DIVERSITY AND ETHNOBOTANICAL USES OF PLANTS IN PROPOSED APRA HILLS FOREST RESERVE IN SOUTHERN GHANA

BY

ADEOYE ADENIYI

(10435562)

THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF M.PHIL BOTANY DEGREE

DEPARTMENT OF BOTANY,

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JULY, 2015

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DECLARATION

I, the undersigned, Adeoye Adeniyi, author of this thesis hereby declare that the work presented in this thesis "DIVERSITY AND ETHNOBOTANICAL USES OF PLANTS IN PROPOSED APRA HILLS FOREST RESERVE IN SOUTHERN GHANA" was done entirely by me under the supervision of Prof. Alex Asase of the Department of Botany, University of Ghana, Legon, from August 2014 to July 2015. This work has never been presented either in part or in whole, for any degree of this University or elsewhere.

SIGN.....

DATE.....

ADEOYE ADENIYI (STUDENT)

SIGN.....

DATE.....

PROF. ALEX ASASE (SUPERVISOR)

DEDICATION

This work is first and foremost dedicated to Almighty God. Secondly to my parents, Alhaji M.A Adeoye and Alhaja Taibat Adeoye.

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I owe my supervisor, Prof. Alex Asase from the Department of Botany, University of Ghana, gratitude for his guidance which led to the successful completion of this research work. I am also indebted to Prof. Gabriel Ameka, Head of Botany Department, University of Legon, Ghana, Mr. Wilson Owusu Asare, Mr. Boafo Ofei, Mr. Kwame Afeez (Forest Guard) of Forestry Commission Winneba District and Chief's of Akrampa, Apra and Loye who hosted me throughout my visit to the study area.

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Finally, I am grateful to everyone whose prayers and support saw me through. I appreciate you and God bless you all.

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ACRONYMS

CBD - Convention of Biological Diversity

DBH - Diameter at breast height

DID - Dermatological infections/diseases

FIVI - Family Importance Value Index

GH - General health

GIA - Gastro-intestinal ailment

GUA - Genio-urinary ailments

HEM - Hemorrhoids

ICF - Informant Consensus Factor

IPD - Infectious and parasitic diseases

IUCN - International Union for Conservation of Nature

IVI - Species Importance Value Index

MCT - Musculoskeletal and connective tissue

REDD - Reducing Emission for Deforestation and Forest Degradation

RSD - Respiratory system disease

SMSD - Skeleton-muscular system disorder

UV - Use Value

ABSTRACT

The Southern Margin forest type in Ghana now occur in small forest fragments due to the overharvesting of plant resources for purpose of food, medicine, construction and fuelwood. The proposed Apra Hills Forest Reserve is one of the remaining forest fragments of this forest type in southern Ghana although there are no previous in depth studies to support effective forest management of its plant resources. In order to achieve the objectives of this study, plant diversity study and ethnobotanical study was carried out. Nine plots of 25 m x 25 m was established in four vegetation types (Open canopy forest, closed canopy forest, seasonal flooded forest and thicket forest) within the study area. A total of 296 individual plants belonging to 127 taxa were identified. Of the 127 taxa, 114 were identified to species level belonging to 45 families, 10 were identified to genus level, 4 were identified to the family level and 9 taxa were undetermined. Nine of the 114 species identified have been assigned IUCN conservation rating. These species included *Afzelia africana*, *Alafia* sp., *Albizia ferruginea*, *Nesogordonia papaverifera* rated as vulnerable and *Hunteria ghanensis* was rated as an endangered species. Inventory completeness ratio was 0.6 (SE ± 0.05) and mean Shannon-Weiner diversity index was 2.0 (SE ± 0.09) for trees, the family sterculiaceae had the highest FIVI value and *Hildergardia barteri* had the highest IVI value. The DBH distribution pattern of trees showed an inverted J shape. A semi-structured questionnaire was used to interview 74 informants living in three communities around the proposed Apra Hills Forest Reserve to investigate the ethnobotanical use. Results obtained from the ethnobotanical study showed that 35 plant species were reported being used by informants. Nine species, namely were recorded both in the plant diversity and ethnobotanical studies, whereas the following 12 species namely, *Afraegle paniculata*, *Jatropha gossipifolia*, *Mangifera indica*, *Milicia excelsa*, *Paulina pinnata*, *Senna siamea*, *Sida acuta* Burm, *Solanum torvum*, *Spondias mombin*, *Strophantus hispidus*, *Swietenia macrophylla* and *Zanthoxylum xantholoides* were not observed in the plant diversity study but were mentioned by the informants during the

interview. In terms of use-values (UV) for the 35 species, *Swietenia macrophylla* had the highest value of 2.0 whereas *Momordica charantia* had the least value of 0.1. In terms of use categories medicine had the highest ICF value of 39.2 and 19.8. Leaves of plants had the highest use reports and fruits had the least use reports. About 65 % of the indigenes collect plants from proposed Apra Hills Forest Reserve on a weekly basis which account for the depletion of species in the area. Bushfire was mostly cited that threaten plant diversity by the informants. Correlation coefficient was positive and statistically significant ($p < 0.05$ for all analysis) between number of useful plants and medicinal plants, against species richness and species abundance whereas the relationships between the number of useful plants and vegetation types were insignificant ($p > 0.05$ for all analysis). Further studies in the proposed reserve should investigate carbon stocks as well as soil characteristics.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

In West Africa, biological diversity is an integral part of the rural economy, providing sources of materials for food, construction, medicine, energy and goods such as mats, baskets, furniture and dyes for many communities (Falconer, 1992; Banahene, 1997). In spite of the important roles biological diversity plays in the life of mankind, anthropogenic activities such as logging, bush burning, farming and mining has contributed significantly to loss of biodiversity (Veblen and Lorenz, 1987; Terborgh, 1992). Losses of biodiversity has various impacts including climate change, loss of ecosystem services, floods and disease introduction on human population (Ahmed, 2008).

About 70 % of the world's plants are used for construction, furniture and medicine (FAO, 2001). The high use of plant resources for several purposes has led to the depletion of forest biodiversity. For example, due to the domestic and industrial demand for plants, there has been increased in logging activities both in Ghana and West Africa (ITTO and IUCN, 2005). Logging action, overharvesting and exportation of biodiversity has caused deforestation and forest degradation in Ghana (Benhin and Barbier, 2004).

Ghana has one of the highest rates of deforestation in West Africa (Damnya *et al.*, 2011). The rate of deforestation is estimated to be 2.19 % per annum between 2005 and 2010 for Ghana (FAO, 2010). About 70 % of deforestation in Ghana is cause by farming activities (Ahmed, 2008). Empirical studies on the cost of deforestation in monetary terms are few despite the fact that in the period of 1990– 2005, 1.9 million ha of Ghana's forest cover was lost (Damnya *et al.*, 2011).

Over the years, the Government of Ghana has been concerned about the extent of deforestation and forest degradation in the country. For this reason, efforts are being made to combat deforestation through sustainable management and rehabilitation measures, including tree planting on degraded forestlands (FAO, 2012).

1.2 Problem Statement

Deforestation and forest degradation is a major environmental problem worldwide. The rate of forest cover loss is estimated to be 16 million hectares in 1990, 5.2 million hectares per year from 2000 to 2010 (FAO, 2010). Consequences of deforestation and forest degradation are biodiversity loss and socio-economic implications. The forests of Ghana contribute significantly both to rural and urban life, providing fodder, building materials, herbal medicines, and household items, as well as intangible benefits, such as cultural symbols, ritual artifacts and sacred sites (Appiah, 2003) but these forests continue to be degraded at a very alarming rate.

The Ghana Forest and Wildlife Policy (2012) aims to manage and enhance the ecological integrity of all forest types in Ghana. The forest vegetation types in Ghana include Wet Evergreen; Moist Evergreen; Moist Semi-Deciduous; Dry Semi-Deciduous; Southern marginal, South-east outlier; and Upland Evergreen (Hall and Swaine, 1981). In recent years there has been an urgent need to rehabilitate deforested areas in Ghana as well as to restore the original forest using native tree species (Ministry of Lands and Forestry, 1994). The Southern Margin forest is one of the most degraded forest types in Ghana.

1.3 Justification of the study

The Southern Marginal forest is found in the south east of the country in areas with rainfall between 1000-1250 mm. Most of the characteristic species are herbaceous, rather than woody and less than 5 % of the species is deciduous. The forest canopy rarely exceeds 30 m whilst the undergrowth is thick and characteristically has high densities of gregarious species. The Southern Margin forest type in Ghana occurs mostly as small forest fragments largely in reserves and sacred groves (Hall and Swaine,1981). These forest fragments are usually close to most coastal towns and may have suffered from continuous anthropogenic pressure for farmlands and collection of plants fuel wood and other uses for centuries.

There are very few forest reserves within Southern Margin forest type in Ghana. The proposed Apra Hills Forest Reserve is one of best remaining forest patches of this forest type in Ghana. The proposed reserved is being managed by traditional authorities. However, to the best of our knowledge there are no previous studies on the biodiversity in the reserve in order to support effective management of its forest resources. This study is about the plant diversity in the proposed Apra Hills Forest Reserve.

1.4 Research Objectives

The overall goal of this study was to investigate diversity and ethnobotanical uses of plants in proposed Apra Hills Forest Reserve towards sustainable management of its forest resources.

Specifically, the objectives of the study are to:

1. Determine floristic diversity and species composition in the proposed forest reserve.
2. Document traditional uses of plants by the communities living around the proposed reserve and,
4. explore relationships between plant diversity and ethnobotanical use.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Biodiversity

"Biological diversity" means 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 part; this includes diversity within species, between species and of ecosystems (CBD, 2006).Biological diversity is subdivided into three levels, namely, genetic diversity, species diversity, and ecological diversity. Genetic diversity refers to the variation in genetic information between species as well as variation between individuals of same species (Veblen and Lorenz, 1987). Genetic diversity determines the extent to which a given population adapt to environmental changes and diseases (Addo-Danso, 2010).Genes play a very important part in the resilience of biodiversity to world changes, such as climate change (Assefa *et al*., 2007). Genetic diversity is the "raw material" that allow species to adapt to a changing world whether these changes are caused naturally or by human (Maclaurin and Sterelny, 2008).

Species diversity is a measure of the number of species in a community (species richness) and the evenness of species abundance. Therefore, a community with abundant species are considered to be more diverse and undisturbed than a community with lesser species and can be concluded to be less diverse or disturbed (Maclaurin and Sterelny, 2008).Ecosystem diversity is a measure of various ecosystem types, diversity of habitats and ecosystem functions within all of them (Addo-Danso, 2010). Ecosystem diversity refers to the conditions and processes which natural ecosystems and the species that make them up, sustain and fulfill human life (Laing, 2002).

2.2 Forest Biodiversity in Ghana

The total land area of Ghana is estimated to be 23.9 million hectares of which 15.7 million hectares lie within the Savannah zone while the remaining 8.2 million hectares lie within the Tropical Rain Forest Zones. Only 2 million hectares of the original 8.22 million hectares remain (Laing, 2002). A total of 2,974 indigenous plant species, 504 fishes, 728 birds, 225 mammals, 221 species of amphibians and reptiles have been recorded in Ghana. Three species of frogs, lizard, and 23 species of butterflies have been reported to be endemic. (NBSAP, 2002). Both indigenous and introduced species have been considered in the assessments of the Ghana's biodiversity. Presently, export of forest-based products is ranked fourth in terms of sources of foreign exchange earnings for Ghana (FAO, 2007).

Forest plant biodiversity in Ghana is distributed across vegetation types, namely, Wet Evergreen; Moist Evergreen; Moist Semi-Deciduous; Dry Semi-Deciduous; Southern marginal, South-east outlier; and Upland Evergreen. The Wet evergreen forest have the highest annual rainfall and leached soil, followed by the Moist evergreen forest which has annual rainfall of 1500 - 1700 mm (Hall and Swaine, 1986). The Moist Semi-deciduous has the richest soil, annual rainfall of 1200 - 1800 mm and rich in timber supply of commercial species such as *Entandrophragma utile* Sprague., *Khaya ivorensis* A. Chev. and *Triplochiton scleroxylon* K. Schum. with height greater than 50 m. The Dry Semi-deciduous is found on the northern side of the Wet Semi-deciduous forest with annual rainfall of 1500 mm. Southern marginal, South-east outlier, and Upland Evergreen occur in patches with trees exceeding 60 m in height (Hall and Swaine, 1986).

2.3 Deforestation

Deforestation is the clearing or conversion of forest for other land use or the long-term reduction of tree canopy cover below the 10 % threshold (FAO, 2001). Deforestation can result from deliberate removal of forest cover for agriculture or urban development, or it can be an unintentional consequence of uncontrolled grazing (which can prevent the natural regeneration of young trees. Deforestation may cause many negative effects such as global warming, biodiversity loss which form basis of traditional and cultural knowledge and soil degradation are often identified (Mahapatra and Kant, 2003). In terms of global warming, about 20 % of increased emission of greenhouse gases (GHGs) are responsible for global warming and climate change (Owusu *et al*., 2011). There is a relationship between deforestation and global warming because forests are major carbon sinks (Gorte and Sheikh, 2010). Therefore, deforestation leads to the collapse of carbon sinks and increase of more carbon dioxide in the atmosphere which is a serious threat to global climate.

Seventy percent of the world's plants are found in forest and this species can be endangered or become rare by deforestation (Knox and Marston, 1998). This loss does not only affect biodiversity but also has negative effect on medicinal research and local people who rely on plants in the forests for food, medicine and fuelwood(Chomitz, 1999).

Clearing of forestlands leads to soil erosion and makes the land infertile. Runoff from deforested hillsides increased the amount of silt and impeded the flow of water into agricultural areas. Eventually, due to the increased depletion of soil nutrients this has led to low agricultural yields.

There are strategies to reduce deforestation and forest degradation in Ghana. These include Reducing Emissions from Deforestation and Forest Degradation (REDD) programme, Practice of sustainable forest management, use of policies and laws, Indigenous knowledge systems and use of protected areas(ITTO, 2004). REDD is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. "REDD+" goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. Reducing Emissions from Deforestation and Forest REDD is a mechanism that has been under negotiation by the United Nations Framework Convention on Climate Change (UNFCCC) since 2005, with the objective of mitigating climate change through reducing net emissions of greenhouse gases through enhanced forest management in developing countries. This mechanism uses incentives to encourage developing countries to reduce deforestation and forest degradation (Chomitz *et al*., 2007).

Sustainable forest management is the use of forests and forest lands in a way that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems (FAO, 2012).

Policies and laws can be effective in controlling deforestation and forest degradation. This approach should not be severe in order to encouraged local people and institutional participation in forest management and conservation as well as to protect the local people’s rights and ensure equal sharing of benefits. These approaches include negotiation, warnings, cancelling work orders, charges and arrests (Chomitz *et al*., 2007).

Indigenous knowledge systems refer to a knowledge and benefits built by a group of local people and handed over to generations (Breemer, 1995). Examples of this indigenous knowledge systems are cultural beliefs, taboos, totems, indigenous agricultural practices and these were used to conserve and manage natural resources. This indigenous knowledge will help reduce the depletion and encourage sustainable management of plant resources which is important for the present and future generations.

Protected areas safeguards biological and cultural diversity, it helps to improve the livelihood of many local communities, provide homelands for indigenous people and brings countless benefit to the society in general. International Union for Conservation of Nature (IUCN) defined a protected area as a geographical area, recognized and managed to conserve nature and its resources (Dudley, 2008). Protected areas can be used as a strategy to manage and conserve plants (Myers, 1994; Myers and Mittermeier, 2000; Nepstad *et al*., 2006).Creating protected areas where human activity is limited is the best way to prevent deforestation and exploitation of plant resources (Heywood, 1995).

2.4 Land use change

The pressure on land-use pose the greatest impact on biodiversity in tropical forests (Sala *et al*., 2000).Forests in Ghana have suffered a serious decline because of over-exploitation to meet the growing needs of the population (EPA, 2004).Land use is the frequent activity practiced on land by humans for purposes such as farming practices of food with the use of fire, shifting cultivation, mono cropping, land rotation and fallow etc (De Bie, 2000). This activities put pressure on forest biodiversity. Also, the increasing human population needs to which the forest is exposed in most tropical countries occur also in Ghana and serious problems have arisen (Hawthorne and Jongkind, 2006).

2.5 Major causes of deforestation and forest degradation in Ghana

2.5.1 Agriculture

Agriculture is a major cause of deforestation and forest degradation in Ghana(FAO, 2007). Over 60 % of Ghana's population use the forest land for large scale farming (Addo-Danso, 2010). There have been increased farming activities and shifting cultivation in different forest communities due to increase in population size. The purpose of agriculture expansion is to meet up with cash crop demands for both domestic consumption, local supply and exportation. There has been pressure on forestlands since agriculture has become incorporated into the global economy. These farming activities are usually established within the forest leading to drastic increase of deforestation and threat to the sustainability of biodiversity (Adu *et al.*, 2012).

2.5.2 Logging and timber extraction

About 94 % of the forest in Ghana are disturbed due to unsustainable logging (De Laat, 2010). Unsustainable logging is one of the main reasons for forest management in Ghana (Addo-Danso, 2010). The scale of illegal exports of timber became clear to the Ghanaian authorities in 1987, when several shiploads of illegally harvested wood were halted and fraud involving export documents were revealed (Glastra, 1999; Koen *et al.*, 2010). Commercial logging and timber extraction is majorly carried out to supply international companies (Addo-Danso, 2010). In most cases, this forest lands are bought or rented in order to harvest timber for medicinal or construction purpose. According to Laporte *et al*., (2007) commercial logging has become the most extensive land use in West Africa and about 30 % of forest are currently disturbed. It is expected that commercial logging will expand further due to their demands for them by local and international industries.

