status of the Reserve, to enable us implement sustainable forest management, in order to reduce the forest degradation process and biodiversity loss.

6.2 Recommendation

Sustainable forest management (SFM) implies various degrees of deliberate human intervention, ranging from actions aimed at safeguarding and maintaining the forest ecosystem and its functions, to favouring specific socially or economically valuable species or groups of species for the improved production of goods and services.

For the sustainable management of the reserve in order to maintain its biodiversity status in Ghana, proper management strategies such as intensive monitoring and patrolling, continuous education of all stakeholders on the need to protect and conserve the forest is required. Also, the survey, demarcation and pillaring of all admitted farms as well as restoration of all illegal farms have to be adopted to restore the integrity of the forest reserve. This may reduce the forest degradation process and enhance it for sustainable forest production.

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