KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF SCIENCE

DEPARTMENT OF ENVIRONMENTAL SCIENCE

ASSESSMENT OF ILLEGAL FOREST ACTIVITIES ON PLANT DIVERSITY IN TANO OFFIN GLOBALLY SIGNIFICANT BIODIVERSITY AREA (GSBA) IN THE NKAWIE FOREST DISTRICT, GHANA

BY:

OPARE ADDO YAW MICHAEL

AUGUST, 2013

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A DISSERTATION PRESENTED TO THE DEPARTMENT OF ENVIRONMENTAL SCIENCE IN PARTIAL FULFILLMENT FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ENVIRONMENTAL SCIENCE

BY:

OPARE ADDO, YAW MICHAEL

AUGUST, 2013

DECLARATION

I hereby declare that this work entitled ''ASSESSMENT OF ILLEGAL FOREST ACTIVITIES ON PLANT DIVERSITY IN TANO OFFIN GLOBALLY SIGNIFICANT BIODIVERSITY AREA (GSBA) IN THE NKAWIE FOREST DISTRICT, GHANA'' is a true account of my own research work under supervision with the exception of references which have been dully acknowledged.

Opare Addo Yaw Micheal Signature:………………..… Date:………..………

(Student)

Dr. S. Aikins Signature:…………………. Date:……….............

(Supervisor)

Rev. S. Akyeampong Signature:………………….. Date:………………...

(Head of Department)

DEDICATION

I dedicate this dissertation to my lovely wife Mrs. Grace Afia Opare, our children; Takyiwaa, Kofi, Mama and Junior and my parents; Mr. and Mrs. W. M. Addo Birikorang

ABSTRACT

Biodiversity in all forms sustains tremendous socio-economic and cultural interests of millions of people all over the world. Increasing human population has resulted in proportional increase in the demand for natural resources for the sustenance of human development needs. It is based on this, that the study was conducted in the Globally Significant Biodiversity Area (GSBA) within the Tano-Offin forest reserve. The aim of the study was to assess the extent of human activities and its effects on the tree community in the GSBA, with specific objectives of measuring the quantum of human activities occurring in the GSBA, examine the effect of unwanted human activities on tree species richness, abundance and diversity in the GSBA, and also examine the impact of the unwanted human activities on tree species composition, basal area and relative dominance. The area was stratified into two, thus, disturbed and undisturbed areas. In each of the stratified areas, a total of 5km transects were established. On the transects, 20m x 20m plots were laid at every 200m, for 5km. The disturbed area was identified by unwanted human activities such as farming, chainsawing and charcoal production. Trees were enumerated at both areas. Moving in clockwise direction within a plot, all trees with diameter at breast height (1.3m from the ground) equal to or greater than 10cm ($\geq$ 10cm dbh), were identified, measured and recorded. The diameter at breast height of each sampled tree was measured over bark with diameter tape. The mean number of trees identified and recorded in the areas affected by unwanted humans activities was 12.8 (SD=4.2, N = 25), while that of the undisturbed areas was 20.1 (SD=4.3, N=25), Mann-Whitney test shows that there was significant difference between the trees found in the disturbed and the undisturbed areas at $p< 0.05$ (U = 80, p = 6.749E-6). Shannon-Wiener's diversity index indicates that the diversity of trees in the areas affected by illegal activities was 3.164 and that of the undisturbed areas was 3.194. The t-test shows that the diversity of trees in both areas were not significantly different ($t = 1.7985$, $p = 0.072674$).

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ABBREVIATIONS

AAC	Annual Allowable Cut
dbh	Diameter at Breast Height
DSD	Dry Semi-Deciduous
FAO	Food and Agriculture Organization
FC	Forestry Commission
FMU	Forest Management Unit
FSD	Forest Services Division
FZ	Fire Zone
GDP	Gross Domestic Product
GHI	Genetic Heat Index
GSBA	Globally Significant Biodiversity Areas
ITTO	International Tropical Timber organization
IUCN	International Union for Conservation of Nature
IZ	Inner Zone
ME	Moist Evergreen
MSD	Moist Semi-Deciduous
NW	Northwestern

PAST	Paleontological Statistics Software Package for Education and Data Analysis
SD	Standard Deviation
SE	Southeastern
UE	Upland Evergreen
WE	Wet Evergreen

CHAPTER ONE

INTRODUCTION

1.1 Background

Life on earth has been successful, supported and perpetuated through a complex system of biological diversity which is little understood at the moment. The wide range of species, the complex biological communities and their genetic variation within species, which is otherwise termed biodiversity, has sustained life on earth for millions of years.

Tropical forest ecosystems host at least two-thirds of the earth's terrestrial biodiversity and provide significant local, regional and global human benefits through the provision of economic goods and ecosystem services. Yet the future of tropical forest species has never been more uncertain. Few areas of the tropics have escaped some form of human impact (Kareiva *et al.*, 2007) and the combined influence of persistently high rates of deforestation and forest degradation (FAO, 2006), over-harvesting, invasive species and global environmental change threaten to make tropical forests the epicentre of current and future extinctions (Bradshaw *et al.*, 2009).

In recent times, biodiversity has become easy targets for human over-exploitation due to burgeoning human populations and the quest for a "better life" through improvements in science and technology. Biodiversity, therefore, is being exploited at much faster rates than ever before with negative implications for sustainable human livelihood (Turner *et al.*, 1990). Wilson (1992) has stated that biodiversity is facing a decline of crisis proportions which could ultimately lead to mass extinctions in the very near future. In Ghana, increasing evidence indicates that the rate of environmental degradation has increased in recent times (Gyasi *et al.*, 1995), with previously rich forests being converted to savanna woodland and existing savanna woodlands converted into near desert (Hawthorne & Abu-Juam, 1995). It has been estimated that Ghana's high forest area of 8.2 million hectares at the turn of last century had dwindled to about 1.7 million hectares by the mid-1980s (Hall and Swaine, 1981), and about one million hectares by the mid-1990s (Forest Services Division, 1996).

Anthropogenic changes to tropical forests will impact human well-being in several ways. Tropical forests are key component of the global carbon cycle and contribute more than 30% of terrestrial carbon stocks and net primary production. (Field *et al*., 1998: Dixon *et al*., 1994). Tropical forests are a key component of global hydrological cycles and evapotranspiration from tropical forests contributes to precipitation at higher latitudes as well as within the tropics (Avissar & Werth, 2005). Tropical forests are the epicenter of global biodiversity and support 50% of all described species and an even larger percentage of undescribed species (Groombridge & Jenkins, 2003). Anthropogenic changes to these forests have the potential to alter global carbon and hydrological cycles, impact global biodiversity, and affect the livelihoods of many of the world's poorest people. Anthropogenic change affects every tropical forest today. The modern drivers of tropical forest change include ancient human activities—hunting, agriculture, and wood extraction—scaled up to unprecedented levels by new technologies and population growth. The modern drivers also include unforeseen consequences of the Industrial Revolution including changes to the composition of the atmosphere and global climate. The mix of drivers differs with proximity to modern infrastructure. Remote forests escape clearing for agriculture and fuel wood extraction, are increasingly accessible to hunters and commercial timber extraction, and bear the full brunt of many aspects of global atmospheric and climate change including rising atmospheric CO_2 concentration and temperature. Every tropical forest is affected.

Globally Significant Biodiversity Areas (GSBAs) are areas within Forest Reserve set aside to ensure that some forest blocks are preserved in a condition that is as close as the natural condition as much as possible for the preservation of unique flora and fauna. The GSBA concept is an innovation in conservation that calls for the protection and conservation of all kinds and sizes of living organisms as well as the ecosystems within which they have evolved (and in this case the tropical high forest). For effectiveness and acceptability, the GSBA concept is being pursued through collaborative management and implementation processes. The communities around these GSBAs are benefiting from schemes such as alternative livelihood, and small financial grants. In return they are among other things to help prevent illegal activities in the GSBAs. It is doubtful if the communities around these GSBAs are fulfilling their responsibilities under the collaborative arrangement for the management and protection of the GSBAs.

1.2 Problem statement

The GSBA was established in the 1990's, with the aim of not producing timber, but to conserve biodiversity, landforms and water bodies. But there has not been limited evaluation as to whether it has been able to achieve the aim of its establishment.

The main principle of the establishment was that timber exploitation is not to be allowed in the GSBA, no matter how rich the area is in terms of timber stocking. However, it has been observed that wanton destruction of timber species is happening through activities such as farming, chainsawing, charcoal production and other human activities.

The impacts of these human activities on tree species cannot be overemphasized. It can lead to reduction of tree density, diversity, growth pattern as well changes in species composition and distribution.

This study has been carried out to assess the impact of unwanted human activities such as illegal chainsawing, farming and charcoal production on the area designated as GSBA.

1.3 Justification

The entire area of the Tano Offin GSBA was designated as a Protection Working Circle under the 1958-68 working plan, including 6.167 km^2 of a village settlement (Kyekyewere) and some farmlands. There were also a number of bauxite concessions in the area and due to its status as a protection forest; no silvicultural operations have taken place in the GSBA portion of the reserve.

However, due to the mineral exploration carried out in the area coupled with increasing population of the Kyekyewere community in the Tano Offin GSBA and the failure of the government of Ghana (under auspices of the Forestry Commission) to provide alternative livelihood activities to the local people within the community after the designated their productive farmlands as GSBA has resulted in all kinds of unwanted human activities within the GSBA. Again, there is paucity of information and documentation materials on the current issues pertaining to these unwanted human activities and its effect on the tree community in the GSBA. There is therefore the need to assess unwanted human activities and the composition of tree species growing in the Tano Offin GSBA.

1.4 Goals and Objectives

The main goal of the study was to measure the magnitude of human activities and its effects on the tree community in the GSBA.

Specific Objectives

The specific objectives of the study were;

1. To measure the quantum of human activities occurring in the GSBA
2. To examine the effect of unwanted human activities on tree species richness, abundance and diversity in the GSBA
3. To examine the impact of the unwanted human activities on tree species composition, basal area and relative dominance.