2.5.3 Bush burning

The effect of bush burning on Ghana's forest has been estimated to be about US$24 million annually (Archibald *et al*, 2010). Charcoal production and farming are major cause of bushfires, threatening the sustainability of forests (Addo-Danso, 2010).Accidental causes of wildfires involved cooking in the farms, palm wine tapping, charcoal burning, honey extraction and cigarette smoking (Kusimi and Appati, 2012).

2.5.4 Fuelwood collection and charcoal production

Fuelwood provides the main energy source for both rural and urban households throughout the entire Ghana. Fuelwood collection and charcoal production are in most cases the major products of the forests in Ghana. The use and demand for these products keep increasing. Fuelwood and charcoal account for more than 75 % of all energy consumed in the country. It is estimated that about 91 % of total round wood produced is used for firewood and charcoal production (Addo-Danso, 2010). Wood extraction for domestic fuel wood or charcoal production remains a major issue in Africa, because most Africans still use wood and charcoal for cooking, since there are no other affordable energy sources available. Only 7.5 % of the rural population currently has access to electricity. Africa has shown a steady increase in wood removals in recent years, reporting a rise from 49,900 hectares annually (1990) to 66,100 hectares 2005 (Koen, 2010).

2.5.5 Mining

A variety of minerals are known to exist in Ghana. Among these are manganese, iron, tin, copper, lead and gold (UNEP, 1999). As these minerals remain in demand on an international scale, mining companies and groups of individuals will continue to search for new sites and in

due process deplete the forest in order to carry out extraction of these minerals. The extraction of minerals are the leading contributors to Ghana's foreign exchange earnings. In 2009, gold rose to 12 % with a production of 2.9 million ounces revenue of $2.8 billion to the economy. Despite the important role these minerals play in the Ghanaian economy, mining has had devastating effects on forests leading to several hectares of forest loss (Glastra, 1999).

2.8 Ethnobotany

"Ethnobotany is the study of the relationship between plants and people (Faruque and Uddin, 2014). The study of plants provides relevant and new information in development of medicines and new uses of plant parts for household purposes. Ethnobotany plays a crucial role in the study of traditional medicine (Pei, 2005). Plants are essential for human beings as they provide food, fuel, fodder, timber, fruit and medicines (Amjad and Arshad, 2014).Indigenous knowledge of traditional uses of plants as well as medicinal uses of plants for healing human ailments is, however, in danger of gradually becoming extinct, because this knowledge is passed on orally from generation to generation without the aid of a writing system and because many traditional healers do not keep written records (Kaido *et al*., 1997).

Ethnobotanical study not only prevents misapprehension and misrepresentation of observed facts, but is positively necessary in many instances to the correct diagnosis and explanation of ethnological facts, of the symbolism of objects used, and the significance of allusions in the text embodied in ceremonial ritual (Poole, 1995).Majority of wild plants can only be conserved in their natural ecosystems (Martin, 1994). Therefore, the use of foods, medicines, and plant materials from the forests can be managed sustainably if forests are properly managed (Wightman, 1992). However, deforestation by humans are rapidly destroying the forest ecosystem causing extinction of species as well (Cunningham, 1993). Ethnobotanical studies

conducted in different local communities have recorded that many forest communities are aware of the usefulness of species occurring in the forest around them (Kotak, 1991). This indigenous knowledge has been gained by trial and error over long periods of time, and in most cases has been passed across generations through oral transmission (Philips, 1993a). Indigenous knowledge is an extremely valuable cultural resource, because so many useful plants and other organisms are known to local people (Poole, 1995). Unfortunately, this local, traditional knowledge is often rapidly lost once indigenous people become integrated into modern, materialistic society. It is important that local indigenous peoples be given the opportunity to conserve their own culture (Martin, 1995). So therefore, ethnobotanical study has been adopted over the years and used to document the traditional uses of plants among different cultures with the use of questionnaires and interviews (Cunningham, 2001). Data collection can be carried out by field interview, household to household interview, focal group discussion or individual interview. Questionnaires is used in the collection of data from informants in written form whereas Interviews are based on what the informant says orally. The use of questionnaires can be either structured and semi-structured whereas the interview could be a focal group discussion or individual based (Martin, 1995).

2.8.1 Field interview

Field based interviews are open ended. They are conducted person to person. They are deliberately designed to produce specific kinds of information, information that portrays the richness of individual experience on uses of plants. (Martin, 1995).

2.8.2 Household to household interview

Household to household interview is one of the most reliable type of surveys for collection of data in ethnobotanical study (Lewis, 1994). The interview is conducted with each family

member of a household or a particular member and is designed in order to collect confidential information on the traditional uses of plants (Philip, 1993a). As knowledge of the uses of plants vary among households and among members of such household (Kotak, 1991).

2.8.3 Focal group interview

Focal group discussion is an open interview among certain members of the community, certain age group with common knowledge about the traditional uses of plants (Cunningham, 2001). This interview is usually allows informants to give information based on self-expression. This type of survey is usually used to document the knowledge of certain cultural groups of particular age or how certain ethnic group understand the use plants in their environment (Tesfaye, 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study area at proposed Apra Hills Forest Reserve is located at Akrampa, a village in the West Effutu Awutu Senya District of the Central Region of Ghana. It lies between latitude 5^{o} 35' N, and 5^{o} 30' and longitude 0^{o} 30' and covers a total land area of 336 hectares. The area is made up of two adjacent West and Eastern Apra Hills surrounded by towns and villages including Apra, Loye, Bududuram, Kwaw Larbi and Ahentia (Fig 1.1).

3.1.1 Vegetation

The study area is made up of approximately three-fourth of coastal semi-deciduous forest and intensively farmed savanna grassland (Fig. 2). These vegetation types run along the twin-hills and covered larger parts of the low lands. Plant species commonly found in the area included *Ceiba pentandra* (L.) Gaertn, *Diospyros sanzaminika* (Hiern) F. White and *Blighia sapida* K.D. Koenig. are frequent in the area whereas *Triplochiton scleroxylon* K.Schum and *Antiaris africana* (Pers.) Lesch. are less frequent but occur occasional (Forestry Section Report, 1989).

Species such as *Ceiba pentandra*(L.) Gaertn, *Mansonia altissima* A.Chev., *Triplochiton scleroxylon* K.Schum, *Nesogordonia papaverifera* (A.Chev.) Capuron ex N.Hallé and *Celtis mildbraedii* Engl. dominate the upper storey whereas *Ficus sagitilfolia* Mildbr. & Burret *Trichilia prieureana* A. Juss., *Albizia* and *Hymenostegia afezelii* (Oliv.) Harms formed majority of plants in the middle storey. The lower storey contains the regeneration of some of the species in the upper stories and is mixed up with thorny thickets of *Baphia nitida* Lodd. and *Uvaria globusa* Hook.f.(Forestry Section Report, 1989).

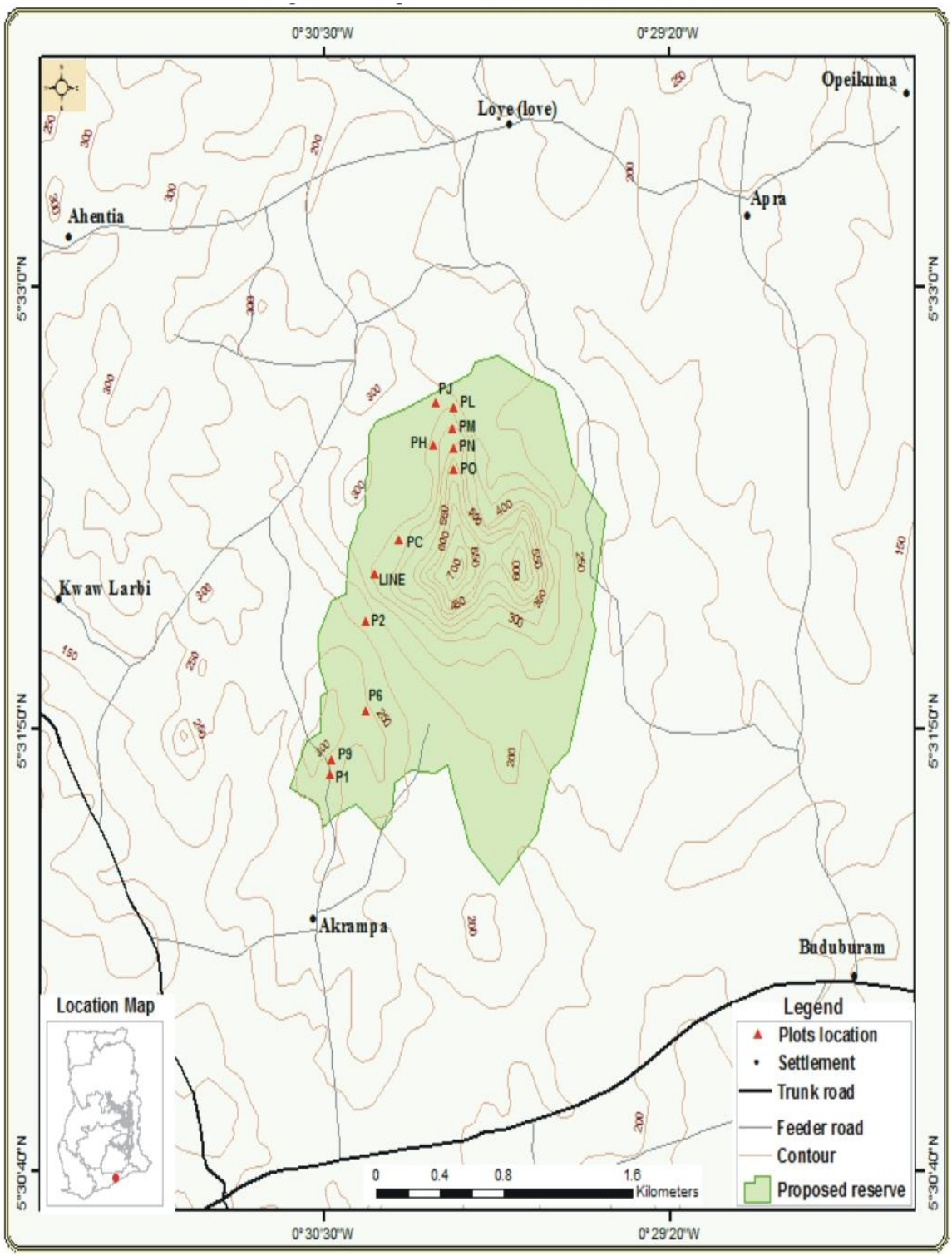


Fig. 1.1: Topography and contour map of the study area.

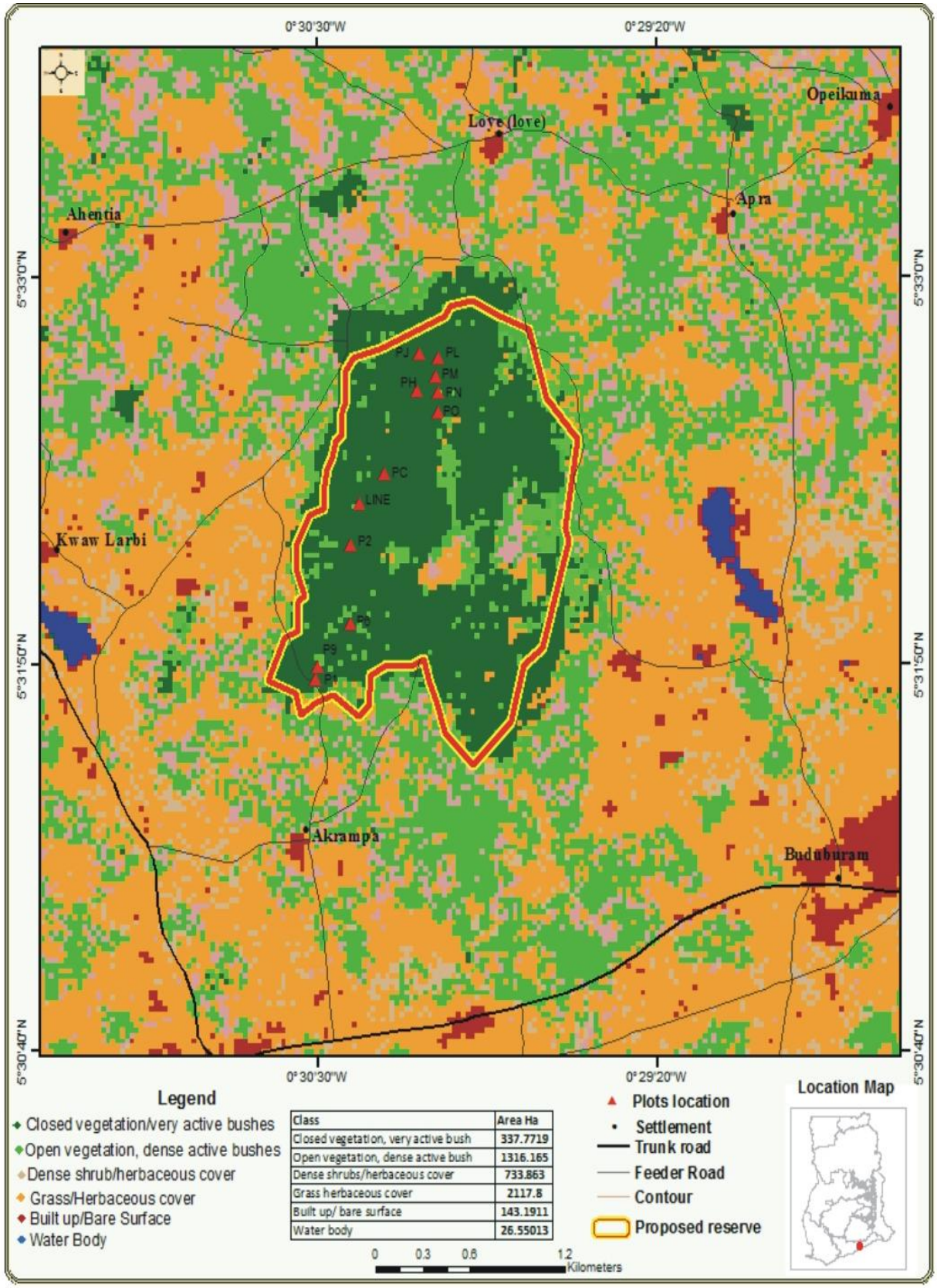


Fig. 1.2:Satellite image of the study area

3.1.2 Land uses

Shifting cultivation is practised in this area and most indigenes are predominantly subsistent farmers who cultivate crops such as orange, maize, pepper, garden egg, cassava, yam, pineapple. Minority of the indigenes in this area are petty traders and carpenters. These indigenes depend on plant resources such as leaves, fruits, roots, bark, woods from the proposed forest reserve for their sources of food, building, fuelwood, charcoal, medicine and construction etc. Charcoal burning activities and firewood collection for domestic purposes in the area threatens the conservation of plant resources in the proposed forest reserve (Forestry Section Report, 1989).

3.1.3 History

The proposed Apra Hills Forest Reserve is a sacred grove owned and managed by the Awutu Traditional Council in Central Region of Ghana (Fig. 1.3). It is a taboo to farm, fall trees, visit or collect plant parts from the grove on Mondays. This law was used to manage and conserve plant resources in the grove. However, logging activities by unknown indigenes was noticed to be rampant throughout the area. In order to cut down logging activity, the Awutu Breku State Council made intruders buy a cow and one carton of schnapps. Despite this measure, the extent of threat to plant resources within the grove increased tremendously. In order to manage the grove sustainably, the Awutu State Council consulted the Forestry Department in 1959.

The process of making the area a forest reserve was suspended in 1961 with no particular reason. According to some beliefs, the suspension was due to the fact that Apra Hills is a fetish grove and its existence as a forest reserve can be hindered by taboos (Forestry Section Report, 1989).

3.1.4 Geology, soil and topography

In the study area, there are small pieces of flat rocks found on the ground having a parent rock known as granite. The proposed forest reserve has a yellow-brown uppermost layer of what? which is made up of a coarse sandy loam soil. The second and third layers are made of up of a hard red-brown soil and an iron stone layer respectively. The valley and grounds in the area have a 2:1 ratio of heavy black clayey soils, which isomer than 4 feet deep. The heavy black clayey soil or montmorillionite is found in the north-eastern area of the reserve and are mostly waterlogged throughout the year. The Western and Eastern Apra Hills are 800 feet and 600 feet above sea level, respectively(Forestry Section Report, 1989).

3.1.5 Ethnography

The inhabitants of Akrampa, Kemor, Loye, Apra and Opeman are majorly farmers and are located outside Northern area of the proposed forest reserve. The Apra and Kemor villages were inhabited by the indigenous Awutu people whereas Opeman and Ahienta were inhabited by the Ewes(Forestry Section Report, 1989).

Most of the people in Akrampa worship the Adoko, Wianda and Amaga. Adoko is a god believed to provide barren women with children and Wianda is a god that protects the farmers and hunters of the area. At the entrance of the Akrampa village is a god called the Amaga that is believed to protect the village and its inhabitants.. According to the people it was brought from the East and is a god that protect the entire village and its inhabitants(Ben, 2013).

Fig. 1.3: A paranomic view of proposed Apra Hills Forest Reserve.

3.2 Methods

3.2.1Field reconnaissance survey

Sampling in the area began with a field reconnaissance survey to gather relevant information on the local history, taboos, land tenure and ownership systems, boundaries and the uses of the natural resources in the area. The land use types were identified by visual observations and LANDSAT imageries.