1.5 Hypothesis

The following hypotheses were tested:

1. The tree abundance found in disturbed and undisturbed areas were not the same.
2. Tree diversity found in disturbed and undisturbed areas were the same.
3. The unwanted human activities reduces with increased distance from the edges of the GSBA

CHAPTER TWO

LITERATURE REVIEW

2.1 Forest Resources in Ghana

The forests in Ghana, which are part of the Guinea-Congolean phytogeographical region, cover about 24.2 % of the country's total land area of the country (FAO, 2010). Ecologically, the country is divided into a high forest zone to the southwest, accounting for about a third of the land area (about 7.5 million hectares), a savanna zone (14.7 million hectares) mostly in the north and a transition zone (1.1 million hectares) (ITTO, 2006). Ghana's natural landscape comprises two major ecological zones. The southwestern part of the country is the high forest zone, which represents about a third of its land area (approx. 7.5 million ha.), while the savanna dominates the north and the east. Forests are categorized into reserved and unreserved forest. The reserved areas account for 1.77 million ha of forest lands, of which 1.634 million ha is under the management and control of the Forest Services Division (FSD), whiles the Wildlife Division (WD) manages 0.136 million ha. (Kotey *et al*., 1998). The FSD of the Forestry Commission (FC) categorized the forest reserves under their jurisdiction into different management areas. The system is based on the forest protection strategy designed in 1993 to replace the old system based on production, protection and conversion 'working circles', which had been ignored in practice for years (Kotey *et al*., 1998). These are the timber production areas 742,600ha (47%), where the forest area is designated primarily for the production of wood, fibre, bio – energy and / or non – wood forest products. The permanent protection areas [(352,000 ha (21%)] consist largely of hill sanctuaries, but also include swamp sanctuaries, shelterbelts, special biological and fire protection area. Of this area, 69% is inaccessible for logging (except at very high cost) and 16% is degraded. Only 15% (which is protected on grounds of genetic diversity) is well stocked and accessible. The convalescence areas [122,000 ha (70%)] are those with reduced stocking through overexploitation, fire and poor management, but which are considered capable of rehabilitation within one felling cycle(40 years). This category includes the conversion areas [27,200 ha (8%)] that require planting and the areas that were not inventoried [2700, 000 ha (17%)] (Kotey *et al.*, 1998).

The high forest zone comprises seven forest types based on their ecological zones (Hall and Swaine, 1981). The wet evergreen (WE) rainforest experiences the highest amount of rainfall throughout the year while the dry semi – deciduous (DSD) type experiences amount of rainfall distributed only at certain times of the year in a well – defined dry season. In south – western part of the country is the wet evergreen forest type. Annual rainfall ranges between 1700 to 2030mm. Some usual tree species include *Cynometra anants*, *Heretiera utilis* and *Tieghemelia heckellii.* In terms of precipitation, the upland evergreen (UE) forest is similar to the (WE) but the two differ in their floristic composition and structure. The (UE) forests are on hills and mountainous areas and therefore referred to as mount forests. They receive up to 1700mm of rainfall and are wet throughout the year. One example is the Tano – Offin Globally Significant Biodiversity Area (GSBA) (Fig. 1). The moist evergreen (ME) forests experiences a lower amount of rainfall of between 1500mm to 1700mm per annum. They do not differ in structure from the WE forest except in floristic composition. The moist semi – deciduous (MSD) forest receives lower amounts of rainfall between 1200mm to 1500mm annually compared to the evergreen sub – types. The MSD forest type has upper and middle strata in terms of species composition and exhibits the deciduous habit during the dry season. This forest type can be conveniently divided into the northwestern (NW) and southeastern (SE) sub – types (ie. MSD – NW and MSD – SE) (MES, 2002).

The dry semi – deciduous (DSD) forest type bordering the Guinea Savanna has a low level of rainfall (1100mm to 1200mm annually) and pronounced dry season often associated with high temperature. This forest type is also known as transitional zone. According to the MES (2002), the DSD forest sub – type is also recognized as forest containing clearings of savanna or savanna with clumps of forest trees. Just like the MSD, this forest type has an inner zone (IZ) sub – type and fire zone (FZ) sub – type. For instance, Odum (*Milicia excelsa*) which is highly important timber species reaches its maximum abundance in the DSD / IZ sub – type but is currently endangered. The DSD / FZ sub – type is associated with the occurrence of periodic fires, especially during the dry season. The southeast outliners on the other hand represent the driest of forest types with an annual rainfall of about 750 – 1275mm. it is the least extensive forest area, occupying an area of approximately 20km^2 in small scattered patches. An example is the Shai Hills Game Production Reserve in the Accra Plains. This forest type also has a low floral diversity coupled with sparse tree canopies. Within this forest types, there are several rare tree species such as *Talbotiella* *gentii* and few commercial timber species (MES, 2002). The characteristics of these zones greatly influence the type of tree species and agricultural crops growing across the forest area.

The biological diversity of the high forest zone is high and of global significance and rich in endemic species (Hall and Swaine, 1976, 1981: Hawthorne and Abu-Juam, 1995; MES, 2002).

2.2 Importance of Ghana's Forest

Forests play a major role in the socioeconomic development of humankind and are essential source of harvestable products and variety of other services (Roy *et al.*, 2002). The forests are important source of timber, raw material for pulp and paper, fuel wood, and energy, and other essential harvestable products like food, medicines, oil and resins. Forests also play vital role in maintaining the ecological balance and environmental make-up of our world (Roy *et al.*, 2002). They do not only help maintain biological diversity, but also mitigate climate change, control hydrology, mineral cycling and soil erosion, improve air quality, create wildlife habitats and alleviate poverty (FAO, 2006; Roy *et al.*, 2002). Some developing countries virtually depend on forests and their resources to support socioeconomic and national developments (Dadebo and Shinohara, 1999). Ghana's forests make significant contribution to the national economy. Timber, which is the major market based forest product is currently the fourth largest contributor to Ghana's foreign exchange earnings aside minerals, cocoa and tourism (Marfo, 2010). The formal timber industry accounts for 11 % of foreign exchange earnings and contributes about 6 % to Gross Domestic

Product (GDP) and directly employs about 100, 000 people (Marfo, 2010). Between 2002 and 2007, Ghana earned an average of € 193.048 million annually from the export of wood products such as sawn wood, veneer and plywood (Marfo, 2010). In 2009 alone, Ghana earned an amount of € 128, 226, 984 from the export of 426, 221 m^3 wood products. Aside timber, the role of forests providing non-timber forest products and other services has been noted and appreciated. Forests contribute to livelihoods by providing food, fodder, fuel, building materials and supplement their incomes in addition to other non-quantifiable benefits such as cultural symbols, and ritual artifacts. Over 2100 plant species have been recorded in the High forest zone of Ghana, of which 23 are considered to be endemic (Hall and Swaine, 1981).

2.3 Deforestation

Change is happening at a very fast rate all over the world, with some implications for sustainable human development. The bio-physical environment which contains the basic human life-support systems has always been characterized by change (Gyasi *et al.*, 1995). Though tropical forests have always had a long history of human interferences, and also characterized by change, the rate at which the changes are occurring have raised a lot of concerns (Gupta *et al.*, 2004; Gyasi *et al.*, 1995; Hawthorne and Abu-Juam, 1993; Myers, 1992). The concerns over the rapid disappearance of tropical forests (Myers, 1992), are as a result of the degree of disturbance and the imbalance between disintegration and recovery rates (Hawthorne and Abu-Juam, 1993). Forests in the tropics are particularly under threat from human-induced disturbances (Gupta *et al.*, 2004; Kozlowski, 2000), and approximately 13 million ha of tropical forests are felled, burned or converted to other land uses each year (FAO, 2006).

The forests in Ghana, like other tropical forests is seen to have been very much influenced by human disturbances. There has been a considerable loss of forests in the country in the last 100 years and over, with serious local, national, regional and global implications (Appiah *et al*., 2009; Foli *et al*., 2009; Gupta *et al*., 2004; Palo and Yirdaw, 1996). Siry *et al.*, (2005), argued that forests loss has a far reaching significance which goes beyond loss of forest land but also affect the decline in the quality of existing forests. Though there are uncertainties about the actual rate of deforestation, the rate of change in Ghana has been rapid and increasing (Appiah *et al*., 2009; FAO, 2006; Benhin and Barbier, 2004; Sandler, 1993). The present rate of deforestation is among the highest in Africa (FAO, 2010). The average estimated annual rate of deforestation between 1990 and 2000 was 2% (135, 000 ha), which is higher than the average annual rate for both Central and Western Africa which stands at 0.6 % (FAO, 2010; FAO, 2006).

Forest resources in Ghana have reduced from 7 million ha in 1990 to approximately 6 million in 2000 (FAO, 2006). Almost all the forests are depleted and 0.39 million ha of forests reserves are considered as degraded (Marfo, 2010). Over harvesting has led to the downward revision of the national Annual Allowable Cut (AAC) in forest reserves from 1.2 million m^3 in 1990 to 500, 000 m^3 in 2005 (ITTO, 2006). The off reserve component of the total national AAC (2 million m^3) was set as high as 1.5 million m^3 mainly due to extensive illegal logging and the assumption that with time those areas are likely to be converted to other land uses (Marfo, 2010). However, some have argued that some of the causes of deforestation in the past were legal, purposeful and arguably necessary for development of the country (Grainger, 1993; Hawthorne and Abu-Juam, 1993). The cause of deforestation in Ghana vary and are by no means easy to change, but they have resulted from a complex interaction of different social, cultural, economic, management and political factors (Teye, 2005; Benhin and Barbier, 2004; Gupta *et al.*, 2004; Capistrano and Kiker, 1995; Grainger, 1993). Though, there are several causes for forest loss in Ghana, they can be broadly divided into internal (country specific issues such as unsustainable agriculture, conversion to agriculture, unsustainable logging, wildfires, firewood collection and charcoal production, mining, plantation strategies and taungya, population pressure, poorly defined land and resource tenure, poverty and unemployment, weak government policies, corruption and weak institutional governance) and external (influences from outside Ghana such as foreign investments, international trade and market failures) factors (Appiah *et al.*, 2009; Codjoe and Dzanku, 2009; Awung, 1998). The internal factors can further be categorized into proximate and underlying causes. The proximate causes include, unsustainable agriculture, conversion to agriculture, unsustainable logging, wildfires, firewood collection and charcoal production, mining, and plantation strategies and taungya, whilst the underlying causes also include but not limited to population pressure, poorly defined land and resource tenure, poverty and unemployment, weak government policies, corruption and weak institutional governance (Codjoe and Dzanku, 2009; Teye, 2005; Benhin and Barbier, 2004; Palo and Yirdaw, 1996; Grainger, 1993; Hawthorn and Abu-Juam, 1993). However, these distinctions are merely conceptual since none of the causes is mutually exclusive but all are interdependent and interactive (Codjoe and Dzanku, 2009; Dadebo and Shinohara, 1999).