3.2.2 Plant inventory

Plant inventory was carried out along a transect (Fig. 1.4). For purposes of convenience, transect was a footpath used by the local people in the area and started from the lowland through to the top of one of the Hills. Four broad vegetation / habitat types were identified along transect. Sample plots of size 25 m x 25 m were demarcated in the different habitat types. The choice of the 25 m x 25 m sized sample plots follows the work of Hall and Swaine (1976). Sampling was stratified based on the size of habitat types. In total 9 sample plots were established (2 plots in Open canopy forest; 5 plots in Closed canopy forest, 1 plot in seasonal flooded forest; and 1 plot a thicket forest). Plots were established using a compass, measuring tape and pegs. Geographical position of each plot was determined using a handheld Global Position System [(GPS) Garmin 62S]. Data were recorded in a field sheet (Appendix 1)

Within each plot, all species of plants including trees, shrubs, climber and herbs were identified. In most of the cases, plant identification was achieved in the field with the assistance of an experienced parataxonomist (Mr. Patrick Ekpe) from the Ghana Herbarium at the Department of Botany, University of Ghana. Voucher specimens were made of species difficult to identify in the field and those species were later identified by comparison with already identified specimens at the Ghana Herbarium to confirm the field plant identification.

The nomenclature of the species was checked using the International Plant Names Index (IPNI) (www.ipni.org).

In order to determine the abundance and distribution of trees within the study area, all trees found in the plot with diameter-at-Breast-Height (DBH) ≥ 10cm at 1.3 m above ground level were individually identified and their DBH measured using diameter tape. For trees with large buttress their DBH was taken above their buttresses following previous studies (Damnyag *et al.*, 2011; Asase *et al.* 2010). The data were recorded in a field data collection sheet (Appendix 2).

3.2.3 Ethnobotanical survey

This part of the study was carried out using semi-structured questionnaire interviewed (Martins, 1995) in three communities, namely, Akrampa, Apra and Loye living around the proposed reserve. A sample of the data questionnaire sheet is presented in Appendix 3. A total of 74 households were interviewed. Before data collections the objectives of the ethnobotanical study was explained to the chiefs and informants in order to obtain their prior-informed consent (Cunningham, 2001).A Forest Guard assisted in interpretation of questions and interviews were carried out on Mondays (taboo days)and weekends in order not to interfere with the indigenes daily activities.

A household-to-household interview approach was used to collect information (Fig. 1.4) because approach has been used to successfully collect ethnobotanical data in many communities (Asase *et al.*, 2005). Data collected were in four major areas; (1) bio-data on informants; (2)Use of Forest Resources (3) Wild Medicines from forest and (4) Conservation of plants. Voucher specimens were collected following standard ethnobotanical practice (Martin, 1995).

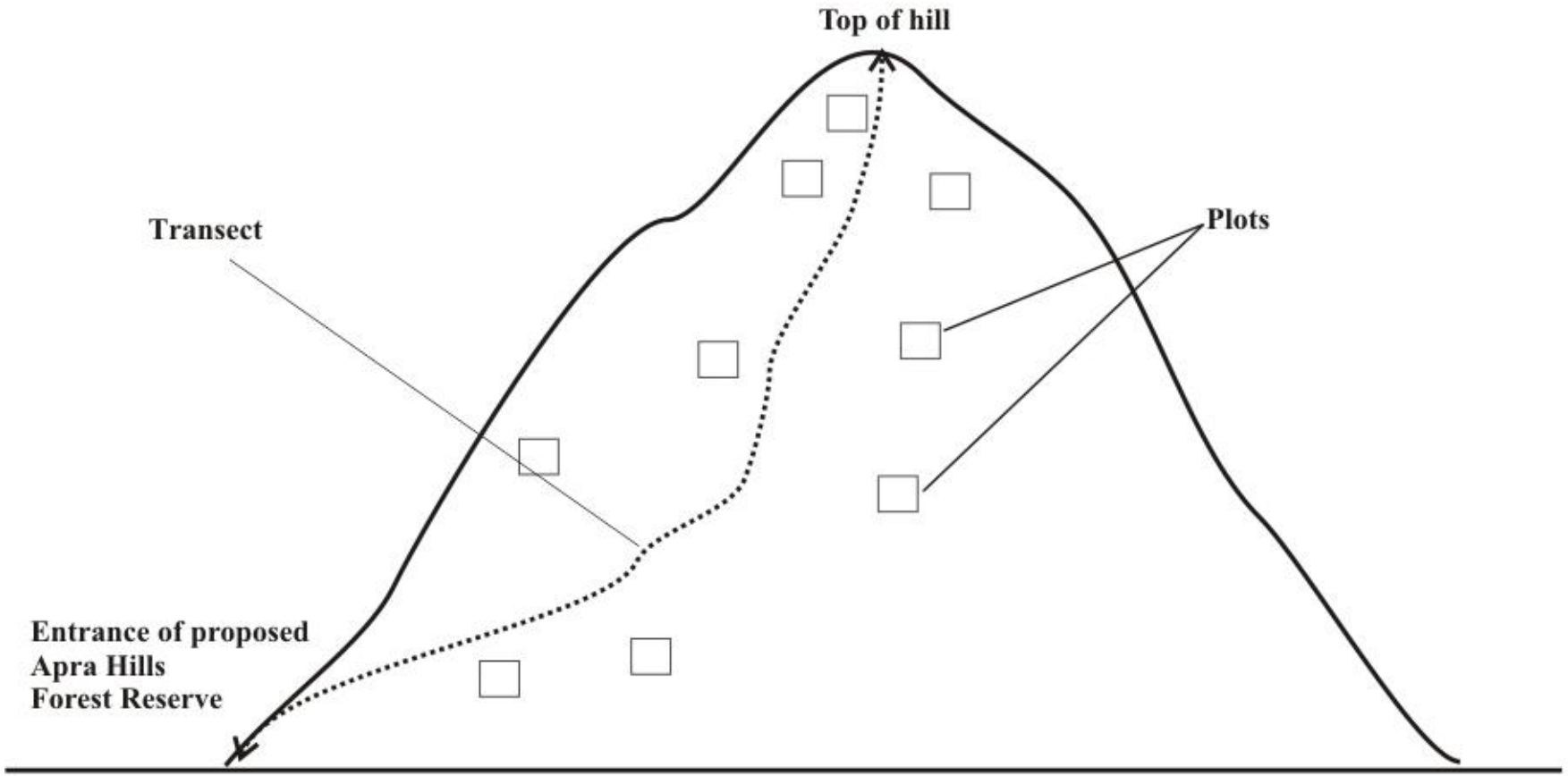


Fig. 1.4: An illustration to show line transect from bottom to top of proposed Apra Hills Forest Reserve

Fig. 1.5: Photograph taken during an interview with an informant

3.3. Data Analysis

3.3.1 Species accumulation curve and diversity index

The species accumulation curve shows increase in the species observed with sampling effort and is an excellent graphical way to summarize the completeness of sampling effort (Magurran, 2010). Data for plotting species accumulation curve was generated based on plot inventory using EstimateSWin 9.10 (Colwell, 2005) software programme. Species accumulation curve was plotted using Microsoft excel.

Shannon-Wiener index (*H'*).

$$H' = \sum_{i=1}^{s} pilnpi$$

where *s* is the total number of species and *p* is the relative abundance of the *i* species

3.3.2 Inventory completeness

Inventory completeness (*C*) is a useful index to indicate whether an area was well sampled or not. An inventory completeness (*C*) value closer to 1 indicate that a study area is well-sampled while a value farther from 1 indicate that a study area is under-sampled (Colwell & Coddington, 1994). Here, inventory completeness of the current study for the study area was estimated using the formula,

$$C = \frac{S_{obs}}{S_{exp}} ,$$

where, C represent Completeness ratio, S_{obs} is number of species observed, and S_{exp} represent number of species expected. The number of species expected was evaluated as follows:

$$Sexp = Sobs + \frac{a^2}{2b},$$

Where, a = singletons or number of species occurring once in the sampling, and

b = doubletons or number of species occurring more than once in the sampling (Colwell & Coddington, 1994).

3.3.3 Family Importance Value index (FIV)

Family Importance Value index (FIV)is useful for determining the overall importance of each taxonomic family in an area (Danquah, 2001).FIV was calculated as the sum of the family relative frequency, family relative density and family relative dominance (Brower, 1997).

3.3.4 Species Importance Value index (IVI)

Species Importance Value index (IVI) was calculated as a sum of the relative density, relative frequency and relative dominance for each species (Addo-Fordjour, 2010; Magurran, 1988).

Calculation of basal area of the different parameters of the index was achieved using the following formulae (Magurran, 1988).

$$\text{Basal area} = \frac{\pi d^2}{4}$$, where, d is the DBH of the tree.

$$\text{Density} = \frac{\text{Total number of individuals of the species in all plots}}{\text{Total number of plots sampled}}$$

$$\text{Relative density} = \frac{\text{Total number of individual of species}}{\text{Total number of individual of all the species}} \text{ x } 100$$

$$\text{Frequency} = \frac{\text{Number of plots in which species occurred}}{\text{Total Number of plots sampled}}$$

$$\text{Relative Frequency} = \frac{\text{Frequency of species}}{\text{Total frequency of all species}}$$

$$\text{Dominance} = \frac{\text{Basal area of species}}{\text{Area sampled}}$$

$$\text{Relative Dominance} = \frac{\text{Dominance of species}}{\text{Total dominance of all species}}$$

3.3.5 Use Value (*UV*)

The relative importance of each plant species known locally to be used for food, fuelwood, building, medicine or for making household items is reported as use value (*UV*) and it was calculated using the formula (Phillips *et al*., 1994).

$$UV = \frac{\sum U}{n}$$

Where *UV* is the use value of the species, *U* is the number of use-reports cited by each informant for a given plant species and *n* is the total number of informants interviewed for a given plant. ∑ represent total sum. The *UV* is helpful in determining the plants with the highest use (the most frequently indicated). *UV*s are high when there are many use-reports for a plant and low when there are few reports related to its use.

3.3.6 Informant Consensus Factor (F_{ic})

The informant consensus factor (F_{ic}) was used to determine if there was agreement in the use of plants in the various use-categories between the plant users in the study area. The F_{ic} was calculated using the following formula (Heinrich *et al*., 1998).

$$F_{ic} = \frac{N_{ur} - N_t}{N_{ur} - 1},$$

Where, N_{ur} refers to the number of use-reports for a particular use-category and N_t refers to the number of taxa or species used for a particular use-category by all informants.

3.3.7 Relationships between plant diversity and ethnobotanical use

The relationship between plant diversity and ethnobotanical use were examined for plots and vegetation types using correlation analysis. Correlation between species richness and abundance per plot and vegetation type, and number of overall species cited used and medicinal plant used were examined.

CHAPTER FOUR

4.0 RESULTS

4.1 General plant diversity

A total of 296 individual plants belonging to 127 taxa were identified. Of the 127 taxa, 114were identified to species level, 10 were identified to genus level, 4 were identified to the family level and 9 taxa were undetermined (Table 1). Nine of 114 species identified have been assigned IUCN conservation rating. These included tree species and liana, namely; *Afzelia africana* Sm., *Alafia* sp., *Albizia ferruginea* (Guill. & Perr.) Benth., *Nesogordonia papaverifera* (A.Chev.) Capuron ex N.Hallérated rated as vulnerable and *Albizia adianthifolia* W.F. Wight, *Baphia nitida* Lodd., *Millettia zechiana* Harms and *Triplochiton scleroxylon* K.Schum. rated as Least Concern. The only species with conservation concern was *Hunteria ghanensis* J.B.Hall & Leeuwenberg, which was rated as an endangered species.

The species accumulation curve (Fig. 2) did not flattened as a result of low sampling in the study area. This is an indication that more species are likely to be present in the area. The species observed ranged from 31.2 to 110.7, singletons ranged from 32.88 to 48.00, doubletons ranged from 0 to 14.00; and number of species expected ranged from 31.2 to 193 (Table 2). Inventory completeness ratio was 0.6 (SE ± 0.05). A high completeness ratio indicate that the area has been well-sampled or is a species-rich area, a lesser *C* value indicate that the area has been under-sampled done or is a species-poor area.

The growth forms of the plants encountered in terms of number of individuals and species are presented in Fig. 3. Trees had the highest number of 53 individuals and 49species followed by shrubs with 30 individuals and 28 species. Only two individuals and two epiphytic species were identified (Fig. 3).

A total number of 45families were identified in the inventory of which Fabaceae had the highest number of 16 individuals and 11 species. The following 20 families namely; Adiantaceae, Anacardiaceae, Asteraceae, Bombacaceae, Capparaceae, Caricaceae, Combretaceae, Commelinaceae, Convolvulaceae, Cucurbitaceae, Ethroxylaceae, Flagellariaceae, Loganiaceae, Malpighiaceae, Myrtaceae, Passifloraceae, Phytolaccaceae, Polygalaceae, Solanaceae and Tiliaceae had the lowest number of one individuals and one species each (Table 3).

Table 1: Checklist of plants identified in the proposed Apra Hills Forest Reserve in southern Ghana.

Species	Family	Growth form	Conservation Status
Abrus precatorius L.	Fabaceae	Climber	Unknown
Acacia kamerunensis Gand.	Fabaceae	Tree	Unknown
Acacia pennata (L.) Willd.	Fabaceae	Tree	Unknown
Achyranthes bidentata Blume	Amaranthaceae	Shrub	Unknown
Acridocarpus longifolius (D.Don) Hook.f.	Malpighiaceae	Tree	Unknown
Adenia lobata Engl.	Passifloraceae	Liana	Unknown
Aerangis biloba Schltr.	Orchidaceae	Epiphyte	Unknown
Afzelia africana Sm.	Fabaceae	Tree	Vulnerable
Alafia sp.	Apocynaceae	Liana	Vulnerable
Albizia adianthifolia W.F. Wight	Fabaceae	Tree	Least concern
Albizia ferruginea (Guill. & Perr.) Benth.	Fabaceae	Tree	Vulnerable
Albizia zygia J.F.Macbr.	Fabaceae	Tree	Unknown
Alchornea cordifolia (Schumach.) Müll. Arg.	Euphorbiaceae	Tree	Unknown
Aningeria altissima (A.Chev.) Aubrév. & Pellegr.	Sapotaceae	Tree	Unknown
Antiaris toxicaria (Pers.) Lesch.	Moraceae	Tree	Unknown
Artabotrys insignis Engl. & Diels	Annonaceae	Liana	Unknown
Asystacia sp.	Acanthaceae	Herb	Unknown
Baissea multiflora A.DC.	Apocynaceae	Shrub	Unknown
Baissea zygodioides (K. Schum.) Stapf	Apocynaceae	Liana	Unknown
Baphia nitida Lodd.	Fabaceae	Shrub	Least concern
Blighia sapida K.D. Koenig	Sapindaceae	Tree	Unknown
Bulbophyllum phaeopogon Schltr.	Orchidaceae	Epiphyte	Unknown

Table 1: (Cont'd)

Species	Family	Growth form	Conservation Status
Callichilia subsessilis Stapf.	Apocynaceae	Shrub	Unknown
Calycobolus sp.	Convolvulaceae	Liana	Unknown
Calyptrochilum emarginatum Schltr.	Orchidaceae	Shrub	Unknown
Canthium sarcocarpum Merr.	Rubiaceae	Herb	Unknown
Canthium cornelia Cham. & Schltdl.	Rubiaceae	Shrub	Unknown
Capparis sp.	Rutaceae	Tree	Unknown
Carica papaya L.	Caricaceae	Tree	Unknown
Carpolobia lutea G. Don	Polygalaceae	Shrub	Unknown
Cassia tuhavalyana	Fabaceae	Tree	Unknown
Ceiba pentandra(L.) Gaertn.	Bombacaceae	Tree	Unknown
Celtis mildbraedii Engl.	Ulmaceae	Tree	Unknown
Celtis wightii Planch.	Ulmaceae	Tree	Unknown
Chaetacme aristata Planch.	Ulmaceae	Tree	Unknown
Chassalia kolly (Schumach.) Hepper	Rubiaceae	Shrub	Unknown
Chromolaena odorata (L.) R.M.King & H.Rob	Asteraceae	Herb	Unknown
Cissus arguta Hoof.K	Vitaceae	Climber	Unknown
Cissus diffusiflora (Baker) Planch.	Vitaceae	Climber	Unknown
Cissus quadrangularis L.	Vitaceae	Herb	Unknown
Cissus sp.	Vitaceae	Liana	Unknown
Clerodendrum capitatum Hook.	Verbanaceae	Shrub	Unknown
Cola millenii K.Schum.	Sterculiaceae	Tree	Unknown

Table 1: (Cont'd)

Species	Family	Growth form	Conservation status
Combretum racemosum P. Beauv.	Combretaceae	Liana	Unknown
Cyathula prostrata (L.) Blume	Amaranthaceae	Herb	Unknown
Cystostemma umbellatum E. Fourn	Ascelpidaceae	Climber	Unknown
Deinbollia pinnata Schumach. & Thonn.	Sapindaceae	Tree	Unknown
Dialium guineense Willd.	Fabaceae	Tree	Unknown
Dichapetalum sp.	Menispermaceae	Liana	Unknown
Digitaria insularis (L.) Mez ex Ekman	Gramineae	Herb	Unknown
Diospyros abyssinica (Hiern) F.White	Ebenaceae	Tree	Unknown
Diospyros kamerunensis Gürke	Ebenaceae	Tree	Unknown
Dracaena arborea Hort.Angl. ex Link	Dracaenaceae	Tree	Unknown
Dracaena surculosa Lindl.	Dracaenaceae	Tree	Unknown
Drypetes parvifolia Pax & K.Hoffm.	Euphorbiaceae	Shrub	Unknown
Elaephorbia drupifera (Thonn.) Stapf	Euphorbiaceae	Tree	Unknown
Elytaria marginata Vahl	Acanthaceae	Herb	Unknown
Erythrococca anomala Prain.	Euphorbiaceae	Shrub	Unknown
Erythroxylum emarginatum Thonn.	Erythroxylaceae	Tree	Unknown
Eugenia coronata. Schumach. & Thonn.	Myrtaceae	Shrub	Unknown
Ficus exasperata Vahl	Moraceae	Tree	Unknown
Ficus sagitilfolia Mildbr. & Burret	Moraceae	Tree	Unknown
Flagellaria guineensis Schumach	Flagellariaceae	Liana	Unknown

Table 1: (Cont'd)

Species	Family	Growth form	Conservation status
Floscopa sp.	Commelinaceae	Herb	Unknown
Gardenia nitida Hook.	Rubiaceae	Tree	Unknown
Graptophyllum pictum Griff.	Acanthaceae	Shrub	Unknown
Grewia megalocarpa P.Beauv.	Tiliaceae	Shrub	Unknown
Griffonia simiplicifolia (Vahl ex DC.) Baill.	Fabaceae	Shrub	Unknown
Hildegardia barteri (Mast.) Kosterm.	Sterculiaceae	Tree	Unknown
Hilleria latifolia H.Walter	Phytolaccaceae	Herb	Unknown
Hunteria ghanensis J.B.Hall & Leeuwenberg	Apocynaceae	Tree	Endangered
Hymenostygia afezelii (Oliv.) Harms	Fabaceae	Tree	Unknown
Hypselodelphys violacea (Ridl.) Milne-Redh.	Marantaceae	Tree	Unknown
Landolphia macratha (K. Schum) Pichon	Apocynaceae	Climber	Unknown
Lantana camara L.	Verbenaceae	Herb	Unknown
Lecaniodiscus cupaniodes Planch. Ex Benth.	Sapindaceae	Shrub	Unknown
Mallotus opposifolius (Geisel.) Müll. Arg.	Euphorbiaceae	Shrub	Unknown
Manilkara obovata (Sabine & G.Don) J.H.Hemsl.	Sapotaceae	Tree	Unknown
Mansonia altissima A.Chev.	Sterculiaceae	Tree	Unknown
Marantochloa leucantha (K.Schum.) Milne-Redh.	Marantaceae	Herb	Unknown
Millettia chrysophylla Dunn	Fabaceae	Tree	Unknown
Millettia thonningi (Schumach. & Thonn.) Baker	Fabaceae	Tree	Unknown
Millettia zechiana Harms	Fabaceae	Tree	Least concern

Table 1: (Cont'd)

Species	Family	Growth form	Conservation status
Momordica charantia L.	Cucurbitaceae	Herb	Unknown
Monodora tenuifolia Benth.	Annonaceae	Tree	Unknown
Nauclea pobeguinii (Pobég.) E.M.A.Petit	Rubiaceae	Tree	Unknown
Nesogordonia papaverifera(A.Chev.) Capuron	Sterculiaceae	Tree	Vulnerable
Olyra latifolia L.	Gramineae	Herb	Unknown
Oplismenus hirtellus (L.) P.Beauv.	Gramineae	Herb	Unknown
Panicum maximum Jacq.	Gramineae	Herb	Unknown
Parquetina nigrescens (Afzel.) Bullock	Ascelpidaceae	Liana	Unknown
Pellaea doniana (J.Sm.) Hook.	Adiantaceae	Shrub	Unknown
Pouteria alnifolia (Baker) Roberty	Sapotaceae	Tree	Unknown
Ritchiea reflexa (Thonn.) Gild & Benedict	Capparaceae	Shrub	Unknown
Rothmannia longiflora Salisb.	Rubiaceae	Shrub	Unknown
Rothmannia urcelliformis Bullock. ex Robyns	Rubiaceae	Tree	Unknown
Salacia sp.	Celastraceae	Shrub	Unknown
Salacighia letestuana (Pellegr.) Blakelock	Celastraceae	Liana	Unknown
Sanseviera liberica Ger. & Labr.	Dracaenaceae	Herb	Unknown
Solanum enriathum D. Don	Solanaceae	Shrub	Unknown
Sorindeia jugladifolia (A.Rich.) Planch. ex Oliv.	Anacardiaceae	Shrub	Unknown
Sterculia tragacantha Lindl.	Sterculiaceae	Tree	Unknown
Strophantus gratus (Hook.) Franch.	Apocynaceae	Shrub	Unknown

Table 1: (Cont'd)

Species	Family	Growth form	Conservation status
Strychnos icaja Baill.	Loganiaceae	Liana	Unknown
Synsepalum sp.	Sapotaceae	Tree	Unknown
Talinum triangulare (Jacq.) Willd.	Portulacaceae	Herb	Unknown
Teclea verdoorniana Exell & Mendonça	Rutaceae	Tree	Unknown
Tiliacora dielsiana Hutch. & Dalziel	Menispermaceae	Shrub	Unknown
Tragia sp.	Euphorbiaceae	Herb	Unknown
Trichilia prieureana A. Juss.	Meliaceae	Tree	Unknown
Triplochiton scleroxylon K.Schum.	Sterculiaceae	Tree	Least Concern
Turraea heterophylla Sm.	Meliaceae	Shrub	Unknown
Uvaria globusa Hook.f.	Annonaceae	Shrub	Unknown
Vigna radiata (L.) R.Wilczek	Fabaceae	Shrub	Unknown
Undetermined	Acanthaceae	Herb	Unknown
Undetermined	Apocynaceae	Tree	Unknown
Undetermined	Apocynaceae	Climber	Unknown
Undetermined	Celastraceae	Tree	Unknown
Undetermined	Unidentified	Tree	Unknown
Undetermined	Unidentified	Tree	Unknown
Undetermined	Unidentified	Shrub	Unknown
Undetermined	Unidentified	Herb	Unknown

Table 1: (Cont'd)

Species	Family	Growth form	Conservation status
Undetermined	Unidentified	Shrub	Unknown
Undetermined	Unidentified	Liana	Unknown
Undetermined	Unidentified	Climber	Unknown
Undetermined	Unidentified	Herb	Unknown
Undetermined	Unidentified	Climber	Unknown

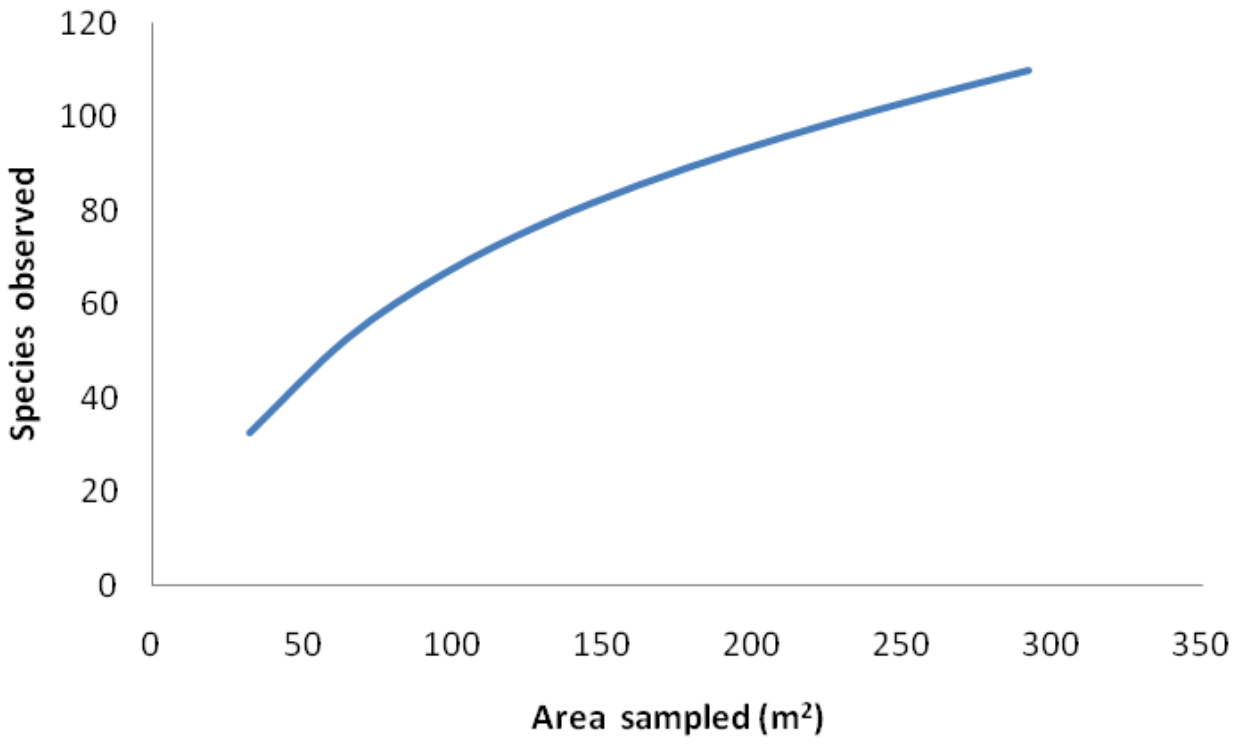


Fig. 2 : Species accumulation curve.

Table 2: Inventory Completeness ratio (*C*).

Plot	Species observed	Singletons Mean (a)	Doubletons Mean (b)	Unobserved species	Species expected	Completeness ratio
1	31.2	32.88	0.000	0.00	31.2	1.0
2	51.4	41.12	12.35	68.5	120	0.4
3	65.6	41.66	19.08	45.5	111	0.6
4	76.3	41.54	20.89	41.3	118	0.6
5	85.0	42.03	20.44	43.2	128	0.7
6	92.5	42.30	19.37	46.2	139	0.7
7	99.1	44.01	17.89	54.1	153	0.6
8	105.1	45.49	15.97	64.8	170	0.6
9	110.7	48.00	14.00	82.3	193	0.6

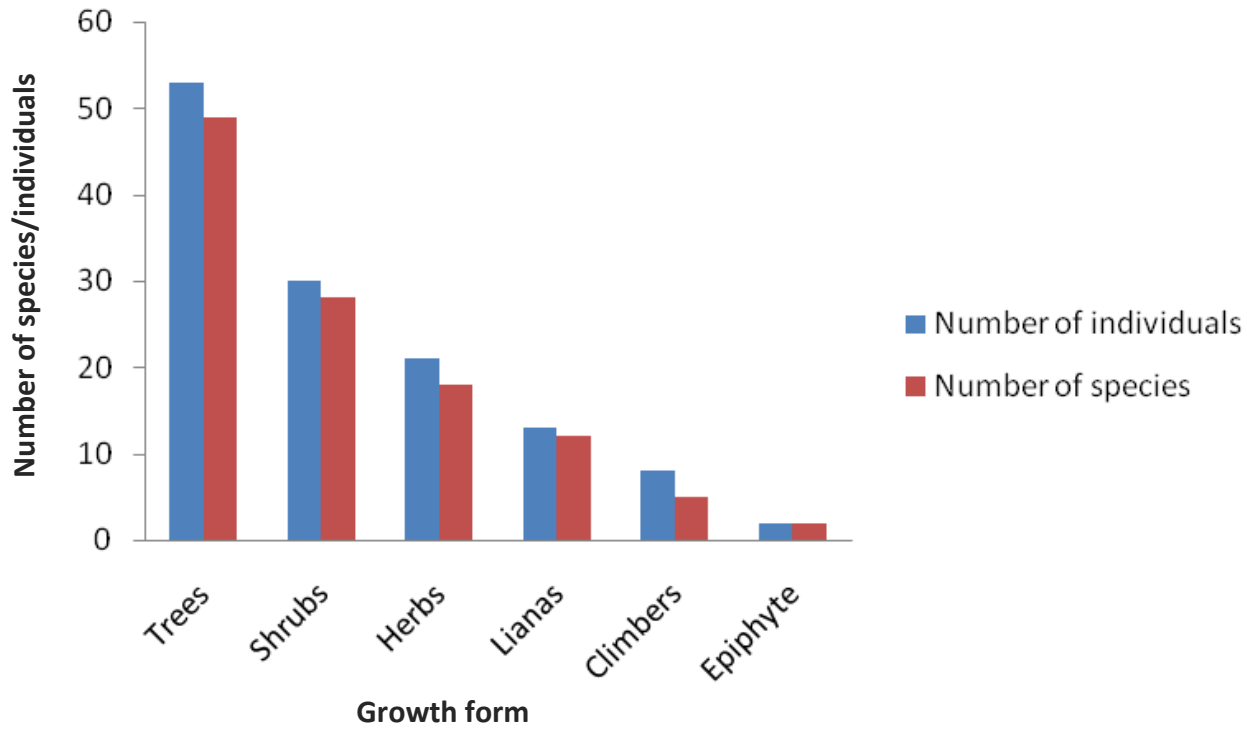


Fig. 3: Growth form of plants in the sampled area.

Table 3: Family composition of plants in the study area

Families	Individuals	Percentage (%)	Species	Percentage (%)
Acanthaceae	4	3.39	4	3.88
Adiantaceae	1	0.85	1	0.97
Amaranthaceae	2	1.69	2	1.94
Anacardiaceae	1	0.85	1	0.97
Annonaceae	3	2.54	3	2.91
Apocynaceae	9	7.63	8	7.77
Ascelpidaceae	2	1.69	2	1.94
Asteraceae	1	0.85	1	0.97
Bombacaceae	1	0.85	1	0.97
Capparaceae	1	0.85	1	0.97
Caricaceae	1	0.85	1	0.97
Celastraceae	3	2.54	3	2.91
Combretaceae	1	0.85	1	0.97
Commelinaceae	1	0.85	1	0.97
Convolvulaceae	1	0.85	1	0.97
Cucurbitaceae	1	0.85	1	0.97
Dracaenaceae	3	2.54	2	1.94
Ebenaceae	2	1.69	1	0.97
Erythroxylaceae	1	0.85	1	0.97
Euphorbiaceae	6	5.08	6	5.83
Fabaceae	16	13.6	11	10.7

Table 3: (Cont'd)

Species	Number of Individuals	Percentage (%)	Number of Species	Percentage (%)
Flagellariaceae	1	0.85	1	0.97
Gramineae	4	3.39	4	3.88
Loganiaceae	1	0.85	1	0.97
Malpighiaceae	1	0.85	1	0.97
Marantaceae	2	1.69	2	1.94
Meliaceae	2	1.69	2	1.94
Menispermaceae	2	1.69	2	1.94
Moraceae	3	2.54	2	1.94
Myrtaceae	1	0.85	1	0.97
Orchidaceae	3	2.54	3	2.91
Passifloraceae	1	0.85	1	0.97
Phytolaccaceae	1	0.85	1	0.97
Polygalaceae	1	0.85	1	0.97
Portulacaceae	1	0.85	1	0.97
Rubiaceae	7	5.93	5	4.85
Rutaceae	2	1.69	2	1.94
Sapindaceae	3	2.54	3	2.91
Sapotaceae	4	3.39	4	3.88
Solanaceae	1	0.85	1	0.97
Sterculiaceae	6	5.08	6	5.83
Tiliaceae	1	0.85	1	0.97
Ulmaceae	3	2.54	2	1.94
Verbanaceae	2	1.69	2	1.94
Vitaceae	4	3.39	1	0.97

4.2. Vegetation types and species composition

Four vegetation types were identified in proposed Apra Hills Forest Reserve. These were Open canopy forest, Closed canopy forest, Seasonal flooded forest and Thicket forest (Fig. 4). The species of plant identified in each of the plots inventorized in each vegetation type are presented in Appendice 4 - 12.

4.2.1 Open Canopy Forest

The tree crowns in this vegetation type do not overlap to form a continuous canopy layer but are more widely spaced, leaving open sunlight areas within the vegetation. A total number of 57 species were identified within this vegetation type and trees were the most dominant species in this area. The density of plants was 200 m^2 per 1 hectare. Species identified in this vegetation included tree species such as *Celtis wightii* Planch., *Cola millenii* K.Schum., *Dracaena arborea* Hort.Angl. ex Link, *Erythroxylum emarginatum* Thonn, *Lecaniodiscus cupaniodes* Planch. Ex Benth., *Mallotus opposifolius* (Geisel.) Müll. Arg., *Pellaea doniana* (J.Sm.) Hook., *Ritchiea reflexa* (Thonn.) Gild & Benedict. Herb species included *Chromolaena odorata* (L.) R.M.King & H.Rob, *Elytaria marginata* Vahl, *Lantana camara* L. *Marantochloa leucantha* (K.Schum.) Milne-Redh., *Momordica charantia* L., *Olyra latifolia* L., *Panicum maximum* Jacq. and Climbers were *Abrus precatorius* L., *Cystostemma umbellatum* E. Fourn, *Griffonia simiplicifolia* (Vahl ex DC.) Baill., *Landolphia macratha* (K. Schum) Pichon.

4.2.2 Closed Canopy Forest

This vegetation type has crowns or canopies of individual trees overlapping to form a virtually continuous layer which prevent sunlight from reaching the surface of the ground. A total number of 60 species were identified within this vegetation type and trees were the most dominant. The density of plants sampled in this vegetation type was 80 m^2 per 1 hectare.

Species identified in this vegetation included tree species such as *Sorindeia jugladifolia* (A.Rich.) Planch. ex Oliv., *Triplochiton scleroxylon* K.Schum., *Erythroxylum emarginatum* Thonn. while shrub species included *Graptophyllum pictum* Griff. *Grewia megalocarpa* P.Beauv. and *Griffonia simiplicifolia* (Vahl ex DC.) Baill., Herbs were *Chromolaena odorata* (L.) R.M.King & H.Rob and *Cyathula prostrata* (L.) Blume.