2.4 Causes of Deforestation

The proximate causes are the immediate activities which have direct human influence. These activities are however precipitated by other underlying influences (Teye, 2005; Yiridoe and Nanang, 2001).

2.4.1 Unsustainable agriculture

Agricultural production is considered as the main contributor to the economy of Ghana. About 60 % of the economically active population is involved in different agricultural activities, with forests and land as the main production input (Teye, 2005; Benhin and Barbier, 2004; Palo and Yirdaw, 1996). The sector engages a lot of people because about 57 % of the country's total land area is suitable for agricultural production (Appiah et al., 2009; Benhin and Barbier, 2004). Despite these huge areas which can support agriculture, Kotey *et al*., (1998) indicated that farming in the southern belt of Ghana which contains the high tropical forests is dominated by bush fallow system. This system otherwise called shifting cultivation involves the clearing of forests, burning the vegetation and growing crops for short periods and subsequently clearing other areas when the soil becomes infertile (Appiah *et al*., 2009; Palo and Yirdaw, 1996; Riswan and Hartanti, 1995; Myers, 1992).

This practice which was seen as one of the proven sustainable uses of land in the tropics is prevalent in Ghana (Appiah *et al*., 2009; Palo and Yirdaw, 1996; Grainger, 1993). The traditional practice of shifting cultivation was in itself not destructive to the forest ecosystems (Riswan and Hartanti, 1995), however the challenge is the continued clearing of large tracts of forest areas (Benhin and Barbier, 2004). Most forest areas have been destroyed by farming particularly the practice of shifting cultivation which has been blamed for the loss of several hectares of forests (Appiah *et al*., 2009; Palo and Yirdaw, 1996; Hawthorne and Abu-Juam, 1993). Shifting cultivation is considered as the main cause of deforestation, accounting for more forest loss than the combined effects of all the other direct factors (Sandler, 1993; Myers, 1992).

This assertion is affirmed by the fact that most nutrients in the tropics are stored in the biomass and therefore clearing the forests leaves the soil infertile. This implies that after two or three harvests, the soil nutrients are depleted leaving the farmer with no other choice than to clear more forest areas. Codjoe and Dzanku (2009) found out that agriculture (driven by shifting cultivation) was a more important cause of deforestation in Ghana than any other factor. It accounts for about 70 % of all deforestation producing several hectares of degraded lands and depleted secondary forests (Yiridoe and Nanang, 2001; Riswan and Hartanti, 1995; IUCN, 1992). Shifting cultivation in Ghana mostly occurs in the off-reserve areas, however increasing portions of reserve areas are being cleared for farming (Palo and Yirdaw, 1996; Hawthorne and Abu-Juam, 1993).

The main concern about shifting cultivation is the fact that it can support low population densities (Grainger, 1993), therefore some argue that farmers involved in these practices are driven by factors such as population pressure, poverty and lack of alternative rural income aside agriculture which shorten the fallow period (Appiah *et al*., 2009; Palo and Yirdaw, 1996; Grainger, 1993; Myers, 1992).

The persistent migration by settlers to the southern parts of the country has been found to contribute to the high rates of forests degradation (ITTO, 2006). Farmers migrating from other areas of Ghana have inundated the Western Region which contains large tracts of the primary high forests (Kotey *et al*., 1998). A study conducted by Gyasi i*et al*., (1995) in some districts of the transition zone in the Eastern Region found that farming had replaced nearly all the original natural forests and changed the vegetation to savannah. The major factor impelling the increased farming activities was population pressure from migrants who had settled in these areas.

2.4.2 Conversion to agriculture

The continued expansion of agriculture in many parts of the tropics is a major threat to forests, contributing immensely to deforestation (Horne, 1996). In Ghana there has been an increase in both legal and illegal farms in most forest reserves (Hawthorne and Abu-Juam, 1993). Forests continue to be converted to croplands especially in areas where lands for cultivation are becoming scarce. Economic reasons have been cited for the persistent conversion of forests to other land uses in the off- reserve areas (Kotey *et al*., 1998).

As incomes decline, rural communities are forced to clear more forests to sustain their livelihoods (FAO, 2001). Forest land clearing has been intensified by the increased emphasis on agricultural production which relies heavily on export commodity crops (Yirdaw, 1996). The quest to diversify the nation's exports with emphasis on non-traditional export commodities have led to an increased expansion of cocoa growing areas (Yiridoe and Nanang, 2001). Large portions of the high forests are therefore cleared annually for cocoa production. Benhin and Barbier (2004) used a four-equation model to show that cocoa land expansion is a significant cause of forest loss in Ghana. However the cultivation of food crops like cassava, plantain and cocoyam by farmers also lead to the clearing of more forest areas. Palo and Yirdaw (1996) stated that so far as the modernization of the agriculture sector continue to receive little attention the conversion of forests to farmlands is likely to continue.

2.4.3 Unsustainable logging

Logging which is one of the main reasons for forest management in Ghana has always been part of the economy of the country (Teye, 2005; Kotey *et al*., 1998). However, studies have shown that deforestation in Ghana mostly begins with the degradation of well-stocked forests due to unsustainable logging (ITTO, 2006). Though, the country practices selective logging, it is seen as one of the most disturbing factors with significant influence on the forests (Appiah *et al*., 2009; Palo and Yirdaw, 1996). Logging has been very intense especially in the semi-deciduous zones and has not only led to changes in the composition but also degradation of the forests (Palo and Yirdaw, 1996; Hawthorne and Abu-Juam, 1993). Though there are many hardwoods, excessive logging in especially the 1970s and 80s almost led to the near extinction of species such as *Pericopsis elata*. 'Salvage felling' which took place during those periods, allowed uncontrolled felling of 'over matured' trees as well as most of the high valued species (Hawthorne and Abu-Juam, 1993). ITTO in 2006 reported that, the 'Scarlet' species which are the most important among the commercial timber species, have been over-harvested at a rate greater than 200 % of the estimated sustainable yield and are under threat of economic extinction. Logging in Ghana has generally been seen as very wasteful (Palo and Yirdaw, 1996). The extraction of timber has been worsened by the high levels of waste which Benhin and Barbier (2004), estimated to be about 50 %. Most of the loggers fail to follow the guidelines provided in the logging plans during harvesting operations leading to damages from felling and extraction (Riswan and Hartanti, 1995; Hawthorne and Abu-Juam, 1993).

This problem is exacerbated by chainsaw milling through illegal loggers who process about 840,000 trees every year (Marfo, 2010). Marfo (2010) also reported that the activities of these illegal loggers generate about 2.5 million m^3 of round wood annually which incidentally exceeds the national AAC of 2 million m^3 designated for the formal timber industry. Apart from the direct effects logging has on the residual stands, it also enhances the spread and intensity of forests fires (Hawthorne and Abu-Juam, 1993). This is due to the fact that excessive logging makes forests more susceptible to fire by causing loading residues which dry up and become more combustible (ITTO, 2006). Ghana has witnessed frequent wildfires since the 1980s especially in the transition zone due to among other things inefficient logging practices. Most of the logging roads which are constructed during logging operations have in away contributed to more deforestation. These roads open up areas which hitherto are inaccessible to farmers and hunters who are usually accused of causing most of the wildfires (Palo and Yirdaw, 1996).

2.4.4 Wildfires

Disturbances such as wildfires are a major part of the natural cycle which influence the development, structure and function of forest ecosystems (Attiwell, 1994). Forest fires may either be caused by natural forces or human activities, the latter mostly been the case in Ghana (Teye, 2005; Hawthorne and Abu-Juam, 1993). Apart from the existing weather conditions, factors such as fuel load and degree of combustibility affect the spread and intensity of wildfires (Attiwell, 1994). Since the early 1980s, fires have occurred regularly and caused severe damage to large tracts of forests (ITTO, 2006; Teye, 2005). The damage caused by wildfires has been estimated at about US$24 million every year (ITTO, 2006). Farming, hunting and charcoal production have been identified as the major causes of wildfires, threatening the survival of forests especially drier forest in the country (Teye, 2005; Woldeamanuel, 2005).Wildfires have been the cause of degradation in especially the Moist semi-deciduous forests zone and the Dry semi-deciduous fire zone in recent years (Teye, 2005; Hawthorne and Abu-Juam, 1993). As noted by Goldammer (1993), these fires eventually rid the forests of common species and favours fire -resistant dry forest and fire-tolerant species. Inefficient logging practices have compounded the problem making the forests more susceptible due to heavy fuel loads from logging residues which become more combustible in drier conditions (ITTO, 2006). Hawthorne and Abu-Juam (1993), cautioned that the continued exploitation of timber and the reluctance of the Forest Services Division (FSD) to reduce timber yields in the fire prone areas are major challenges in dealing with wildfires in the country. Though recent figures from the Wildfire Management Project suggest a reduction in the frequency of fires, the spread and intensity are still causing serious effects on the forests.

2.4.5 Firewood collection and charcoal production

Firewood collection and charcoal production are in most cases the major products of the forests in Ghana (Palo and Yirdaw, 1996). The use and demand for these products keep increasing (Foli *et al*., 2009). Firewood and charcoal account for more than 75 % of all energy consumed in the country (FAO, 2006). It is estimated that about 91 % of total round wood produced is used for firewood and charcoal production (Teye, 2005). The use of firewood and charcoal is not only limited to domestic purposes but also used in local breweries, bakeries and fish processing (Yiridoe and Nanang, 2001). The demand for firewood and production of charcoal especially in the transition zone has contributed to the loss of forests in Ghana (Foli *et al*., 2009; Teye, 2005; Yiridoe and Nanang, 2001). Most of the firewood are collected from the off-reserve areas and fallow lands, however wood in these areas have become scarce therefore leading to increased pressure on the forest reserves (Kotey *et al*., 1998; IUCN, 1992).

Charcoal production has also impacted both the forest reserves and off-reserve areas (Yiridoe and Nanang, 2001). The entire chain in the production of charcoal from the extraction has negative impacts on the structure of the forests (Webi, 2005). With increasing population, the demand and consumption of firewood and charcoal has increased creating a gap, and this gap will continue to intensify the pressure on forest reserves (Yirdaw, 1996).

2.5 Drivers of change and pressures on loss of Biodiversity

Ecosystems vary greatly in size and composition, ranging from a small community of microbes in a drop of water, to the entire Amazon rain forest. The very existence of people, and that of the millions of species with which the planet is shared, is dependent on the health of our ecosystems. People are putting increasing strain on the world's terrestrial and aquatic ecosystems. Despite the importance of ecosystems, they are being modified in extent and composition by people at an unprecedented rate, with little understanding of the implications this will have in terms of their ability to function and provide services in the future (World Bank, 2003).