4.2.3 Seasonal Flooded Forest

This vegetation type is seasonally flooded during the raining season. A total number of 43 species were identified within this vegetation type. The density of plants within this vegetation was 40 m^2 per 1 hectare. Example of species observed in this vegetation type included trees *Ceiba pentandra*(L.) Gaertn, *Celtis mildbraedii* Engl. and *Chaetacme aristata* Planch. Shrub species included *Canthium cornelia* Cham. & Schltdl. and *Clerodendrum capitatum* Hook. while herbs included *Chromolaena odorata* (L.) R.M.King & H.Rob and *Olyra latifolia* L.

4.2.4 Thicket forest

This vegetation is a very dense stand of trees or tall shrubs, often dominated by only one or a few species. Thirty species were identified within this vegetation and density of plants was 40 $m^{2.}$ per 1 hectares. Trees were the most dominant species in this area as well and this vegetation correspond to the dense shrub/herbaceous cover vegetation identified in the satellite imaginary map. Species identified included trees *Nesogordonia papaverifera*(A.Chev.) Capuron ex N.Hallé, *Trichilia prieureana* A. Juss. and *Cola millenii* K.Schum. Shrub species included *Clerodendrum capitatum* Hook. and *Ritchiea reflexa* (Thonn.) Gild & Benedict while herb species included *Chromolaena odorata* (L.) R.M.King & H.Rob.

Fig. 4: Vegetation types within proposed Apra Hills Forest Reserve showing (a) Open Canopy Forest, (b) Closed Canopy Forest, (c) Seasonal Flooded Forest and (d) Thicket Vegetation.

4.3 Diversity, abundance and distribution of trees

A total number of 165 individual trees with DBH ≥ 10 cm belonging to 23 species in 12 families were identified. The Shannon-Weiner diversity index ranged from 1.4 to 2.3 Mean Shannon-Weiner diversity index was 2.0 (SE ± 0.09).

The families Sterculiaceae and Fabaceae had the highest number of 5 species each. In contrast, the least number of one species each was recorded for Annonaceae, Apocynaceae, Bombacaceae, Caricaceae, Ebenaceae, Moraceae, Rubiaceae and Ulmaceae. In terms of relative frequency and density, Sterculiaceae had the highest values of 49.0 followed by Fabaceae and Annonaceae, Caricaceae, Rubiaceae and Ulmaceae had the least values of 4.86. Relative dominance was highest for Sterculiaceae and least in Ulmaceae. Overall, the family with the highest FIVI value was Sterculiaceae followed by Fabaceae whereas Ulmaceae had the least FIVI value (Table 4).

With respect to species, *Dracaena aborea* had the highest relative frequency whereas *Albizia adianthifolia, Carica papaya, Chaectame aristata, Dracaena perrottettii, Millettia thonningii, Monodora tenuifolia, Rothmania longiflora* and *Triplochiton sclerexylon* were least frequently encountered. In terms of density, *Ceiba pentandra, Cola millenii* and *Dracaena aborea* had the highest values. *Hildegardia barteri* was observed to have the largest IVI value whereas *Albizia adianthifolia, Carica papaya, Chaectame aristata, Dracaena perrottettii, Millettia thonningii, Monodora tenuifolia, Rothmania longiflora* and *Triplochiton sclerexylon* was observed to have the lowest IVI of 3.6 each (Table 5).

The DBH distribution pattern of trees showed an inverted J shape because individual trees with smaller DBH were greater than those with large DBH in the study. The DBH distribution of trees is presented in Fig. 5.

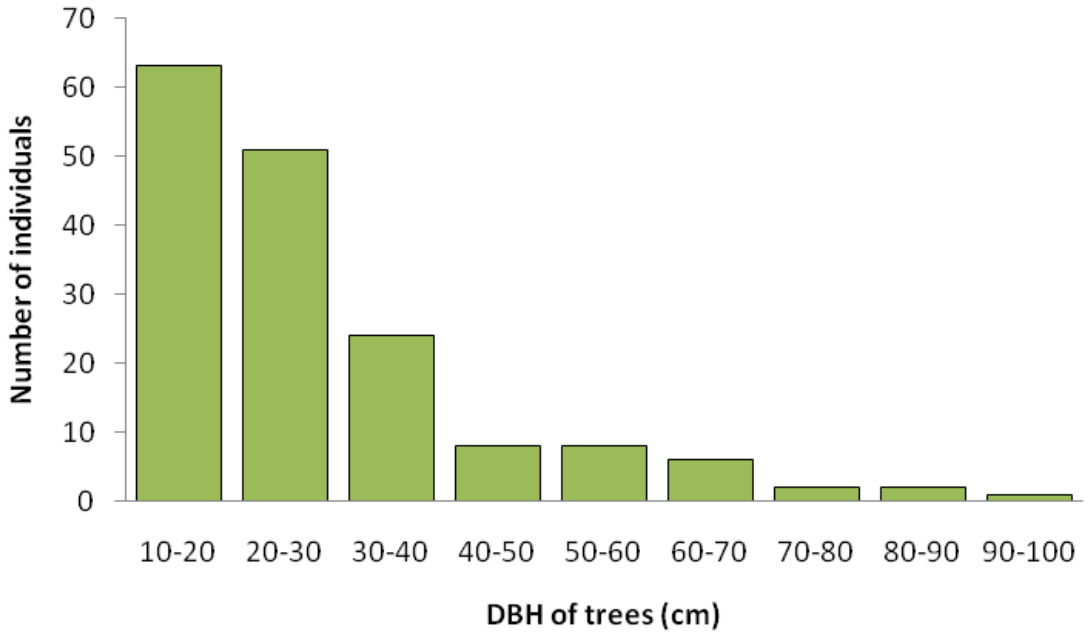


Fig.5 : DBH of tree species at different intervals.

Table 4: Family Importance Value Index of trees.

Family	Family Richness	Frequency (%)	Relative Frequency	Density (m^2)	Relative Density	Diameter (cm)	Basal area (m^2)	Dominance	Relative Dominance	Family Importance Value Index
Annonaceae	1	11.1	2.44	0.001	2.42	23.00	415.2	0.074	0.001	4.86
Apocynaceae	1	22.2	4.88	0.003	4.85	57.00	2552	0.454	0.011	9.73
Bombacaceae	1	77.8	17.1	0.011	17.0	392.0	1207	21.45	0.310	34.3
Caricaceae	1	11.1	2.44	0.001	2.42	36.00	1018	0.181	0.003	4.86
Dracaenaceae	2	77.8	17.1	0.011	17.0	116.0	1057	1.879	0.030	34.0
Ebenaceae	1	22.2	4.88	0.003	4.85	157.0	1936	3.442	0.050	9.78
Euphorbiaceae	2	33.3	7.32	0.004	7.27	136.0	1461	2.598	0.040	14.6
Fabaceae	5	55.6	12.2	0.555	841	501.0	1971	35.05	0.500	29.6
Moraceae	1	22.2	4.88	0.003	4.85	150.0	1767	3.142	0.050	9.77
Rubiaceae	1	11.1	2.44	0.001	2.42	19.00	283.5	0.050	0.001	4.86
Sterculiaceae	5	55.6	12.2	0.555	841	2249	3973	706.3	10.10	49.0
Ulmaceae	1	11.1	2.44	0.001	2.42	13.00	132.7	0.024	0.001	4.86

Table 5: Species abundance and Importance Value Index of Trees.

Species	Frequency (%)	Relative Frequency	Diameter (cm)	Density (m^2)	Relative Density	Basal area (m^2)	Dominance	Relative Dominance	Species Importance Value Index
Afzelia africana	55.6	8.93	367	0.556	8.93	1055	18.75	4.36	22.2
Albizia adianthifolia	11.1	1.79	15.0	0.111	1.79	176.6	0.031	0.01	3.60
Antiaris toxicaria	22.2	3.57	129	0.222	3.57	1302	2.315	0.53	7.70
Carica papaya	11.1	1.79	36.0	0.111	1.79	1017	0.180	0.04	3.60
Ceiba pentandra	66.7	10.7	392	0.667	10.7	1203	21.38	4.97	26.4
Chaectame aristata	11.1	1.79	13.0	0.111	1.79	132.7	0.023	0.01	3.60
Cola millenii	66.7	10.7	1024	0.667	10.7	8229	146.3	34.0	55.4
Crotun aubrevillei	11.1	1.79	19.2	0.111	1.79	289.4	0.051	0.01	3.60
Dialium guineense	22.2	3.57	102	0.222	3.57	8151	1.449	0.33	7.50
Diospyros abyssinica	33.3	5.36	157	0.333	5.36	1934	3.439	0.80	11.5

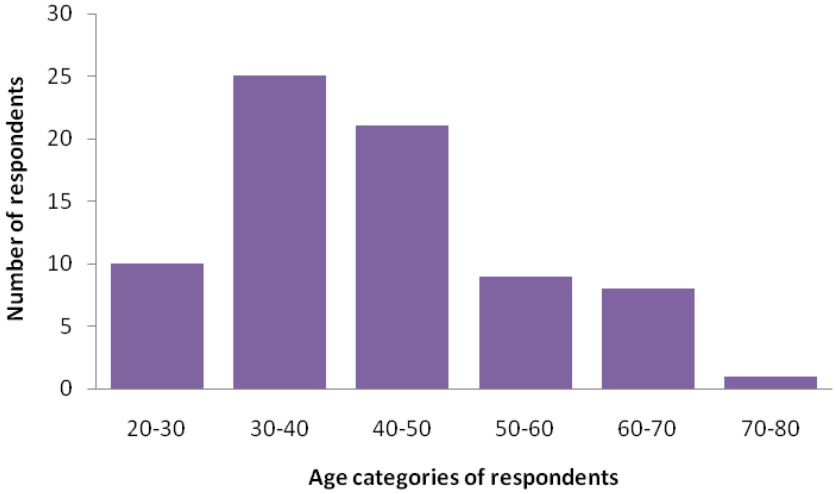
Table 5: (Cont'd)

Species	Frequency (%)	Relative Frequency	Diameter (cm)	Density (m^2)	Relative Density	Basal area (m^2)	Dominance	Relative Dominance	Species Importance Value Index
Dracaena aborea	66.7	10.7	71.8	0.667	10.71	4046	0.719	0.167	21.6
Dracaena perrottettii	11.1	1.79	44.4	0.111	1.79	1547	0.275	0.064	3.60
Drypetes parvifolia	22.2	3.57	26.8	0.222	3.57	563.8	0.100	0.023	7.20
Elaeophobia drupifera	22.2	3.57	90.6	0.222	3.57	6443	1.145	0.266	7.40
Hildegardia barteri	55.6	8.93	1195	0.556	8.93	1120	199.2	46.33	64.2
Hunteria ghanensis	22.2	3.57	56.5	0.222	3.57	2505	0.445	0.104	7.20
Hymenostygia afezelii	22.2	3.57	492	0.222	3.57	1900	33.79	7.858	15.0
Mansonia altissima	22.2	3.57	13.7	0.222	3.57	147.3	0.026	0.006	7.10
Millettia thonningii	11.1	1.79	32.0	0.111	1.79	803.8	0.142	0.033	3.60
Monodora tenuifolia	11.1	1.79	22.5	0.111	1.79	397.4	0.070	0.016	3.60
Rothmania longiflora	11.1	1.79	19.0	0.111	1.79	283.4	0.050	0.012	3.60
Sterculia tragacantha	22.2	3.57	20.0	0.222	3.57	314.0	0.055	0.013	7.20
Triplochiton sclerexylon	11.1	1.79	19.0	0.111	1.79	283.4	0.050	0.012	3.60

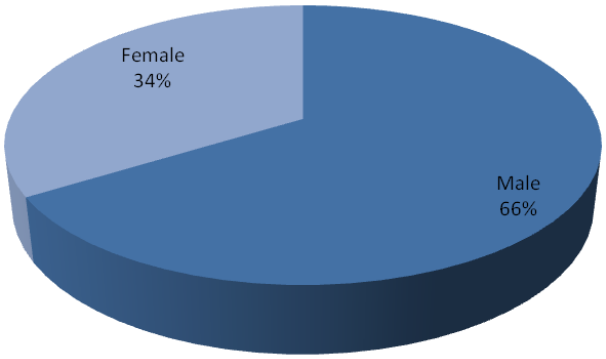
4.5 Ethnobotanical Studies

4.5.1 Social-economic background of informants

The 74 informants interviewed were between the ages of 20 to 80 years, 49were males and 25were females. The age categories, sex ratio, primary occupation of the informants are presented in Fig. 6. A total number of 60 informants were married, 9 were single, 3 widows and 2 were divorced.



(a)



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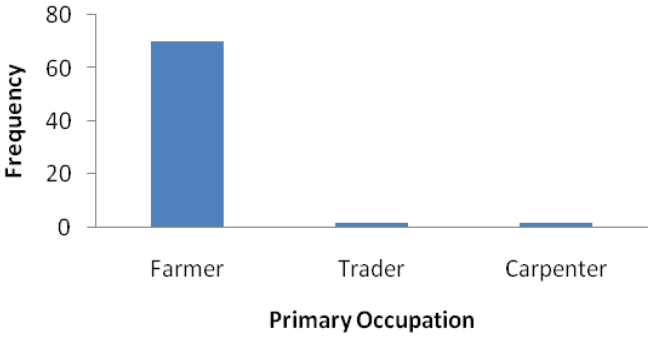

(c)

Fig. 6: Socio-economic background shows (a) age categories; (b) sex distribution and (c) primary occupation of informants in the study area.

4.6 Use Categories, Use-Value (UV) and Informant Consensus factor (F_{ic})

A total of 35 plant species were reported being used by informants. Nine species, namely, *Baphia nitida, Ceiba pentandra, Chassalia kolly, Chromolaena odorata, Lantana camara, Nauclea latifolia, Ritchiea reflexa, Teclea verdoorniana* and *Triplochiton scleroxylon* were recorded both in the plant diversity and ethnobotanical studies. On the other hand, the following 12 species namely, *Afraegle paniculata* (Schumach. & Thonn.), *Jatropha gossipifolia* L., *Mangifera indica* L., *Milicia excelsa* (Welw.) C.C.Berg, *Paulina pinnata*L., *Senna siamea* (Lam.) H.S.Irwin & Barneby, *Sida acuta* Burm.f., *Solanum torvum* Sw., *Spondias mombin* Jacq., *Strophantus hispidus* D.C., *Swietenia macrophylla* King and *Zanthoxylum xantholoides* L. were not observed in the plant diversity study but were mentioned by the informants during the interview.

The uses of the plants was grouped into five use-categories, namely; agricultural tools, furniture, construction materials, food, fuelwood and medicine. The use category with the highest number of taxa recorded was medicine whereas categories with the least number of taxa mentioned was food and agriculture tool (Fig. 7). In terms of use-values (UV) for the 35 species, *Swietenia macrophylla* UV (2.0) has the highest value whereas *Momordica charantia* UV (0.1) had the least value (Table 6).

The use of plant for medicine was observed to have the highest use report and ICF value, followed by construction , fuelwood (Fig.8) furniture whereas food and agricultural tool had the lowest use reports and ICF values. A high F_{ic} value indicate a high use reports for a particular use category while a low F_{ic} value indicate low use reports for a use category (Table 7).

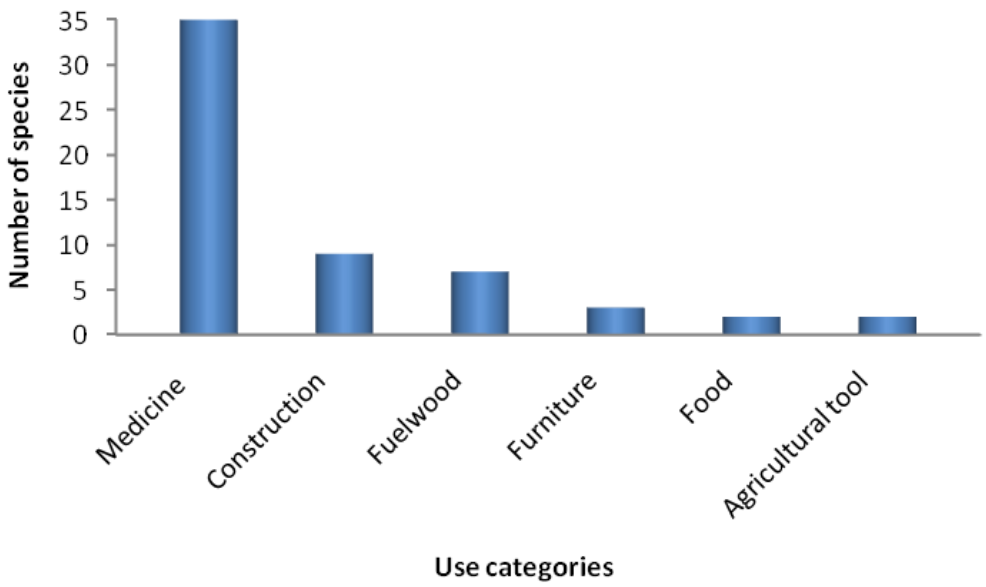

Fig. 7: Plant use category in the study area.

Fig. 8: Plant parts collect for use in the proposed Apra Hills Forest Reserve.