Currently, population growth and patterns of consumption, which lead to increased demand for ecosystem services and energy, are the most important drivers affecting biodiversity. These drivers result in pressures that have direct impacts on ecosystems, species and genetic resources. Human activities cause changes in both the living and non-living components of ecosystems and these pressures have increased dramatically over the past few decades. Drivers and pressures seldom act in isolation. They tend to interact in synergistic ways, and their impacts on biodiversity are more than the sum of the effects of the individual drivers and pressures themselves (World Bank, 2003). Drivers and pressures act at different temporal and spatial scales. For example, sediments from deforestation in the headwaters of the Orinoco River, deep in South America, have impacts far out in the Wider Caribbean Sea basin, changing the nutrient availability and turbidity of the waters (Hu *et al*., 2004).

2.5.1 Pressures of illegal chainsawing activities

Illegal exploitation of forest resources, by means of encroachment through extension of admitted farms and timber harvesting by means of chainsaw milling is quite high in Ghana and are reported to play important roles in forest management activities (Kotey *et al*., 1998; Ohene-Gyan, 2004). Even though it is not clear exactly which illegal activities cost the forest more, illegal chainsaw activities have caught the attention of forest managers and policy makers in terms of its contribution to forest destruction, lost revenue to the state and the amount of conflict that it generates (Marfo, 2010).

Lack of employment is a critical factor driving many people to use forests resources unsustainably through illegal chainsaw operation (Putz *et al*., 1996). Studies in some countries indicate that there are five general factors contributing to the occurrence of illegal chainsawing activity in the forest sector (FAO, 2001). These include; flawed policy and legal framework, minimal enforcement capacity, insufficient data and information about the forest resource and illegal operations, corruption in the private sector and in government and high demand for cheap timber.

Brown (1994), determined adverse agricultural conditions due to sector policy that influence illegal forest activities. Such and other policies upset the conditions of production and productivity for rural people and thus pressure them into illegal forest activities. Dudley (2004) analyzed the intricacies of villagers' willingness to participate in illegal chainsawing. Based on a series of community interviews and social behavior patterns, the study showed that involvement in illegal chainsawing primarily interplay between the need for income, the fact that others are already illegally logging, and the realizations of loss of their community's control over traditional forest areas.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

3.1.1 Location and Extent

The Tano Offin GSBA forms part of the larger Tano Offin Forest Reserve which is part of FMU 35 and lies between latitudes $6^0$54' and $6^0$35' north and longitudes $1^0$57' and $2^0$17' west. The reserve is located between the Kumasi-Tepa and the Kumasi- Bibiani trunk roads. The Kumasi-Tepa road forms its northern boundary whilst the southern boundary is bordered by the Nyinahin-Sereso Tinpom road (Fig. 1). The Tano Offin Forest Reserve falls within the Atwima-Mponua and Ahafo Ano South District Assemblies and covers a gross area of 413.92km^2 (including village land and farms) out of which 178.34 km^2 (44.5%) constitutes the GSBA.

The Tano Offin GSBA is 178.34 km^2, which is 44% of the entire Tano Offin Forest Reserve. There is block of farms and an admitted settlement covering an area of approx. 627 ha. The large size of the Tano Offin GSBA is an indication of its potential to support diverse flora and fauna and their respective life processes. Since the GSBA covers only 44% of the larger Tano Offin reserve, the rest of the Reserve (56%) is large enough to supply the local communities with all the forest products they need without disturbing the GSBA.

3.1.2 Status and Property/Communal Rights

The Tano Offin Forest Reserve was constituted under the Kumasi Native Authority (Tano Offin Forest Reserve) Rules of 15th December 1949. Originally, a portion of the current GSBA was designated as Protection Working Circle (Forestry Department, 1958). This was later re-designated a Special Biological Protection Area as well as a hill sanctuary in 1995 (Hawthorne Abu-Juam, 1995) and eventually a GSBA in 1999. This GSBA is one of a three Upland Evergreen Forests in Ghana. There are 627 ha of village land and farmland in the GSBA.

Following logging and occasional wildfires, the southern boundary and many of the slopes are degraded seriously resulting in a high degree of soil erosion. Botanical surveys in 1998 noted that the area is patchy; some parts are mined or logged and others slightly burnt.

The ownership of the Tano Offin GSBA is vested in the Golden Stool (Asantehene) for whom the Nyinahinhene, Hiahene and Nkawie Paninhene act as caretakers. Communal Rights in the Tano Offin Forest Reserve are listed in section 4(1) of the Rules establishing the entire reserve and recognized by the Forest Services Division.

a) Communal rights: shooting, hunting, fishing, collecting snails or firewood, chew-stick, cane, raffia and rattan cutting.

b) Farming and village land rights: demarcated areas for individuals or groups of individuals. There is an admitted village (Kyekyewere) and a farm block in the GSBA covering an area of 6.27 km^2.

3.1.3 Climate and Physical Features

The elevation of the hill summits leads to increased rainfall and misty conditions. The rainfall pattern in the area is bi-modal with the peaks occurring in May-June and September-October. There is a dry spell between mid-November and mid-March with January being the driest month. The mean annual rainfall is 1250mm. The wet seasons are associated with the Southwesterly winds whereas the dry spells are associated with the northeasterly which, come in with a mild harmattan between November and March. Temperatures within the vicinity of the reserve are normally uniformly high, with mean maximum temperature being 33^0C whilst a mean minimum of 21^0C has been recorded. The maximum monthly average of 33.04^oC occurs in March the minimum 19.6^oC in January. Relative humidity is generally high with an annual mean of 80%.

Forest ochrosol is the main soil type. The Geological Survey Map shows that the locality of the reserve is on a rocky base of the Cape Coast granite complex. This is composed of granite, biotite, muscovite, granodiorite, pegmatite and apatite with schist pendants (Forestry Department, 1958).

The Tano Offin Forest Reserve has an elongated mountainous range that varies between 200m and 750m above sea level. The range has many steep slopes and drained by two major rivers, Tano and Offin.

The Tano Offin GSBA forms part of the Tano Offin Forest Reserve area that was classified as an Upland Evergreen Forest (Hall and Swaine, 1976) because of its location on isolated hills within the area of the Moist Semi-Deciduous Forest Type. Trees in this vegetation type attain an average maximum height of about 45m.

3.1.4 Flora and Fauna

The Upland Evergreen Forest in Ghana is known to be botanically very unique in terms of floral richness and diversity. The dominant timber species in the area include *Mansonia altissima*, *Pterygota macrocarpa* and *Terminalia superba*. According to Hall and Swaine (1981), sample plots in Upland Evergreen forest generally provide longer species lists than those in the surrounding Moist Semi-Deciduous forests. The area therefore recorded a Genetic Heat Index (GHI) value of 176.4. Between 2001/2002 a botanical survey recorded three rare species in some farmlands around this area. These include two Black Star species (*Guibotia dinklagei* and *Aubregrinia tainsis*) and Blue Star species (*Pterocarpus mildbraedii*) that is rare in Ghana.

Important birds identified in the area include the Yellow-throated green bulbul (*Cringer olivaceaus*), Green-tailed bristle-bill (*Bledaeximia*) and (*Illaposis rufenscencens*). It is believed there also exists, a variety of mammals (including chimpanzees) and reptiles in the reserve.

3.1.5 Diversity and Rarity

The Tano Offin GSBA harbours a wide range of biological resources in the area. Important birds identified in the area include the Yellow-throated green bulbul (*Cringer olivaceaus*), Green-tailed bristle-bill (*Bledaeximia*) and (*Illaposis rufenscencens*).

Three Black Star and 17 Gold Star species have been identified in the forest and a GHI index of 176.4 has been recorded for the area. The Tano Offin GSBA is very important because it supports a diverse community of flora and fauna species some of which need special protection to prevent them from getting extinct. Since the area harbours a wide range of biological resources, the area needs to be conserved and prevented from exploitations of all forms.

The Tano Offin Forest Reserve constitutes about 25% of the Upland Evergreen Forest type in Ghana. It is one of the only three of this forest type in Ghana. The rare tree fern (*Cyathea manniana*) is known to occur in this forest type which makes it very important so far as conservation is concerned.