Table 6: List of plants used in communities around proposed Apra Hills Forest Reserve

Species	Family	Local names	Growth form	Use Category	Use value	Part used	Uses
Afraegle paniculata	Rutaceae	Atimpo	Tree	M	1.0	Le	To treat pile and back pain
Azadirachta indica	Meliaceae	Kolebu	Tree	M	0.2	Ba, Le, Ro	To treat malaria and fever
Baphia nitida	Fabaceae	Joun	Climber	M, Fd, A	0.4	Le, St	To treat waist pain, for fuelwood, farm handles
Capparis erythrocarpus	Cappparaceae	Peti-peti	Herb	M	0.5	Le, Ro	Pile and back pain
Ceiba pentandra	Bombacaceae	Sepa	Tree	C	1.0	St	For making of doors and windows
Chassalia kolly	Rubiaceae	Ekodibe	Shrub	M	0.5	Le, Ro	For fever
Chromolaena odorata	Asteraceae	Acheampong	Herb	M	0.2	Le	To treat fatigue, measles and stomach ache
Gymnema sylvestres	Apocynaceae	Asamon	Shrub	M	1.0	Le, Ro	To treat measles
Holarrhena floribunda	Apocynaceae	Osese	Tree	M, Fu	0.3	Le, Ro	For waist pain, infertility in women, mortar and pestle
Jatropha gossipifolia	Euphorbiaceae	Adatin	Tree	M	1.0	Le	To treat fatigue
Lantana camara	Verbenaceae	Nbili-nbili	Herb	M	1.0	Le	To treat swollen eyes

Keys: M - Medicine, Fd - Fuelwood, Fu - Furnitures, A - Agricultural tool, C - Construction, Le- Leaves, Ba - Stem bark, Ro-roots and St-Stem.

Table 6: (Cont'd)

Species	Family	Local names	Growth form	Use Category	Use value	Part used	Uses
Lecaniodiscus cupaniodes	Sapindaceae	Ojujumaba	Climber	M	1.0	Le	To treat broken bones
Mallotus oppositifolius	Euphorbiaceae	Satidua (male)	Tree	M	0.2	Ba, Ro, Le	To treat menstrual pain and stomach ache
Mangifera indica	Anacardiaceae	-	Tree	M, F	0.5	Ba, Le	To treat measles, fever and Food
Mezoneuron benthamianun	Fabaceae	Krokonso	Herb	M	1.0	Le	For chest pain
Milicia excelsa	Moraceae	Odum	Tree	Fu, C	1.0	St	For roofing, doors, windows, chairs and table
Momordica charantia	Cucurbitaceae	Yenye	Herb	M, Fu	0.1	Le, Ro, Ba	To treat fever, stomach ache, roofing of houses and for furnitures
Nauclea latifolia	Rubiaceae	Odanta	Tree	Fd, C	0.4	St	For fuelwood and for roofing
Paulina pinnata	Sapindaceae	Twintin	Herb	M	0.3	Le, Ro	To treat waist pain and fatigue
Ricinus cumminis	Euphorbiaceae	Adidankruma	Tree	M	0.5	Le	To treat hiccups, measles
Ritchiea reflexa	Cappparaceae	Oputi nado	Shrub	M	0.3	Le, Ro	For headache

Keys: M - Medicine, F - Food, Fd - Fuelwood, Fu - Furnitures, C - Construction, Le- Leaves, Ba - Stem bark, Ro-roots and St-Stem.

Table 6: (Cont'd)

Species	Family	Local names	Growth form	Use Category	Use value	Part used	Uses
Securinega virosa	Euphorbiaceae	Kokobro	Shrub	M	0.3	Le	To treat pile, back pain and fatigue
Senna siamea	Caesalpinioideae	Cassia	Tree	M	0.2	Le, Ba	To pile, back pain, swollen eyes and malaria
Sida acuta	Malvaceae	Mofesan	Herb	M	0.2	Le, Ro	For waist pain
Solanum erianthum	Solanaceae	Boyun	Shrub	M	1.0	Le, Ro	For malaria
Solanum torvum	Solanaceae	Amajuradi	Shrub	M	0.5	Ro, Fr, Le	To treat measles and back pain
Spondias mombin	Anacardiaceae	Afaba	Tree	M	0.2	Le	To treat fatigue
Strophantus hispidus	Apocynaceae	Edupeyin	Liana	M	0.5	Le	To treat headache
Swietenia macrophylla	Meliaceae	Mahogany	Tree	M	2.0	Fr, Ba, Le	To treat fatigue
Teclea verdoorniana	Rutaceae	Osu punapu	Tree	M	0.5	Le, Ba	For cold and fever
Tiliacora dielsiana	Menispermaceae	Oprofe	Shrub	M	0.2	Ro	To treat stomach ache

Keys: M - Medicine. Parts used: Le- Leaves, Ba - Stem Bark, Ro-roots and Fr-Fruits.

Table 6: (Cont'd)

Species	Family	Local names	Growth form	Use Category	Use value	Part used	Uses
Triplochiton scleroxylon	Sterculiaceae	Wawa	Tree	A, F, C	0.3	St	For roofing, doors, windows, chairs and table
Uvaria sp.	Annonaceae	Apotompo	Shrub	M	0.5	Le	For waist pain
Vernonia cinerea	Asteraceae	-	Herb	M	1.0	Le	To treat swollen eyes
Zanthoxylum xantholoides	Rutaceae	Cantum	Tree	M	0.3	Le, Ba, Ro	To treat headache

Keys: M - Medicine, F - Food, A - Agricultural tool and C - Construction. Parts used: Le- Leaves, Ba - Stem bark, Ro-roots and St-Stem.

Table 7: Informant Consensus Factor (ICF) for commonly used plants.

Use category	Number of use reports (N_{ur})	% all species	Number of taxa (N_t)	Informant Consensus factor (F_{ic})
Agricultural tool	2	3.51	1	0.5
Food	2	3.51	1	0.5
Furniture	3	5.26	2	1.3
Fuelwood	7	12.3	2	5.7
Construction	9	15.8	3	7.7
Medicine	41	61.4	31	39.2

4.6.1 Medicinal uses of plants

A total number of 31 species were recorded to treat seven ailment categories namely; Gastro-intestinal ailment (5 species), Respiratory system disease (2 species), Skeleton-muscular system disorders (3 species), Hemorrhoids (9 species), Genio-urinary ailments (2 species), Infectious and parasitic diseases (5 species), Dermatological infections/diseases (6 species), General health (2 species) and Musculoskeletal and connective tissue (1 species).

Afraegle paniculata, *Baphia nitida*, *Capparis erythrocarpus*, *Chromolaena odorata*, *Jatropha gossipifolia* and *Swietenia macrophylla and Paulina pinnata* were used to treat hermorrhoids (pile, back and waist pain), *Azadirachta indica*, *Chassalia kolly* and *Mangifera indica* were used to treat infectious and parasitic disease (fever and malaria). *Mallotus opposifolius*, *Tiliacora dielsiana* and *Momordica charantia* were used to treat Gastro-intestinal ailment (Stomach ache and ulcer), *Ritchiea reflexa*, *Zanthoxylum xantholoides* and *Strophantus hispidus* were used to treat skeleton-muscular system disorders (headache). *Ricinus cumminis*, *Chromolaena odorata* and *Solanum torvum* were used to treat

dermatological infections/diseases (measles). *Mallotus oppositifolius* was the only species used to treat genio-urinary ailments (menustral pain and infertility). *Mezoneuron benthamianun* and *Teclea verdoorniana* are used to treat respiratory system disease (cold). *Azadirachta indica* and *carica papaya* was used to treat general health (Table 9).

Table 8: Medicinal plants used in communities around proposed Apra Hills Forest Reserve

Species	Local names	Habit	Use value	Part used	Use
Afraegle paniculata	Atimpo	Tree	1.0	Leaves	To treat pile and back pain
Azadirachta indica	Kolebu	Tree	0.2	Stem bark, leaves and roots	To treat malaria and fever
Baphia nitida	Joun	Climber	0.4	Leaves and Stem	To treat waist pain and fatigue
Capparis erythrocarpus	Peti-peti	Herb	0.5	Leaves and roots	Pile and back pain
Chassalia kolly	Ekodibe	Shrub	0.5	Leaves and roots	For fever
Chromolaena odorata	Acheampong	Herb	0.2	Leaves	To treat fatigue, measles and stomach ache
Gymnema sylvestres	Asamon	Shrub	1.0	Leaves and roots	To treat measles
Holarrhena floribunda	Osese	Tree	0.3	Leaves and roots	For waist pain, infertility in women
Jatropha gossipifolia	Adatin	Tree	1.0	Leaves	To treat fatigue
Lantana camara	Nbili-nbili	Herb	1.0	Leaves	To treat swollen eyes
Lecaniodiscus cupaniodes	Ojujumaba	Climber	1.0	Leaves	To treat broken bones
Mallotus oppositifolius	Satidua (male)	Tree	0.2	Stem bark, roots and leaves	To treat menstrual pain and stomach ache

Table 8: (Cont'd)

Species	Local names	Habit	Use value	Part used	Use
Mangifera indica	Mango	Tree	0.5	Stem bark and leaves	To treat measles and fever
Mezoneuron benthamianun	Krokonso	Herb	1.0	Leaves	For chest pain
Momordica charantia	Yenye	Herb	0.1	Leaves, roots and stem bark	To treat fever, stomach ache, measles,
Paulina pinnata	Twintin	Herb	0.3	Leaves and root	To treat waist pain and fatigue
Ricinus cumminis	Adidankruma	Tree	0.5	Leaves	To treat hiccups, measles
Ritchiea reflexa	Oputi nado	Shrub	0.3	Leaves and roots	For headache
Securinega virosa	Kokobro	Shrub	0.3	Leaves	To treat pile, back pain and fatigue
Senna siamea	Cassia	Tree	0.2	Leaves and stem bark	To pile, back pain, swollen eyes and malaria
Sida acuta	Mofesan	Herb	0.2	Leaves and roots	For waist pain
Solanum erianthum	Boyun	Shrub	1.0	Leaves and roots	For malaria
Solanum torvum	Amajuradi	Shrub	0.5	Roots, fruits and leaves	To treat measles and back pain
Spondias mombin	Afaba	Tree	0.2	Leaves	To treat fatigue

Table 8: (Cont'd)

Species	Local names	Habit	Use Category	Use value	Part used	Use
Strophantus hispidus	Edupeyin	Liana	Medicine	0.5	Leaves	To treat headache
Swietenia macrophylla	Mahogany	Tree	Medicine	2.0	Fruit, stem bark, leaves	For strength
Teclea verdoorniana	Osu punapu	Tree	Medicine	0.5	Leaves and stem bark	For cold and fever
Tiliacora dielsiana	Oprofe	Shrub	Medicine	0.2	Roots	To treat stomach ache
Uvaria sp.	Apotompo	Shrub	Medicine	0.5	Leaves	For waist pain
Vernonia cinerea	-	Herb	Medicine	1.0	Leaves	To treat swollen eyes
Zanthoxylum xantholoides	Cantum	Tree	Medicine	0.3	Leaves, Stem bark and roots	To treat headache

Table 9: Informant Consensus factor for medicinal plants

Ailment Categories	Number of reports	Number of taxa (N_t)	Informant Consensus factor (F_{ic})
Gastro-intestinal ailment (GIA)	21	5	19.8
Respiratory system disease (RSD)	3	2	1.33
Skeleton-muscular system disorders (SMSD)	10	3	8.7
Hemorrhoids (HEM)	13	9	11.3
Genio-urinary ailments(GUA)	4	2	2.5
Infectious and parasitic disease	9	5	7.44
Dermatological infections/diseases(DID)	5	6	2.8
General health(GH)	9	2	7.78
Musculoskeletal and connective tissue	4	1	2.75

4.6.2 Plant parts and use-categories

Generally, leaves were the most common plant part used , followed by roots then stem bark, stem and fruit (Fig. 9). Plant parts and the relationships with use-categories are presented in Table 10. In terms of plant parts used for medicine, leaves had the highest use report followed by roots and then stems, barks (Fig.10) and fruits were the least reported for construction and fuelwood purposes stem were used. In terms of agricultural tool, 2 use report was recorded for Stem. The least use report was recorded for food.

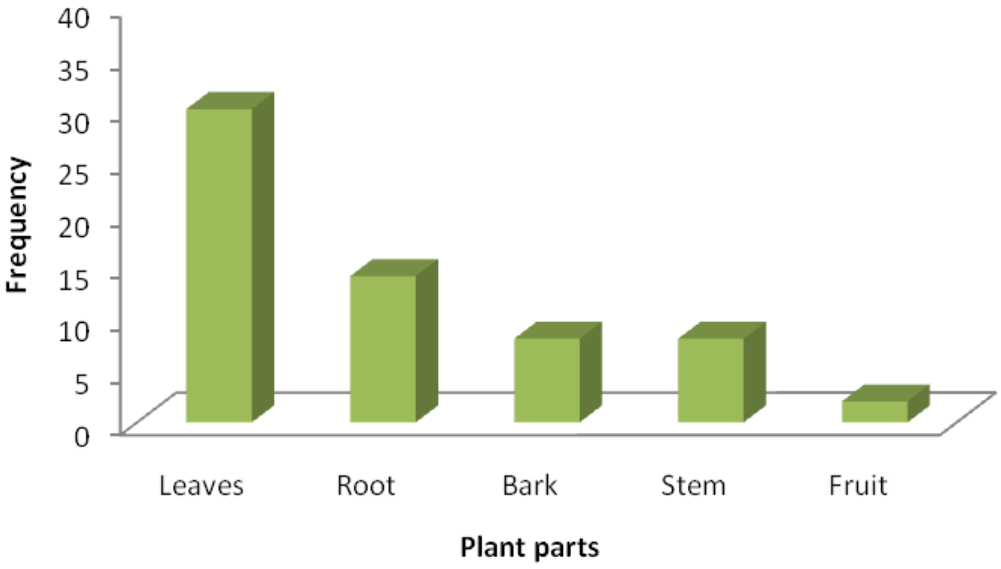

Fig. 9: Plant parts used by informant in the study area.

Fig. 10 : Harvesting of the stem bark of *Swietenia macrophylla* in the study area.

Table 10: Relationship between use categories and plant parts used

Use category	Leaves	Root	Stem Bark	Stem	Fruit
Food	0	0	0	0	1
Medicine	30	14	8	0	1
Construction	0	0	0	3	0
Fuelwood	0	0	0	3	0
Furniture	0	0	0	0	0
Agricultural tool	0	0	0	2	0

4.7 Relationships between plant diversity and ethnobotanical use

Data on useful plant species per plot and vegetation types in relation to species abundance and richness are presented in Tables 11 and 12. The results of the correlation analysis showed significant relationship ($p > 0.05$) between plant diversity and number of overall useful plants as well as medicinal plants (Fig. 11). However, there were no significant relationships between vegetation type and plant use (Table 13).

Table 11: Relationship between plant diversity and ethnobotanical uses per plot

Plot	Plant diversity		Ethnobotanical use	
	Species richness	Species abundance	Number of useful plant	Number of medicinal plants
1	43	46	8	6
2	46	50	7	6
3	43	45	8	6
4	30	30	7	5
5	34	37	6	6
6	24	25	2	2
7	25	26	6	6
8	26	27	5	4
9	10	11	1	1

Table 12: Relationship between plant diversity and ethnobotanical uses per vegetation type

Vegetation types	Plant diversity		Ethnobotanical use	
	Species richness	Species abundance	Number of useful plant	Number of medicinal plants
Open canopy forest	46	57	9	8
Closed canopy forest	69	164	9	7
Seasonal flooded forest	43	45	8	6
Thicket	30	30	7	6

Table 13: Results of correlation analysis between plant diversity study and ethnobotanical use

Plant diversity	Ethnobotanical use	Correlation (r, p-value)
Species richness	Number of useful plants	r = 0.82, p = 0.1847
Species richness	Number of medicinal plants	r = 0.43, p = 0.5709
Species abundance	Number of useful plants	r = 0.67, p = 0.3323
Species abundance	Number of medicinal plants	r = 0.32, p = 0.6804

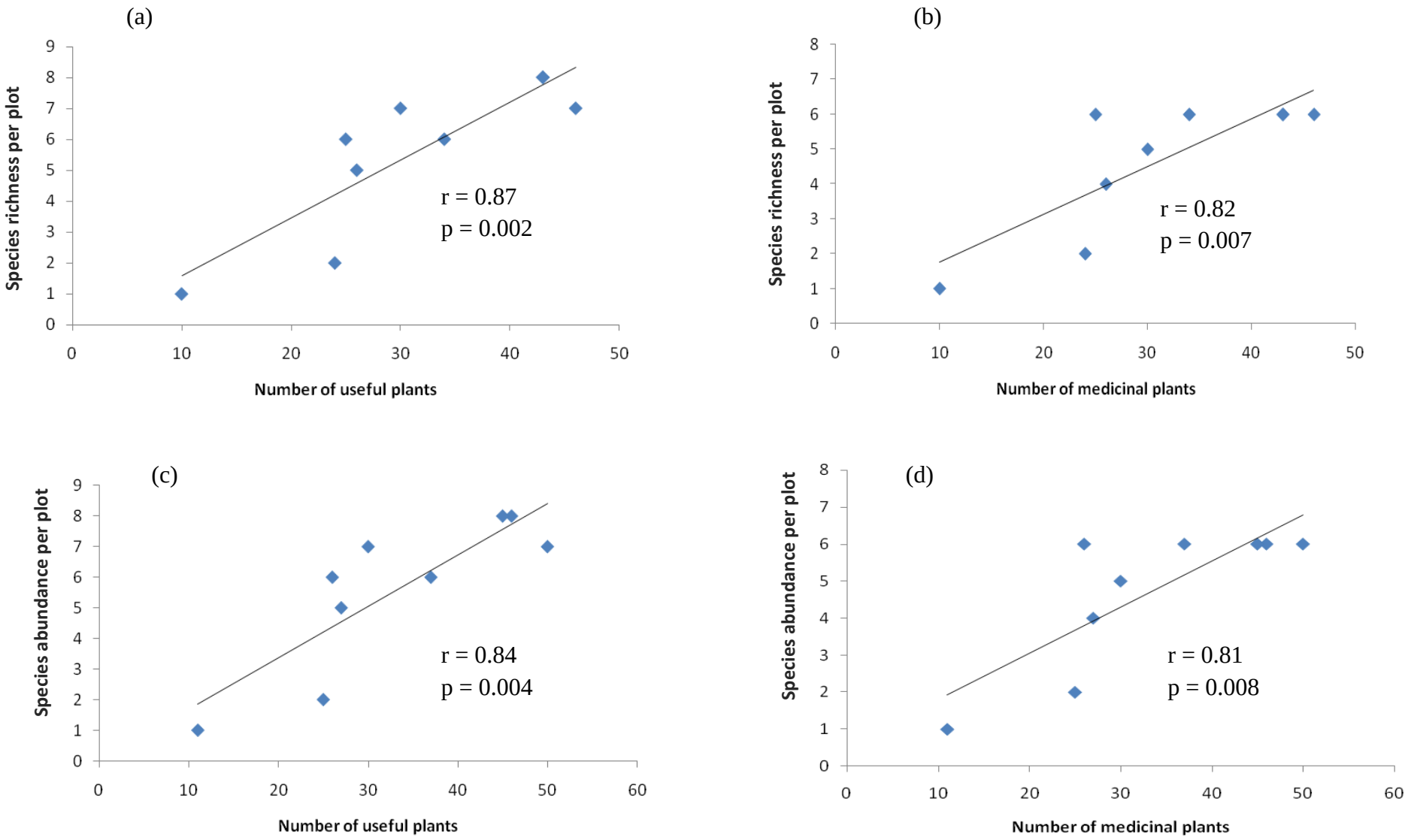

Fig. 11: A relationship graph of plant diversity and useful plant within plots

A high percentage of informants collected plant resources from the proposed Apra Hills Forest Reserve once per week, followed by informants who visited monthly. Others collected plant resources on daily and irregularly basis while very few collect plant parts once per year (Fig. 12). Informant also collected plant materials for use from other areas outside the proposed reserve.