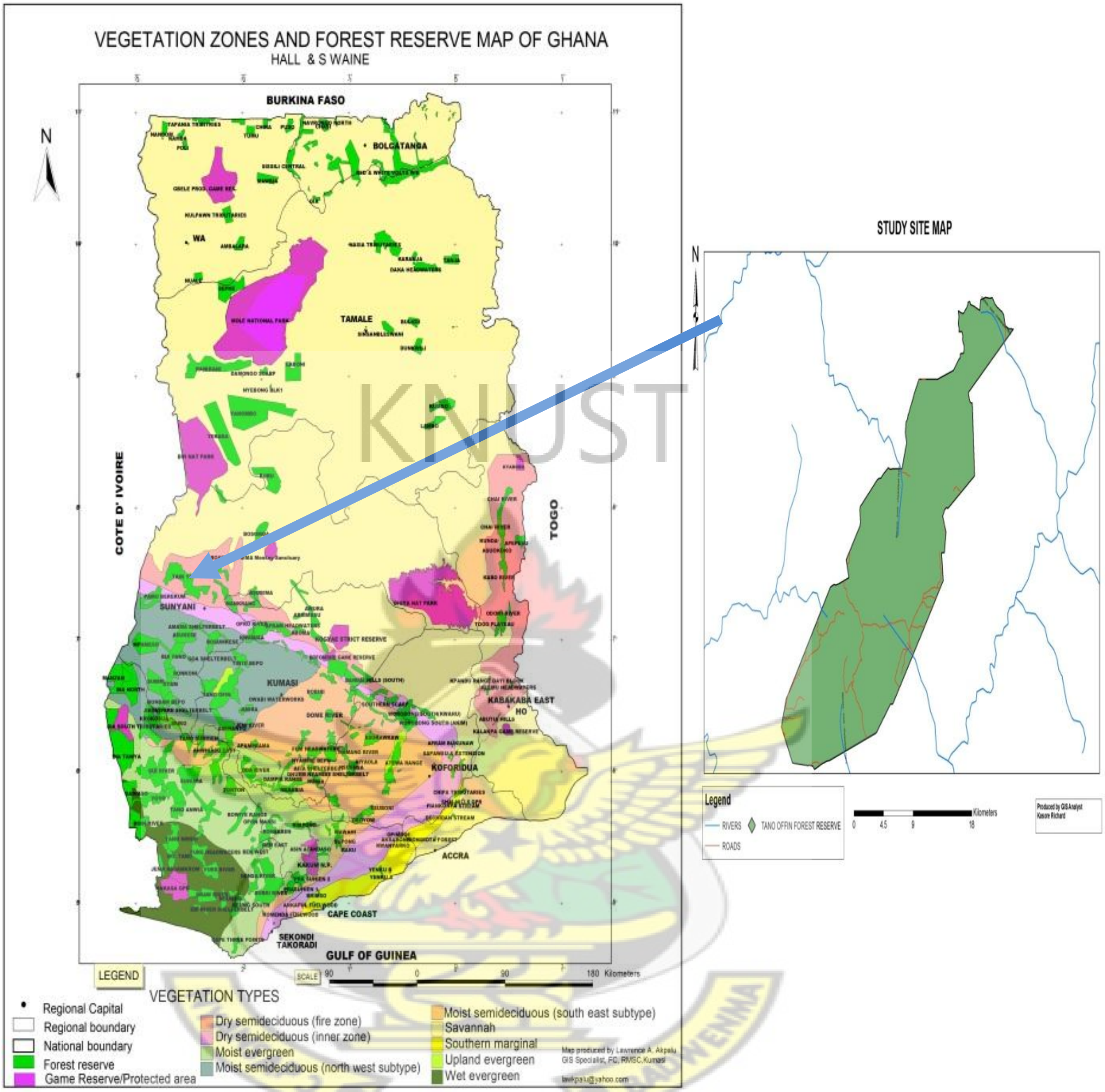

Figure 1: Map of Tano Offin GSBA (right) with arrow pointing to location on Ghana map (left)

3.2 Data Collection Procedure

The area was stratified into two, thus, disturbed and undisturbed areas. In each of the stratified areas, a total of 5km transects were established. On the transects, 20m x 20m plots were laid at every 200m, for 5km. The disturbed area was identified by activities of illegal farming, illegal chainsawing and illegal charcoal production. Trees were enumerated at both areas.

The enumeration team was made up of a recorder, a tree spotter and assistant. The main duty of the tree spotter was to record all the information about the trees, including identification and measurements and the assistant helped in measurements and specimen collection. Moving in clockwise direction within a plot, all trees with diameter at breast height (DBH) (1.3m from the ground) equal to or greater than 10cm (≥ 10cm dbh), were identified, measured and recorded. The diameter at breast height of each sampled tree was measured over bark with diameter tape. However, there were some reasons to deviate sometimes from this standard "breast height" and execute the diameter measurement at another position on the sample tree. These were as follows:

1. Sample trees with buttress: the stem diameter was measured approximately 30cm above the buttress.
2. Sample trees with aerial or stilt roots: the stem diameter was measured at 1.3m above the beginning of the stem.
3. Forked trees were regarded as two sample trees if fork is above 1.3m.

3.3 Data Analysis and Calculation of Community Parameters

The data was analyzed using PAST software (Paleontological Statistics Software Package for Education and Data Analysis) Mann-Whitney U-test was used to test the differences in abundance, while t-test was used to test the difference between diversities.

Regression was used to measure the relationships between the unwanted human activities and the distance from the GSBA boundary.

The following formulas were used to calculate the community parameters:

$Basal\ area(cm^2) = \frac{\pi D^2}{4}$……………………………………………….equation I

$Relative\ dominance(\%) = \frac{basal\ area\ of\ species}{total\ basal\ area\ of\ all\ species} x100$ ………..equation II

Shannon (H') = $-\sum_{i=1}^{s} piln(pi)$………………………………………equationIII

Where: H'= The Shannon-Wienner Diversity Index

Pi = the relative abundance of each group of organisms

∏ = 3.1423

D = Diameter at Breast Height

CHAPTER FOUR

RESULTS

4.1 Rate of occurrence of unwanted human activities

The number occurrence of unwanted human activities identified and recorded for farming was 42, chainsaw recorded 32; charcoal production was 18. Their mean values were 1.68, 1.28 and 0.72 respectively as shown in Table 1.

Table 1: **Total, mean and standard deviation of illegal activities recorded**

Illegal Activity	Total No/ha	Mean ±SD	Standard Deviation
Farming	42	1.6±0.9	0.9
Chainsaw	32	1.28±1.3	1.3
Charcoal Production	18	0.72±0.8	0.8

Moving from the edge to the interior of the GSBA, a negative relationship emerged indicating that the chainsaw activities decreases as one moves away from the edge as shown in Figure 2.

On the contrary, a positive relationship emerged in the farming activities, which indicates that the farming activities increases as one moves away from the edge as shown in Figure 3. However, there was virtually no relationship between the charcoal activities and the distance, indicating that the charcoal activities were distributed at random, as shown in Figure 4.

Pearson's correlation (r) was used to test the hypothesis that unwanted human activities reduces with increased distance from the edges of the GSBA. The details of the results have been presented in Table 2.

Table 2: **Pearson's Correlation**

Human Activity/Distance	R	P-value	Significance
Chainsaw	-0.70787	2.502E-6	*
Farming	0.540977	0.004	**
Charcoal	0.134377	0.304	Ns

*significant at 0.01; **significant at 0.05; ns-non significance

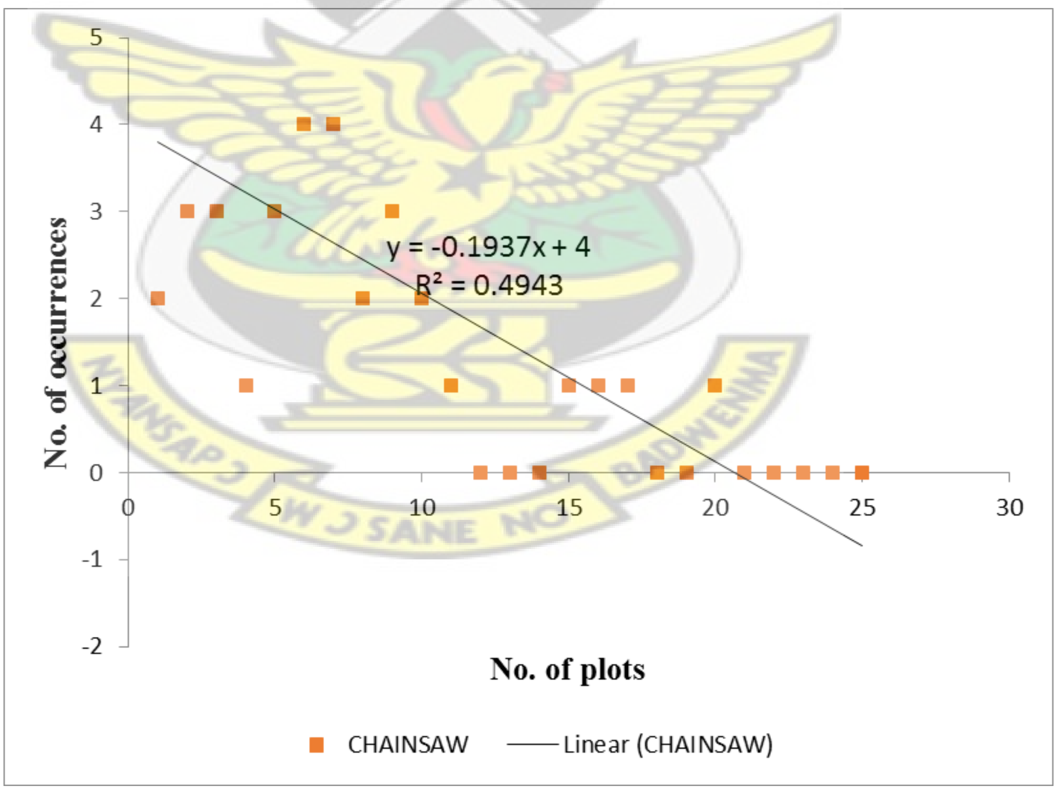

Figure 2: The relationship between chainsaw activities and distance away from the boundary

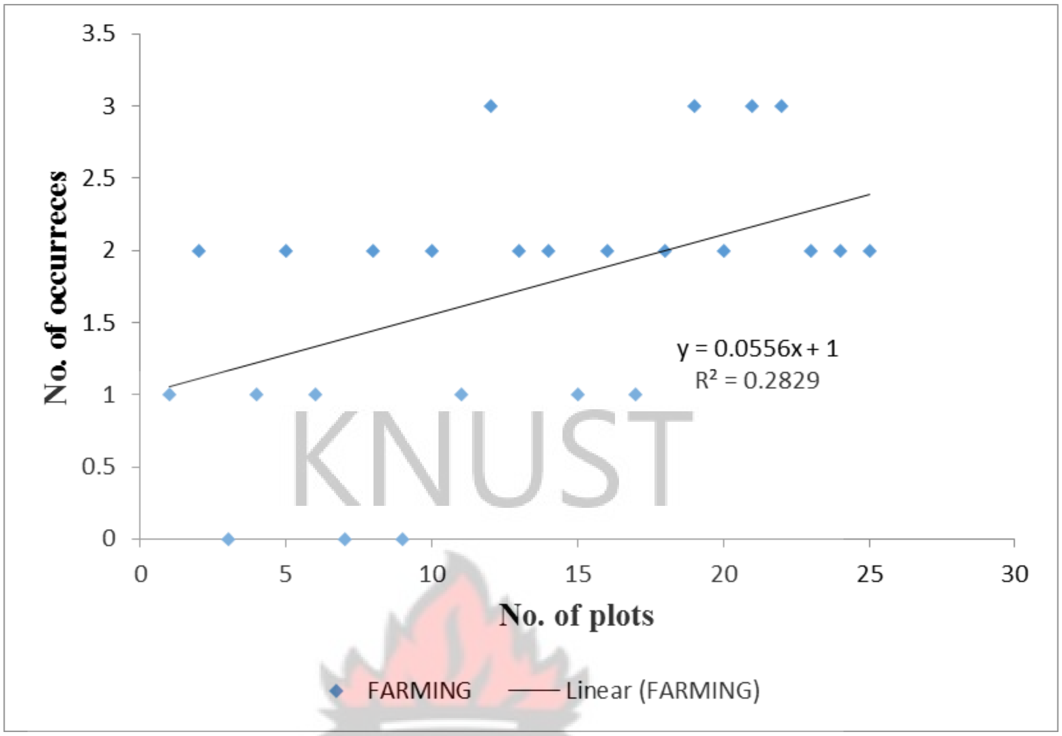

Figure 3: The relationship between farming and distance away from the boundary

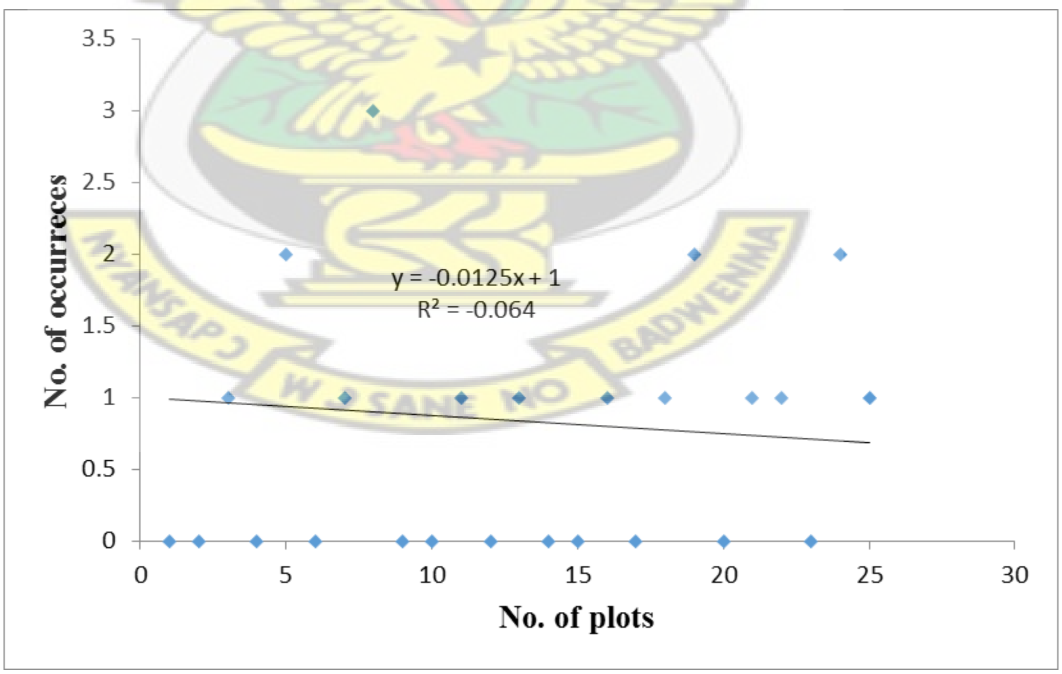

Figure 4: The relationship between charcoal production and distance away from the boundary

4.2 Tree species composition and abundance

The mean number of tree species identified and recorded in the areas affected by the illegal activities was 12.8 (SD=4.2, N = 25), while that of the undisturbed areas was 20.1 (SD=4.3, N=25), as illustrated in Figure 5. Mann- Whitney test shows that there was significant difference between the trees found in the disturbed and the undisturbed areas at $p < 0.05$ (U = 80, p = 6.749E-6). Shannon-Wienner's diversity index indicates that the diversity of trees in the areas affected by illegal activities was 3.164 and that of the undisturbed areas was 3.194. The t-test shows that the diversity of trees in both areas were not significantly different (t= 1.7985, p= 0.072674).

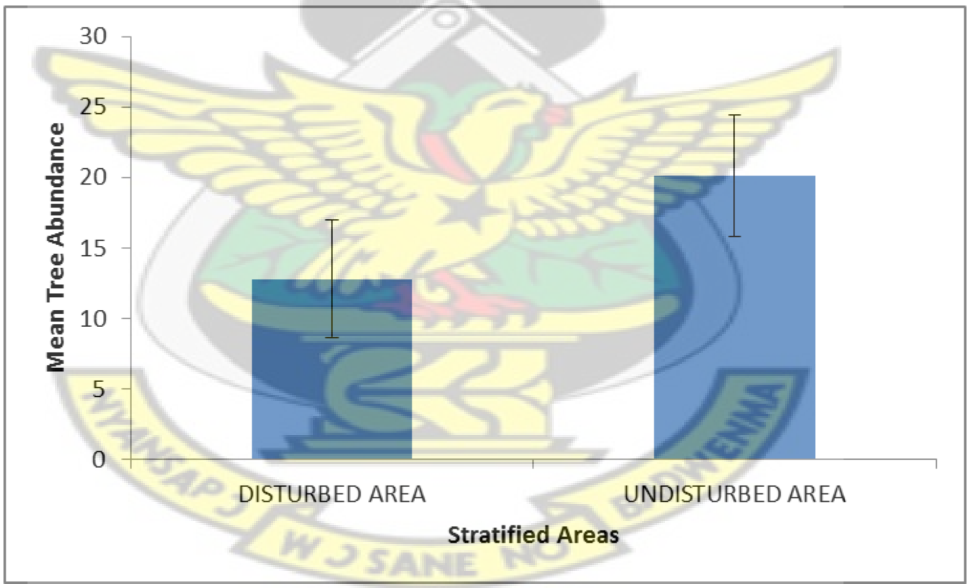

Figure 5: Mean tree abundance with error bars showing standard deviation

4.3 Tree species composition, basal area and relative dominance of trees in undisturbed areas and areas affected by illegal activities**.**

Tables 3 and 4 show details of species composition, basal area and relative dominance of plants identified in the undisturbed areas and areas affected by unwanted human activities. A total of 502 trees distributed over 47 species were identified in the undisturbed areas (Table 3), while a total of 321 trees distributed over 37 species were identified in areas affected by unwanted human activities (Table 4). In the undisturbed areas, *Ceiba pentandra* and *Piptadeniastrum africanum* occupied large area with relative dominance of 7.9% and 7.9% respectively, followed by *Celtis mildbraedii* with relative dominance of 6.4% (Table 3). In the areas affected by illegal activities, *Ceiba pentandra* occupied larger area with relative dominance of 21.9%, *Antiarias toxicaria* followed with 8.5%, while *Celtis mildbraedii* recorded 5.9% of relative dominance (Table 4).

Table 3: Tree species identified in undisturbed areas

Scientific Name	Family	Local Name	Abundance	Basal Area(cm^2)
Albizia ferruginea	Leguminosae	Awiemfosamina	12	13275
Albizia zygia	Leguminosae	Okoro	14	24887.8
Alstonia boonei	Apocynaceae	Sinuro	11	31420
Amphimas pterocarpoides	Leguminosae	Yaya	12	29868.6
Antiaris toxicaria	Moraceae	Kyenkyen	10	32051.5
Antrocaryon micraster	Anacardiaceae	Aprokuma	12	22701
Baphia nitida	Leguminosae	Odwen	10	11311.2
Blighia sapida	Sapindaceae	Akye	10	90803.8
Bombax buonopozense	Malvaceae	Akata	8	49093.8
Bussea occidentalis	Leguminosae	Kotoprepre	12	43379.2
Calpocalyx brevibracteatus	Leguminosae	Atrotre	16	71640.7
Ceiba pentandra	Malvaceae	Onyina	8	159063.8
Celtis adolfi-friderici	Ulmaceae	Esakosua	10	70695
Celtis mildbraedii	Ulmaceae	Esa	18	128841.6
Celtis philippensis	Ulmaceae	Prepresa	15	61583.2

Chrisophyllum albidum	Sapotaceae	Akasa	12	59403.4
Cola gigantean	Malvaceae	Watapuo	15	49093.8
Daniellia ogea	Leguminosae	Hyedua	9	32689.4
Didelotia afzelii	Leguminosae	Hyedua-kokoo	3	32689.4
Discoglypremna caloneura	Euphorbiaceae	Fetefre	12	32369.7

Table 3 continued

Scientific Name	Family Name	Local Name	Abundance	Basal Area(cm^2)	Relative dominance (%)
Drypetes aubrivellei	Euphorbiaceae	Duamako	10	49093.8	2.4
Entandrophrabma angolense	Meliaceae	Edinam	9	31420	1.6
Entandrophragma cylindricum	Meliaceae	Penkwa	6	30794.7	1.5
Funtumia elastic	Apocynaceae	Funtum	14	29868.6	1.5
Guarea cedrata	Meliaceae	Kwabohoro	8	26883.7	1.3
Hannoa klaineana	Simaroubaceae	Fotie	10	25450.2	1.3
Hexalobus crispiflorus	Annonaceae	Duabaha	8	25450.2	1.3
Holopteliea grandis	Ulmaceae	Anakwa	14	24055.9	1.2
Khaya anthotheca	Meliaceae	Krumben	16	47149.6	2.3

Mansonia altissima	Malvaceae	Oprono	12	47149.6	2.3
Morus mesozygia	Moraceae	Wonton	10	17673.8	0.9
Myrianthus arboreus	Cecropiaceae	Nyankoma-bere	9	16515.1	0.8
Nesogordonia papaverifera	Malvaceae	Danta	8	61583.2	3.0
Parkia bicolor	Leguminosae	Asoma	12	49093.8	2.4
Petersianthus macrocarpus	Lecythidaceae	Esia	13	24055.9	1.2
Piptadeniatrum africanum	Leguminosae	Dahoma	6	159063.8	7.9
Pterygota macrocarpa	Malvaceae	Kyereye	11	63802.2	3.2
Sterculia oblonga	Malvaceae	Ohaa	8	13275	0.7
Sterculia rhinopetala	Malvaceae	Wawabima	6	9504.6	0.5

Table 3 continued

Scientific Name	Family Name	Local Name	Abundance	Basal Area(cm^2)	Relative Dominance (%)
Strombosia glaucescens	Olacaceae	Afena	10	8172.3	0.4
Terminalia ivorensis	Combretaceae	Emire	8	18628.9	0.9
Terminalia superba	Combretaceae	Ofram	6	47149.6	2.3
Trichilia monodelpha	Meliaceae	Tanuro	10	11311.2	0.6
Trichilia prieuriana	Meliaceae	Tanurobere	7	4418.4	0.2
Trichilia tessmannii	Meliaceae	Tanuronini	12	11311.2	0.6
Triplochiton scleroxylon	Malvaceae	Wawa	10	71640.7	3.5
Turraeanthus africanus	Meliaceae	Apapaye	20	51077.1	2.5
Total			**502**		**100.0**