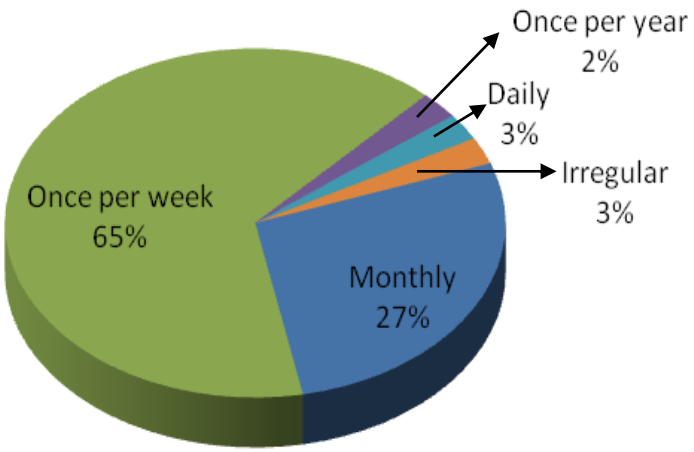

Fig. 12: Collection of plant resources by informants in the study area.

In terms of threats to plants, several informants mentioned bushfire (18.9 %), inadequate rain (10.8 %) and application of excess agrochemicals (2.7 %), other factors were illegal logging (Fig. 13) overharvesting and climate change.

Fig. 13 : Photograph showing evidence of illegal logging in proposed Apra Hills Forest Reserve.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Plant diversity

The proposed Apra Hills Forest Reserve falls within the Southern Marginal (SM) forest type in Ghana (Hall and Swaine, 1981). This forest type has suffered from continuous anthropogenic pressure such as illegal logging, collection of plant part for medicinal uses and fuelwood. Conservation wise, most of the plant species in the study area were not of priority. . *Hunteria ghanensis* which was rated as an endangered species. These species needs special protection in the reserve. Other species including *Afzelia africana*, *Alafia* sp., *Albizia ferruginea*, *Nesogordonia papaverifera* rated as vulnerable should also be protected.

In this study, *Hildergardia barteri* and *Cola millenii* were the most predominant species recorded. According to Hall and Swaine (1981) these tree species are mostly predominant species in the Southern Marginal forest Ghana. In contrast, compared to the Moist semi-deciduous forest species such as *Celtis mildbraedii*, *Triplochiton scleroxylon* and *Nesogordonia papaverifera* are most predominant (Obeng *et al.* 2009).

Species accumulation curve did not flattened and this indicates that more species would have been discovered with increased sampling. Indeed the number of species expected was 1163 (S.E ± 15.1) showing that more could have been discovered with increased sampling. In relation to families, Fabaceae had the highest number of individuals and species as documented for forest ecosystem. According to Powers *et al*. (2009), four families namely, Apocynaceae, Fabaceae and Euphorbiaceae are the most species rich families in all the forest blocks.

The inventory of plants showed that tree species had the highest population, which is a typical feature of a forest vegetation. Shrubs and herbaceous species including grasses are uncommon in forests. The current study confirms the work of other authors that trees constitute the predominant growth forms in forests (Vordzogbe *et al*., 2005; Anning *et al*., 2008; Addo-Fordjour *et al*., 2009b).

In relation to trees diversity, abundance and distribution, mean Shannon-Weiner diversity index was low compared to those recorded for other forest areas. For example Murali *et al.* (1996) recorded mean Shannon diversity value of 2.0 in the tropics and Lucky *et al*. (2010), recorded Shannon-Weiner index value of 2.2 in dry semi-deciduous forest. The commonest genera recorded in the area was *Hildergardia* belonging to Sterculiaceae was recorded with the highest FIVI value and Ulmaceae had the least value. This result is similar to Lucky *et al.* (2010), who found Euphorbiaceae and Sterculiaceae with the highest number of species.

The results of study in terms of DBH distribution pattern showed resemblance with observation made by Okali and Ola-Adams (1987). Both studies showed that greater number of trees are of smaller DBH than trees of larger DBH.

5.2 Ethnobotanical use

Documentation of plant diversity and preserving indigenous knowledge are fundamental urgent issues to be accomplished due to the huge loss of plant diversity (Cunningham, 1996) According to Haimanot (2010), the usage of plants usually relate to peoples conceptualization of the importance of plants.

With respect to plant use value in this study, *Swietenia macrophylla* was highly used especially for medicine, whereas *Momordica charantia* was least used by the local people. Abbiw (1990), recorded that *Swietenia macrophylla* is an important species used for building purposes and for making furniture. Thus, *Swietenia macrophylla* could be highly exploited besides its medicinal values, and thus need to be protected.

In terms of ICF of use categories, medicine had the highest value, followed by construction, fuelwood, furniture while food and agricultural tool had the least values. High ICF indicate consistency of the informant knowledge in the plants being used (Heinrich, 1998). This result is in agreement with previous studies (Mohammed, 2014; Prod, 2014), in medicine had a high ICF value of 0.95 and 0.60, respectively. For medicinal use, gastro-intestinal ailments had the highest ICF value whereas Respiratory system disease had the least ICF value. The high ICF value for gastro-intestinal ailment could be that this ailment category is common in the study area and there is a good knowledge among informants about plants for treating ailments in this category. A study by Frei *et al.*, (1998) showed gastro-intestinal ailment category to have a low ICF value of 0.15. In another study, Gondar *et al.* (2012) found that infectious and parasitic disease had the highest ICF value.

Result obtained in terms of plant parts used in this study showed that leaves of trees had the highest use reports whereas fruits had the least use report. According to Magurran (1988), leaves had the highest use report by the informants in Southern Ghana. Similarly, Asase *et al.* (2010) and Lulekal *et al.* (2008), reported that fresh leaves were the most common plant part used in studies. In a study in Uganda, harvesting leaves for use has less impact on plant species (Ssegawa and Kasenene, 2007).

5.3 Relationship between plant diversity and ethnobotanical use

The results of the correlation analysis showed that plant diversity was related to ethnobotanical use. This results is similiar to that of Reyes-garcía *et al.* (2005) that found a statistically significant relation between individual ethnobotanical knowledge and consumption of plants. Despite the fact that the closed canopy forest contained more plants than the seasonal flooded forest and thicket vegetation number of useful plants was not related to the vegetation types. This means that the entire vegetation in the study area is useful ethnobotanicaly to the people.

The high frequencies indicated that the people collect plants from the proposed reserve and this means that the proposed reserve is an important source of their livelihood. In a study carried out in Wechian Hippotamus Sanctuary of Ghana a similar result was found Asase and Oteng-Yeboah, (2012). There is a need to regulate collection of plants materials from the reserve in order to ensure that plants are not overharvested.

The factors cited which threatens plant conservation in this study are similar to the work of Pereira *et al*. (2001) and Lulekal *et al*. (2008), which showed that agricultural expansion, overgrazing, drought, collection of charcoal and fuelwood, bush burning, illegal logging and are directly responsible for poor conservation of plants in the area. Darko (2012), also recorded that illegal logging, wild fire and urbanization were mentioned as the major sources of threats to plant availability. According to Afua (2011), threats to forests in Ghana is due to population density of the communities located around the area.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusions

The following conclusions may be drawn from the study;

i. The proposed Apra Hills Forest Reserve contain high diversity of plants. Although the majority of the species of plant are of little conservation concern, few of the species have been categorized as endangered and vulnerable and needs special protection.

ii. The proposed reserve contain significant number of species characteristics of the Southern outliner vegetation type in Ghana and the establishment of the area as a formal Forest Reserve will ensure that the species are protected.

iii. The communties living around the proposed reserve depends on the plants in the area for the sources of livelihood especially their primary health care. The local people should therefore be given regulated permits to continue to use the resources when the place is formally established as a reserve.

iv. The study has showed that significant relationship exist between plant diversity and ethnobotanical use. However, plant use and vegetation type are not related.

v. The plant resources in the proposed reserve are threatened by a number of factors such as bushfires, fuelwood collection, charcoal production and other anthropogenic activities.

6.2 Recommendations

i. Further inventory of plants should be carried out in the area in order to eventually capture all species present there. In doing so, new or endangered species maybe identified which might be relevant to conservation of proposed Apra Hills Forest Reserve.

ii. Carbon stock of the trees and soil characteristics present in the proposed Apra Hills Forest Reserve should be studied. This will increase the value of the reserve in terms of the need for conservation of its species.

iii. Communities around the proposed Apra Hills Forest Reserve should be encouraged to use gas and electricity instead of fuelwood which causes depletion of the forest.

iv. There is a need to raise public awareness about the importance of plant diversity in the proposed Forest Reserve. Such awareness can be created through teaching in communities, schools, rural and urban events and documentaries.

v. The Forestry Commission Winneba District, Ghana should take necessary steps to ensure sustainably forest management of proposed Apra Hills Forest Reserve in order to avoid loss of biodiversity.

vi. The local people should be granted access into proposed Apra Hills Forest Reserve for collection of plants on specific periods for regulated quantities only. The local people should be encouraged to cultivate plants such as *Azadirachta indica, Chromolaena odorata, Baphia nitida, Momordica charantia, Lecaniodiscus*

cupaniodes, *Swietenia macrophylla* and *Zanthoxylum xantholoides* that are commonly used in their home gardens and farms. This measure will help control the exploitation of plant resources in proposed Apra Hills Forest Reserve in southern Ghana.

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APPENDICES

Appendix 1: Data collection sheet for plant inventory

Date : ...../...../.....

dd / mm / yyyy

Data Collectors:.....

.....

.....

.....

Plot Code: .....

GPS Coordinates :.....

Geology:……..…..

Slope:……...

Aspect:……..…..

Altitude:……..…..

Other:.....

.....

S/N	VOUCHER NO.	SPECIES	NOTES
1.			
2.			
3.			
4.			
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6.			
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8.			
9.			
10.			
11.			
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21.			

APPENDIX 2

Appendix 2: Data collection sheet for tree enumeration

Date : ...../...../.....

dd / mm / yyyy

Data Collectors:.....

.....

.....

.....

Plot Code: .....

GPS Coordinates :.....

Geology:……

Slope:……

Aspect:……

Altitude:……

Other:.....

.....

S/N	SPECIES	DBH (cm)
1.		
2.		
3.		
4.		
5.		
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APPENDIX 3

Appendix 3: Diversity and Ethnobotanical Uses of Plants in Apra Hills Proposed Forest Reserve in Southern Ghana

In partial fulfilment of the requirements for the degree of Master of Philosophy in Botany, University of Legon, Ghana. Please tick the appropriate box and fill in the gaps where necessary

Name of Student: Adeoye Adeniyi **Date:_____**

Bio-data of informant

1. Name of informant:
2. Age (years):
3. Sex: Male [ ], Female [ ]
4. Marital status: Married [ ], Divorced [ ], Separated [ ], Single [ ]
5. Educational background: None [ ], Primary school [ ], Secondary [ ], Tertiary [ ], Others (Specify) _____
6. Primary Occupation: _____
7. Name of Community: _____
8. Household number: _____

Use of Forest Resources

9. Do you collect plants from Apra forest reserve: Yes [ ], No [ ]
10. How often do you collect plants from the forest? Daily [ ], Once per week [ ], Monthly [ ], Once per year; [ ] Irregular / as and when _____
11. Mention the plants you collect and their uses/economic importance

    A. Timber [ ], B. Medicine [ ], C. Firewood [ ], D. Furniture [ ], E. Craft [ ], F. Fodder [ ], G. Food [ ], H. Construction [ ], I. Oil. Dye and spices [ ], J. Fencing [ ], K. Tools [ ], L. Magic [ ] M. For other purposes (specify below)

    _____

Species/ Voucher #	Local Name	Uses

12. Specify names of plants, parts and how used

Species	Parts	How used	Frequency of Collection Once? weekly? or monthly?

Wild Medicines from forest

13. Which do you prefer: Herbal medicine [ ], Orthodox [ ]

14. Do you know how to prepare any herbal medicine: Yes [ ], No [ ]

15. What diseases can you treat with your knowledge of herbal medicine? A. Headache [ ], B. Fever [ ], C. Malaria [ ], D. Impotency [ ], E. Infertility [ ], F. Pile and Back pain [ ], G. insomnia [ ], H. Stomach ache [ ], I. Ulcer [ ] J. Fatigue [ ]

16. Specify name of plants used for the above

Ailments	Names of plant	Parts	How used
Headache			
Fever			
Malaria			
Impotency			
Infertility			
Pile and back pain			
Insomnia			
Stomach ache			
Ulcer			
Fatigue			

19. What volume of plant parts do you collect?

A. Low [ ], B. Moderate [ ], C. A lot [ ]

Conservation of plants

20. Names of plants that you use that is becoming rare / threatened in the area
21. List factors that threaten plants e.g. bush fires, overharvesting etc
22. Do you also collect the same plants from elsewhere? List plants and other places you collect from?

APPENDIX 4

Appendix 4: Species, families and Growth form sampled in plot 1

Altitude = 81m, Aspect = East-North, Vegetation type = Open canopy and GPS Coordinate = N05.53202°, W000.50760°

Species	Family	Growth form
Acridocarpus longifolius	Malpighiaceae	Tree
Aerangis biloba	Orchidaceae	Epiphyte
Alafia sp.	Apocynaceae	Liana
Antiaris toxicaria	Moraceae	Tree
Artabotrys insignis	Annonaceae	Liana
Asystacia sp.	Acanthaceae	Herb
Baissea zygodioides	Apocynaceae	Liana
Carpolobia lutea	Polygalaceae	Shrub
Ceiba pentandra	Bombacaceae	Tree
Celtis wightii	Ulmaceae	Tree
Chassalia kolly	Rubiaceae	Shrub
Chromolaena odorata	Asteraceae	Herb
Cissus arguta	Vitaceae	Climber
Cissus sp.	Vitaceae	Liana
Cola millenii	Sterculiaceae	Tree
Dialium guineensis	Fabaceae	Tree
Dichapetalum sp.	Menispermaceae	Liana
Digitaria insularis	Gramineae	Herb
Dracaena aborea	Dracaenaceae	Tree

Appendix 4: (Cont'd)

Altitude = 81m, Aspect = East-North, Vegetation type = Open canopy and GPS Coordinate = N05.53202°, W000.50760°

Species	Family	Growth form
Drypetes parvifolia	Euphorbiaceae	Shrub
Elaephorbia drupifera	Euphorbiaceae	Tree
Elytaria marginata	Acanthaceae	Herb
Erythrococca anomala	Euphorbiaceae	Shrub
Erythroxylum emarginatum	Erythroxylaceae	Tree
Ficus exasperata	Moraceae	Tree
Graptophyllum pictum	Acanthaceae	Shrub
Grewia megalocarpa	Tiliaceae	Shrub
Griffonia simiplicifolia	Fabaceae	Shrub
Hildegardia barteri	Sterculiaceae	Tree
Hypselodelphys violacea	Marantaceae	Tree
Landolphia macratha	Apocynaceae	Climber
Lantana camara	Verbenaceae	Herb
Mallotus opposifolius	Euphorbiaceae	Shrub
Millettia thonningi	Fabaceae	Tree
Millettia zechiana	Fabaceae	Tree
Monodora tenuifolia	Annonaceae	Tree
Pellaea doniana	Adiantaceae	Shrub
Ritchiea reflexa	Capparaceae	Shrub
Salacia sp.	Celastraceae	Shrub
Sanseviera liberica	Dracaenaceae	Herb

Appendix 4: (Cont'd):

Altitude = 81m, Aspect = East-North, Vegetation type = Open canopy and GPS Coordinate = N05.53202°, W000.50760°.