Table 4: **Tree species identified in areas affected by illegal activities**

Scientific Name	Family Name	Local Name	Abundance	Basal Area(cm^2)	Relative dominance (%)
Albizia zyogia	Leguminosae	Okoro	8	21385.2	2.9
Antiaris toxicaria	Moraceae	Kyenkyen	13	61583.2	8.5
Baphia nitida	Leguminosae	Odwen	8	5281.7	0.7
Broussonetia papyrifera	Malvaceae	Yorke	10	8333.4	1.1
Bussea occidentalis	Leguminosae	Kotoprepre	12	12273.4	1.7
Ceiba pentandra	Malvaceae	Onyina	10	159063.8	21.9
Celtis mildbreadii	Ulmaceae	Esa	16	43010.8	5.9
Celtis zenkeri	Ulmaceae	Esakokoo	12	20108.8	2.8
Cola caricifolia	Malvaceae	Ananseaya	6	2827.8	0.4
Cola gigantean	Malvaceae	Watapuo	9	32689.4	4.5
Corynanthe Pachyceras	Rubiaceae	Pampenama	5	4779	0.7
Diospyros Kamerunensis	Ebenacae	Omena	8	5027.2	0.7

Entandrophragma Angolense	Meliaceae	Edinam	6	17673.8	2.4
Ficus exasperate	Moraceae	Nyankyerene	6	6362.6	0.9
Funtumia elastic	Apocynaceae	Funtum	6	14315.7	2.0
Hannoa klaineana	Simaroubaceae	Fotie	4	4418.4	0.6
Mansonia altissima	Malvaceae	Oprono	6	14315.7	2.0
Milicia excels	Moraceae	Odum	2	2376.1	0.3
Morinda lucida	Rubiaceae	Konkroma	9	7089.1	1.0

Table 4 continued

Scientific Name	Family Name	Local Name	Abundance	Basal Area(cm^2)	Relative dominance (%)
Morus mesozygia	Moraceae	Wonton	10	22701	3.1
Musanga cecrepioide	Cecropiaceae	Odwuma	12	26593.9	3.7
Myrianthus arboreaus	Cecropiaceae	Nyankoma	7	4301.4	0.6
Nesogodonia Papaverifera	Malvaceae	Danta	8	12077.8	1.7
Piptadeniastrum africanum	Leguminosae	Dahoma	5	4418.4	0.6
Pterigota macrocarpa	Malvaceae	Kyereye	7	18871.6	2.6
Ricinodendron Heudelotii	Euphorbiaceae	Wama	8	36309.7	5.0
Solanum erianthum	Leguminosae	Pepediawuo	14	15395.8	2.1
Sterculia oblonga	Malvaceae	Ohaa	6	10388.2	1.4
Sterculia oblonga	Malvaceae	Ohaa	10	8660.1	1.2
Sterculia rhinopetela	Malvaceae	Wawabema	11	22701	3.1

Sterculia tragacantha	Malvaceae	Sofo	9	6362.6	0.9
Terminalia ivorensis	Combretaceae	Emire	6	5675.2	0.8
Terminalia superba	Combretaceae	Ofram	10	13686.6	1.9
Trema orietalis	Ulmaceae	Sesea	21	34640.6	4.8
Trichilia monadelpha	Meliaceae	Tanuro	5	3318.7	0.5
Trichilia tessmannii	Meliaceae	Tanuronini	6	6362.6	0.9
Triplochiton scleroxylon	Malvaceae	Wawa	10	32051.5	4.4
Total			**321**	**727431.9**	**100.0**

CHAPTER FIVE

DISCUSSION

5.1 Distribution of Illegal Forest Activities in Disturbed and Undisturbed Areas in the Tano Offin GSBA

Biodiversity in all its forms sustains tremendous socio-economic and cultural interests of millions of people all over the world. Increasing human population has resulted in proportional increase in the demand for natural resources for the sustenance of human development needs. Unsustainable pattern of utilization of biodiversity in most parts of the world have necessitated the need for new thinking in the management of biodiversity.

In Ghana, where the majority of tropical rain forests have already been destroyed and the remaining forest patches are only a few hundred km^2 in area. It can be stated that it is essentially too late for a compromise between conservation and exploitation.

The three major types of illegal activities identified and assessed in the GSBA area were illegal farming, illegal chain sawing and charcoal production. The total number of occurrence of illegal activities identified and recorded for illegal farming was 42/ha, illegal chainsaw recorded 32/ha while illegal charcoal production was 18/ha. This shows that the rate of illegal farming was higher in the GSBA, followed by illegal chainsaw, while illegal charcoal production recorded the least occurrence.

This development has been so because forest fringe communities were given parts of degraded forest adjacent to the GSBA to farm and plant trees, i.e. taungya system, and the farms have been extended into the GSBA.

One of the underlying factors that drive the chainsaw activities is the lack of employment opportunities for the youth in the forest fringe communities. This is supported by Marfo (2010), who stated that the demand for chainsawn lumber in the rural forested areas has provided economic opportunities for young people who are unemployed or who want to supplement livelihood activities such as farming. However, the operators always search for big tree species and what is termed as "hard wood" by the operators.

The low rates of charcoal production activities may be attributed to the fact that those who engage in this activity sometimes depend on the remnants of the chainsaw activities, and also the kind of tree species that can produce quality charcoal are always located far away from the boundary.

5.2 Unwanted Human Activities and Richness, Abundance and Diversity of Tree species in the disturbed and undisturbed areas in the Tano Offin GSBA

A total of 502 trees distributed over 47 species were identified in the undisturbed areas in the GSBA (Table 3), while 321 trees distributed over 37 species were identified in the areas affected by unwanted human activities (Table 4). The dominating species in the undisturbed areas were *Ceiba pentandra*, *Piptadeniastrum africanum* and *Celtis mildbraedii,* which are emergent species.

Tree species that dominated in the disturbed areas were *Ceiba pentandra*, *Antiaris toxicaria*, and *Celtis mildbraedii*. These species are light demanding species.

The mean number of trees identified and recorded in the areas affected by the unwanted human activities was 12.8 (SD=4.2, N = 25), while that of the undisturbed areas was 20.1 (SD=4.3, N=25). Mann- Whitney test shows that there was significant difference between the trees found in the disturbed and the undisturbed areas at $p< 0.05$ ($U = 80$, $p = 6.749E-6$). This trend might have come about as a result of the differences in the intensities of the activities as they reduce with the approach to the less disturbed area. In other words human activities were found to be higher in the more disturbed (forest edge) than undisturbed areas (forest interior).

However, the disturbance did not affect the diversity of tree species as indicated by Shannon-Wienner's diversity index. It indicates that the diversity of trees in the areas affected by unwanted human activities was 3.164 and that of the undisturbed areas was 3.194. The t-test shows that the diversity of trees in both areas were not significantly different ($t = 1.7985$, $p = 0.072674$). This can be attributed to the resilient capacity of both areas which appears to be the same.

Depending on the type of activity, there was a relationship between the type of activity and the distance from the boundary. In some cases the activity decreases with an increased distance, while some activities increase with increased distance.

Trends of unwanted human activities (farming, chainsawing and charcoal production) differed from one to the other. In Figure 2, the chainsaw activities decreased with an increase distance from the boundary. This may be due to the fact that there is high cost in conveying the sawn lumber from the interior of the forest to the boundary. On the other hand, farming activities increased with an increase distance into the GSBA (Figure 3). The reason for this relationship may be that the interior parts of the area is more fertile, and also when the farms are located far away from the boundary, its detection by forestry officers would be difficult. The distance from the boundary had no effect on charcoal production (Figure 4). The reason may be that charcoal production as unwanted human activity was identified in the transect irrespective of the distance from the boundary.

5.3 Tree species composition, basal area and relative dominance of trees in undisturbed areas and areas affected by unwanted humans activities.

Tables 3 and 4 show details of species composition, basal area and relative dominance of identified in the undisturbed areas and areas affected by illegal activities. In the undisturbed areas, *Ceiba pentandra* and *Piptadeniastrum africanum* occupied large area with equal relative dominance of 7.9%, followed by *Celti smildbraedii* with relative dominance of 6.4% (Table 3). In the areas affected by illegal activities, *Ceiba pentandra* occupied larger area with relative dominance of 21.9%, followed *Antiaris toxicaria* with 8.5%, while *Celtis mildbraedii* recorded 5.9% of relative dominance (Table 4). It was observed that most of the species in the undisturbed areas were emergent and with larger basal area, while those identified in areas affected by unwanted human activities were light demanding with lower basal area.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study has provided information on the composition of tree species in the undisturbed and disturbed areas of the GSBA. The number occurrence of unwanted human activities identified and recorded for farming was 42/ha, chainsaw recorded 32/ha, while charcoal production was 18/ha, whiles their mean value were 1.68, 1.28 and 0.72 respectively. In the undisturbed areas, *Ceiba pentandra* and *Piptadeniastrum africanum* occupied large area with relative dominance of 7.9% and 7.9% respectively, followed by *Celtis mildbraedii* with relative dominance of 6.4%. In the areas affected by unwanted human activities, *Ceiba pentandra* occupied larger area with relative dominance of 21.9%, *Antiaris toxicaria* followed with 8.5%, while *Celtis mildbraedii* recorded 5.9% of relative dominance. Chainsaw activities decreased with an increase distance from the boundary, also farming activities increased with an increase distance into the GSBA boundary, whiles the distance from the boundary had no effect on charcoal production.

6.2 Recommendations

Based on the results of the study, the following recommendations were made;

- Further studies should be conducted to assess other human activity such as poaching and illegal mining which goes on in the GSBA, apart the ones mentioned in this study.

- Studies should be carried out to find out the impact of these unwanted human activities on the fauna community in the GSBA
- Intensive education should be carried out in the fringe communities to sensitize them on the need to help conserve the GSBA.
- The Forestry Commission (FC) should adequately resource the field officers to guard against these identified unwanted human

REFERENCES

Appiah, M., Blay, D., Damnyag, L., Dwomoh, F.K., Pappinen, A., and Luukkanen, O. (2009). Dependence on Forest Resources and Tropical Deforestation in Ghana. *Environ. Dev. Sustain.*, 11: 471-487

Attiwell, P.M. (1994). The Disturbance of Forest Ecosystems: the ecological basis for conservative management. *Forest Ecology and Management*, 63: 247-300

Avissar, R. and D. Werth. (2005). Global hydroclimatologicalteleconnections resulting from tropical deforestation.J. Hydrometeorology 6: 134–145.

Awung, W.J. (1998). Underlying Causes of Deforestation and Forest Degradation in Cameroon. Paper presented at the Underlying Causes Initiative Workshop, 26-30 Oct., Accra, Ghana

Benhin, J.K.A., and Barbier, E.B. (2004). Structural Adjustment Programme, Deforestation and Biodiversity Loss in Ghana.*Environmental and Resource Economics*, 27: 337-366

Bradshaw, C.J.A., Sodhi, N.S. and Brook, B.W. (2009). Tropical turmoil: a biodiversity tragedy in progress. Front. Ecol. Environ., 7, 79–87.

Brown, K. (1994) In Pearce D. W., editor. The Cause of Tropical Deforestation: The Economic and Statistical Analysis of Factors Giving Rise to the loss of the Tropical Forests. Vancourer: UBC Press

Capistrano, A.D., and Kiker, C.F. (1995). Macro-scale Economic Influences on Tropical Forests Depletion.*Ecological Economics*, 14: 21-29.

Codjoe, S.N., and Dzanku, F.M. (2009). Long-term Determinants of Deforestation in Ghana: the role of Structural Adjustment policies. *African Development Review,* 21(3): 558-588

Dadebo, M. A., and Shinohara, T. (1999) Forest Resource and Timber Production of Ghana: current instruments for sustainable development.*J. For. Res*. 4: 1-12. Development Series No.3. ITTO, Yokohama.vailable at: http://www.itto.int/mis_detail/.

Dixon, R. K., Perry, J. A., Vanderklein, E. L. and Hiol, F. (1994). Vulnerability of forest resources to global climate change: case study of Cameroon and Ghana‘, *Climate Res*. 12, 127–133.

Dudley, N. (2004). Transnational Companies and Global Forest Resources. WWF United Kingdom, Godalming.

FAO (2001) Global Forest Resources Assessment 2000.Main Report.FAO ForestryPaper140, Food and Agriculture Organization of the United Nations, Rome, 479 pp.

FAO, (2006). Global Forest Resources Assessment 2005. Progress towards Sustainable Forest Management.*FAO Forestry Paper 147*, Rome.

FAO, (2010). Global Resources Assessment 2010.Country Report, Ghana.*FRA 2010/077*, Rome.

Field, C.B., M.J. Behrenfeld, J.T. Randerson and P.Falkowski. (1998). Primary production of the biosphere :integrating terrestrial and oceanic components. Science281: 237–240.

Foli, E., Agyeman, V.K., and Pentsil, M. (2009). Ensuring Sustainable Timber Supply in Ghana: a case for plantations of indigenous timber species. Forestry Research Institute of Ghana, Technical Note No. 1, pp. 15

Forest Services Division (FSD) (1996). Annual Report.Ministry of Lands and Forestry, Accra, Ghana.

Forestry Department (FD) (1958). Tano Offin Working Plan 1958 – 68, FD, Accra, Ghana

Gyasi E. A., Agyepong G. T., Ardayfio-Schandorf E., Enu-Kwesi L., Nabila J. S. and Owusu-Bennoah E. (1995). Production pressure and environmental change in the forest-savanna zone of southern Ghana. Global Environmental Change 5 (4): 355–366.

Goldammer, J.G. (1993). Fire management *in* Pancel L. (ed.). *Tropical Forestry Handbook*, Vol. 2. Springer-Verlag, Berlin, Germany.

Grainger, A. (1993). Controlling Tropical Deforestation.Earthscan Publications Ltd. pp. 310.

Groombridge, B. and Jenkins, M.D. (2003). World Atlas of Biodiversity Earth's Living Resources in the 21st Century. University of California. Berkeley, Los Angeles, London.

Gupta, S., Porwal, M. C., and Roy, P. S. (2004) Human Modification of the Tropical Rain Forest of Nicobar Islands: Indicators from Land Use Land cover Mapping. J. Hum. Ecol., 16 (3): 163-171.

Hall, J.B. and Swaine, M.D. (1976). Classification and Ecology of Closed Canopy Forests in Ghana. J. Ecol. 64: 913 – 951.

Hall J. B., and Swaine M. D. (1981). Distribution and ecology of vascular plants in a tropical rain forest: forest vegetation in Ghana. The Hague. W. Junk Publishers. Hague, Netherlands, p. 383.

Hawthorne, W. D. and Abu-Juam, M. (1993). Forest Protection in Ghana. IUCN, Gland, Switzerland and Cambridge, UK. pp. 203

Hawthorne W. D. and Abu-Juam A. M. (1995). Forest protection in Ghana. IUCN/ODA, Cambridge, U.K.

Horne, P. (1996). Deforestation as Environmental-Economic Problem in the Philippines *in* Palo, M., Mery, G. (eds.), *Sustainable Forestry Challenges for Developing Countries*, pp. 157-173. Kluwer Academic Publishers, Dordrecht, the Netherlands.

Hu, C., Montgomery, E.T., Schmitt, R.W. and Muller-Karger, F.E. (2004). The dispersal of the Amazon and Orinoco River water in the tropical Atlantic and Caribbean Sea: Observation from space and S-PALACE floats. Deep Sea Research II. In *Topical Studies in Oceanography* 51(10-11):1151-1171.

IUCN (1992) Protected Areas of the World: A review of national systems. Volume 3: Afrotropical. Prepared by the UNEP World Conservation Monitoring Centre (UNEP-WCMC). IUCN, Gland, Switzerland and Cambridge, UK.

ITTO (2006): Status of tropical forest management 2005. ITTO Technical Series 24. International Tropical Timber Organization, Yokohama, Japan. pp. 302.

Kareiva, P., Watts, S., McDonald, R. and Boucher, T. (2007). Domesticated nature: shaping landscapes and ecosystems for human welfare. Science, 316, 1866–1869.

Kotey, N.A., Francois, J., Owusu, J.G.K., Yeboah, R., Amanor, K.S. and Antwi, L. (1998). *Falling into place. Ghana country study*.Policy that works for forests and people. Series no. 4. Study coordinated by the IIED, United Kingdom, in collaboration with MLF, Ghana.

Kozlowski, T.T. (2000). Responses of Woody Plants to Human-induced Environmental Stresses: issues, problems and strategies for alleviating stress. *Critical Review in Plant Sciences*, 19(2): 91-170.

Marfo, E. (2010). Chainsaw milling in Ghana: context, drivers and impacts. Tropenbos International, Wageningen, the Netherlands. pp. 64.

Myers, N. (1992). Tropical Forests: the policy challenge. *The Environmentalist*, 12(1): 15-27.

M E S, (2002). National Biodiversity Strategy for Ghana. Unpublished.

Ohene-Djan, G. (2004) Conflicts in forest management and land use: Assessment on land reform policies on forest establishments towards sustainable land use development in Ghana-case study: Desire Forest Reserves. M A Thesis, Bandies University.

Palo, M., and Yirdaw, E. (1996). Deforestation and Sustainable Forestry Challenge in Ghana *in* Palo, M., Mery, G. (eds.), *Sustainable Forestry Challenges for Developing Countries*. Kluwer Academic Publishers, Dordrecht, the Netherlands, pp. 343-357.

Putz, F.E., Pinard, M.A., Fredericksen, T.S. and Pena-Claros, M. (1996) Forest Science and the Bolfor Experience: Lessons Learned About Natural Forest Management in Bolivia. (Mimeo).rainforest. Forest vegetation in Ghana.Junk publications, The Hague 383pp.

Riswan S., and Hartanti, L. (1995). Human Impacts on Tropical Forests Dynamics. *Vegetatio,* 121: 41-52.

Roy, P.S., Dutti, C.B.S., and Joshi, P.K. (2002). Tropical Forests Resource Assessment and Monitoring.*Tropical Ecology*, 43 (1):21-37.

Sandler, T. (1993). Tropical deforestation: markets and markets failures. *Land Economics,* 69 (3): 225-33.

Siry, J.P., Cubbage, F.W., and Ahmed, M.R. (2005). Sustainable Forest Management: global trends and opportunities. *Forest policy and Economics*, 7: 551-561.

Teye, J. K. (2005) Deforestation in Ghana *in* Potthoff, K. (ed.) *Human Landscape Ecology (MNFEL 330/ RFEL 303). Selected Term Papers 2003/*

*2004.*ActaGeographica-Trondheim, Serie A, Nr. 10.Department of Geography, NTNU, Trondheim. ISSN 1502-2390, pp. 9-21.

Turner B. L., Clark W. C., Kates R. W., Richards J. F., Matthews J. T. and Meyers W. B. (1990). The earth as transformed by human action. Cambridge University Press, Cambridge.

Webi, P.S. (2005). Woodfuel Use its Socio-economic and Ecological Effects: a comparative study of Embu and Marsabit districts in Kenya *in* Potthoff, K. (ed.) *Human Landscape Ecology (MNFEL 330/ RFEL 303). Selected Term Papers 2003/2004.* ActaGeographica-Trondheim, Serie A, Nr. 10. Department of Geography, NTNU, Trondheim. ISSN 1502-2390, pp. 33-47.

Wilson D. E. (1992). The diversity of life. Belknap, Cambridge, Massachusetts.

Woldeamanuel, S.G. (2005). Deforestation in Ethiopia: causes and consequences *in* Potthoff, K. (ed.). *Human Landscape Ecology (MNFEL 330/ RFEL 303). Selected Term Papers 2003/ 2004.*ActaGeographica-Trondheim, Serie A, Nr. 10. Department of Geography, NTNU, Trondheim, ISSN 1502-2390, pp. 9-21.

World Bank. (2003). Governance of Natural Resources in the Philippines: Lessons from the Past, Directions for the Future (internal review draft).

Yiridoe, E., Nanang, D.M. (2001). An Econometric Analysis of the Causes of Tropical Deforestation: Ghana. *Selected Paper Presented at the American Agricultural Economics Association Conference*, August 5-8, 2001, Chicago, IL

Yirdaw, E. (1996). Deforestation and Forest Plantations in Ethiopia *in* Palo, M., Mery,G. (eds.), *Sustainable Forestry Challenges for Developing Countries*. Kluwer Academic Publishers, Dordrecht, the Netherlands, pp. 327-357.

Appendix 1: Details of Diversity Indices

	Disturbed Area	Lower	Upper	Undisturbed Area	Lower	Upper
Taxa	47	46	47	37	45	47
Individuals	502	502	502	321	321	321
Shannon index	3.802	3.696	3.768	3.53	3.656	3.752

Appendix II: Farms and their areas

Farm No.	Area(Ha)	Farm No.	Area(Ha)
1	3	23	2.5
2	2.5	24	3
3	2	25	3.2
4	3	26	2
5	1.6	27	1.6
6	4	28	2.5
7	2	29	4
8	3	30	3
9	1.5	31	2.2
10	4	32	1.8
11	3	33	2
12	2.5	34	2.4
13	1	35	1.5
14	3	36	2.8
15	2	37	4
16	1	38	2.8
17	3	39	3
18	6	40	4
19	5	41	2
20	2	42	3.5
21	5		
22	3.2	Total	117.1