Species	Family	Growth form
Strophantus gratus	Apocynaceae	Shrub
Talinum triangularis	Talinaceae	Herb
Teclea verdoorniana	Rutaceae	Tree
Tiliacora dielsiana	Menispermaceae	Shrub
Tragia sp.	Euphorbiaceae	Tree
Uvaria globusa	Annonaceae	Shrub
Undetermined	Unidentified	Tree

APPENDIX 5

Appendix 5: Species, families and Growth form sampled in plot 2

Altitude = 67m, Aspect = None, Vegetation type = Open canopy and GPS Coordinate = N05.53414°, W000.50574°.

Species	Family	Growth form
Abrus precatorius	Fabaceae	Climber
Achyranthes bidentata	Amaranthaceae	Tree
Acridocarpus longifolius	Malpighiaceae	Tree
Afzelia africana	Fabaceae	Tree
Alafia sp.	Apocynaceae	Shrub
Albizia adianthifolia	Mimosaceae	Shrub
Albizia zygia	Mimosaceae	Tree
Artabotrys insignis	Annonaceae	Tree
Baissea zygodioides	Apocynaceae	Shrub
Baphia nitida	Fabaceae	Climber
Bulbophyllum phaeopogon	Orchidaceae	Shrub
Callichilia subsessilis	Apocynaceae	Tree
Calyptrochilum emarginatum	Orchidaceae	Herb
Capparis sp.	Rutaceae	Tree
Carpolobia lutea	Polygalaceae	Tree
Celtis mildbraedii	Ulmaceae	Tree
Celtis wightii	Ulmaceae	Tree
Chassalia kolly	Rubiaceae	Tree
Chromolaena odorata	Compositae	Shrub
Cissus arguta	Vitaceae	Tree

Appendix 5: (Cont'd)

Altitude = 67m, Aspect = None, Vegetation type = Open canopy and GPS Coordinate = N05.53414°, W000.50574°.

Species	Family	Growth form
Clerodendrum capitatum	Verbanaceae	Shrub
Cola millenii	Sterculiaceae	Shrub
Cyathula prostrata	Amaranthaceae	Herb
Dialium guineensis	Fabaceae	Tree
Diospyros abyssinica	Ebenaceae	Tree
Diospyros kamerunensis	Ebenaceae	Shrub
Dracaena arborea	Dracaenaceae	Shrub
Dracaena surculosa	Dracaenaceae	Tree
Drypetes parvifolia	Euphorbiaceae	Tree
Floscopa sp.	Commelinaceae	Shrub
Gardenia nitida	Rubiaceae	Tree
Graptophyllum pictum	Acanthaceae	Shrub
Griffonia simplicifolia	Fabaceae	Tree
Hunteria ghanensis	Apocynaceae	Shrub
Hypselodelphys violacea	Marantaceae	Herb
Lecaniodiscus cupaniodes	Sapindaceae	Climber
Mallotus opposifolius	Euphorbiaceae	Tree
Momordica charantia	Cucurbitaceae	Shrub
Monodora tenuifolia	Annonaceae	Tree
Nesogordonia papaverifera	Sterculiaceae	Liana

Appendix 5: (Cont'd)

Altitude = 67m, Aspect = None, Vegetation type = Open canopy and GPS Coordinate = N05.53414°, W000.50574°.

Species	Family	Growth form
Oplismenus hirtellus	Gramineae	Shrub
Pouteria alnifolia	Sapotaceae	Liana
Ritchiea reflexa	Capparaceae	Tree
Rothmannia longiflora	Rubiaceae	Epiphyte
Rothmannia urcelliformis	Rubiaceae	Tree
Sorindeia jugladifolia	Anacardiaceae	Shrub
Sterculia tragacantha	Sterculiaceae	Herb
Tragia sp.	Euphorbiaceae	Shrub
Trichilia prieureana	Meliaceae	Herb
Vigna radiata	Fabaceae	Shrub
Undetermined	Celastraceae	Liana
Undetermined	Apocynaceae	Climber
Undetermined	Acanthaceae	Shrub
Undetermined	Celastraceae	Herb
Undetermined	Unidentified	Tree
Undetermined	Unidentified	Shrub
Undetermined	Unidentified	Liana
Undetermined	Unidentified	Herb
Undetermined	Unidentified	Herb

APPENDIX 6

Appendix 6: Species, families and Growth form sampled in plot 3

Altitude = 51m, Aspect = South-East, Vegetation type = Seasonal flooded forest and GPS Coordinate = N05.53867°, W000.50567°.

Species	Family	Growth form
Abrus precatorius	Fabaceae	Climber
Acridocarpus longifolius	Malpighiaceae	Tree
Afzelia africana	Fabaceae	Tree
Albizia adianthifolia	Mimosaceae	Tree
Albizia zygia	Mimosaceae	Tree
Antiaris toxicaria	Moraceae	Tree
Artabotrys insignis	Annonaceae	Liana
Baissea multiflora	Apocynaceae	Shrub
Baphia nitida	Fabaceae	Shrub
Blighia sapida	Sapindaceae	Tree
Canthium cornelia	Rubiaceae	Shrub
Carpolobia lutea	Polygalaceae	Shrub
Ceiba pentandra	Bombacaceae	Tree
Celtis mildbraedii	Ulmaceae	Tree
Celtis wightii	Ulmaceae	Tree
Chaetacme aristata	Ulmaceae	Tree
Chassalia kolly	Rubiaceae	Shrub
Undetermined	Apocynaceae	Tree
Undetermined	Unidentified	Tree

Appendix 6: (Cont'd)

Altitude = 51m, Aspect = South-East, Vegetation type = Seasonal flooded forest and GPS Coordinate = N05.53867°, W000.50567°.

Species	Family	Growth form
Chromolaena odorata	Asteraceae	Herb
Cola millenii	Sterculiaceae	Tree
Deinbollia pinnata	Sapindaceae	Tree
Dialium guineensis	Fabaceae	Tree
Dicapetallum sp.	Dichapetalaceae	Liana
Diospyros abyssinica	Ebenaceae	Tree
Dracaena surculosa	Dracaenaceae	Tree
Drypetes parvifolia	Euphorbiaceae	Shrub
Erythroxylum emarginatum	Erythroxylaceae	Tree
Flagelaria guineense	Flagellariaceae	Liana
Griffonia simiplicifolia	Fabaceae	Shrub
Hypselodelphys violacea	Marantaceae	Tree
Lecaniodiscus cupaniodes	Sapindaceae	Shrub
Mallotus opposifolius	Euphorbiaceae	Shrub
Mansonia altissima	Sterculiaceae	Tree
Millettia chrysophylla	Fabaceae	Tree
Monodora tenuifolia	Annonaceae	Tree
Nesogordonia papaverifera	Sterculiaceae	Tree
Olyra latifolia	Gramineae	Herb
Rothmannia longiflora	Rubiaceae	Shrub

Appendix 6: (Cont'd)

Altitude = 51m, Aspect = South-East, Vegetation type = Seasonal flooded forest and GPS Coordinate = N05.53867°, W000.50567°.		
Species	Family	Growth form
Sorindeia jugladifolia	Sapindaceae	Shrub
Strychnos icaja	Loganiaceae	Liana
Synsepalum sp.	Sapotaceae	Tree
Teclea verdoorniana	Rutaceae	Tree
Trichilia prieureana	Meliaceae	Tree
Triplochiton scleroxylon	Sterculiaceaae	Tree
Turraea heterophylla	Meliaceae	Shrub

Appendix 7: Species, families and Growth form sampled in plot 4

Altitude = 79m, Aspect = West-South, Vegetation type = Thicket and GPS Coordinate = N05.54188°,W000.50384°.

Species	Family	Growth form
Adenia lobata	Passifloraceae	Liana
Albizia zygia	Fabaceae	Tree
Alchornea cordifolia	Euphorbiaceae	Tree
Antiaris toxicaria	Moraceae	Tree
Baissea multiflora	Apocynaceae	Shrub
Carica papaya	Caricaceae	Tree
Ceiba pentandra	Bombacaceae	Tree
Chromolaena odorata	Asteraceae	Herb
Cola millenii	Sterculiaceae	Tree
Deinbollia pinnata	Sapindaceae	Tree
Dracaena aborea	Dracaenaceae	Tree
Ficus exasperata	Moraceae	Tree
Graptophyllum pictum	Acanthaceae	Shrub
Griffonia simplicifolia	Fabaceae	Shrub
Hypselodelphys violacea	Marantaceae	Tree
Lecaniodiscus cupanioides	Sapindaceae	Shrub
Marantochloa leucantha	Marantaceae	Herb

Appendix 7: (Cont'd)

Altitude = 79m, Aspect = West-South, Vegetation type = Thicket and GPS Coordinate = N05.54188°,W000.50384°.		
Species	Family	Growth form
Momordica charantia	Cucurbitaceae	Herb
Nauclea pobeguinii	Rubiaceae	Tree
Nesogordonia papaverifera	Sterculiaceae	Tree
Olyra latifolia	Gramineae	Herb
Panicum maximum	Gramineae	Herb
Parquetina nigrescens	Ascelpidaceae	Liana
Ritchiea reflexa	Capparaceae	Shrub
Solanium erianthum	Solanaceae	Shrub
Trichilia prieureana	Meliaceae	Tree
Triplochiton scleroxylon	Sterculiaceae	Tree

APPENDIX 8

Appendix 8: Species, families and Growth form sampled in plot 5

Altitude = 79m, Aspect = West-South, vegetation type = Closed canopy forest and GPS Coordinate = N05.54188°,W000.50384°.

Species	Family	Growth form
Acacia kamerunensis	Mimosaceae	Tree
Acridocarpus longifolius	Malpighiaceae	Tree
Aninigeria altissima	Sapotaceae	Tree
Antiaris toxicaria	Moraceae	Tree
Baissea multiflora	Apocynaceae	Shrub
Baissea zygodioides	Apocynaceae	Liana
Baphia nitida	Fabaceae	Shrub
Blighia sapida	Sapindaceae	Tree
Celtis wightii	Ulmaceae	Tree
Chassalia kolly	Rubiaceae	Shrub
Cissus diffusiflora	Vitaceae	Climber
Cola millenii	Sterculiaceae	Tree
Diospyros abyssinica	Ebenaceae	Tree
Dracaena aborea	Dracaenaceae	Tree
Dracaena surculosa	Dracaenaceae	Tree
Drypetes parvifolia	Euphorbiaceae	Shrub
Elaephorbia drupifera	Euphorbiaceae	Tree
Erythroxylum emarginatum	Erythroxylaceae	Tree
Ficus exasperata	Moraceae	Tree
Griffonia simplicifolia	Fabaceae	Shrub

Appendix 8: (Cont'd)

Altitude = 79m, Aspect = West-South, vegetation type = Closed canopy forest and GPS Coordinate = N05.54188°,W000.50384°.

Species	Family	Growth form
Hilleria latifolia	Phytolaccaceae	Herb
Hunteria ghanansis	Apocynaceae	Tree
Hymenostygia afezelii	Fabaceae	Tree
Hypselodelphys violacea	Marantaceae	Tree
Lecaniodiscus cupaniodes	Sapindaceae	Shrub
Mansonia altissima	Sterculiaceae	Tree
Nesogordonia papaverifera	Sterculiaceae	Tree
Ritchiea reflexa	Capparaceae	Shrub
Salacighia letestuana	Celastraceae	Liana
Solanum enriathum	Solanaceae	Shrub
Sterculia tragacantha	Sterculiaceae	Tree
Teclea verdoorniana	Rutaceae	Tree
Trichilia prieureana	Meliaceae	Tree
Triplochiton scleroxylon	Sterculiaceae	Tree
Uvaria globusa	Annonoceae	Shrub
Vigna radiata	Fabaceae	Shrub
Undetermined	Fabaceae	Climber

APPENDIX 9

Appendix 9: Species, families and Growth form sampled in plot 6

Altitude = 80m, Aspect = South-West, vegetation type = Closed canopy forest and GPS Coordinate = N05.541589°, W000.50192°.

Species	Family	Growth form
Abrus precatorius	Fabaceae	Climber
Acacia pennata	Mimosaceae	Tree
Afzelia africana	Fabaceae	Tree
Antiaris toxicaria	Moraceae	Tree
Baissea multiflora	Apocynaceae	Shrub
Baissea zygodioides	Apocynaceae	Liana
Baphia nitida	Fabaceae	Shrub
Chassalia kolly	Rubiaceae	Shrub
Cola millenii	Sterculiaceae	Tree
Dialium guineensis	Fabaceae	Tree
Dracaena aborea	Dracaenaceae	Tree
Drypetes parvifolia	Euphorbiaceae	Tree
Elaephorbia drupifera	Euphorbiaceae	Tree
Erythroxylum emarginatum	Erythroxylaceae	Tree
Ficus exasperata	Myrtaceae	Tree
Griffonia simplicifolia	Fabaceae	Shrub
Hildegardia barteri	Sterculiaceae	Tree
Hilleria latifolia	Phytolaccaceae	Herb
Hypselodelphys violacea	Marantaceae	Tree
Manilkara obovata	Sapotaceae	Tree

Appendix 9: (Cont'd):

Altitude = 80m, Aspect = South-West, vegetation type = Closed canopy forest and GPS Coordinate = N05.541589°, W000.50192°.

Species	Family	Growth form
Mansonia altissima	Sterculiaceae	Tree
Millettia zechiana	Fabaceae	Tree
Nesogordonia papaverifera	Sterculiaceae	Tree
Sanseviera liberica	Dracaenaceae	Herb
Trichilia prieureana	Meliaceae	Tree

APPENDIX 10

Appendix 10: Species, families and Growth form sampled in plot 7

Altitude = 93m, Aspect = North-East, Vegetation type = Closed canopy and GPS Co. = N05.54714°, W000.50080°.

Species	Family	Growth form
Artabotrys insignis	Annonaceae	Liana
Baphia nitida	Fabaceae	Shrub
Celtis mildbraedii	Ulmaceae	Tree
Celtis wightii	Ulmaceae	Tree
Chaetacme aristata	Ulmaceae	Tree
Chassalia kolly	Rubiaceae	Shrub
Cola millenii	Sterculiaceae	Tree
Dialium guineensis	Fabaceae	Tree
Diospyros abyssinica	Ebenaceae	Tree
Dracaena aborea	Dracaenaceae	Tree
Drypetis parvifolia	Euphorbiaceae	Shrub
Erythroxylum emarginatum	Erythroxylaceae	Tree
Griffonia simplicifolia	Fabaceae	Shrub
Hilleria latifolia	Phytolaccaceae	Herb
Hunteria ghanensis	Apocynaceae	Tree
Lecaniodiscus cupaniodes	Sapindaceae	Shrub
Mallotus opposifolius	Euphorbiaceae	Shrub
Manilkara obovata	Sapotaceae	Tree
Mansonia altissima	Sterculiaceae	Tree
Monodora tenuifolia	Annonaceae	Tree

Appendix 10: `(Cont'd)

Altitude = 93m, Aspect = North-East, Vegetation type = Closed canopy and GPS Co. = N05.54714°, W000.50080°.

Species	Family	Growth form
Nesogordonia papaverifera	Sterculiaceae	Tree
Pouteria alnifolia	Sapotaceae	Tree
Ritchiea reflexa	Capparaceae	Shrub
Sterculia tragacantha	Sterculiaceae	Tree
Teclea verdoorniana	Rutaceae	Tree
Trichilia prieureana	Meliaceae	Tree

APPENDIX 11

Appendix 11: Species, families and Growth form sampled in plot 8

Altitude = 80m, Aspect = North-East, Vegetation type = Closed canopy and GPS Coordinate = N05.54642°, W000.54643°.

Species	Family	Growth form
Acridocarpus longifolius	Malpighiaceae	Tree
Afzelia africana	Fabaceae	Tree
Bassia multiflora	Apocynaceae	Shrub
Ceiba pentandra	Bombacaceae	Tree
Celtis wightii	Ulmaceae	Tree
Chassalia kolly	Rubiaceae	Shrub
Cissus quadrangularis	Vitaceae	Herb
Cola millenii	Sterculiaceae	Tree
Dialium guineensis	Fabaceae	Tree
Diospyros abyssinica	Ebenaceae	Tree
Dracaena aborea	Dracaenaceae	Tree
Dracaena surculosa	Dracaenaceae	Tree
Drypetis parvifolia	Euphorbiaceae	Shrub
Griffonia simiplicifolia	Fabaceae	Shrub
Hildegardia barteri	Sterculiaceae	Tree
Hymenostygia afezelii	Fabaceae	Tree
Lecaniodiscus cupaniodes	Sapindaceae	Shrub

Appendix 11: (Cont'd)

Altitude = 80m, Aspect = North-East, Vegetation type = Closed canopy and GPS Coordinate = N05.54642°, W000.54643°.

Species	Family	Growth form
Mallotus opposifolius	Euphorbiaceae	Shrub
Millettia zechiana	Fabaceae	Tree
Olyra latifolia	Gramineae	Herb
Ritchiea reflexa	Capparaceae	Shrub
Sorindeia jugladifolia	Anacardiaceae	Shrub
Tragia sp.	Euphorbiaceae	Tree
Uvaria globusa	Annonaceae	Tree

APPENDIX 12

Appendix 12: Species, families and Growth form sampled in plot 9

Altitude = 125m, Aspect = North-West, Open canopy veg. type and GPS Coordinate = N05.54570°, W000.50084°.

Species	Family	Growth form
Baphia nitida	Fabaceae	Shrub
Canthium sarcocarpum	Rubiaceae	Herb
Cissus arguta	Vitaceae	Shrub
Dracaena surculosa	Dracaenaceae	Tree
Drypetis parvifolia	Euphorbiaceae	Shrub
Hildergadia barteri	Sterculiaceae	Tree
Hypselodelphys violacea	Marantaceae	Tree
Millettia chrysophylla	Fabaceae	Tree
Millettia zechiana	Fabaceae	Tree
Sanseviera liberica	Dracaenaceae	Herb
Uvaria globusa	Annonaceae	Tree