AN ASSESSMENT OF THE CURRENT ECOLOGICAL STATUS OF KAGORO/TSONJE RIPARIAN FOREST, KADUNA STATE

By

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DECLARATION

I declare that the work in the thesis entitled AN ASSESMENT OF THE CURRENT ECOLOGICAL STATUS OF KAGORO/TSONJE RIPARIAN FOREST has been performed by me in the department of Biological Sciences under the supervision of Dr M.L Balarabe and Dr F.A Tisser. The information derieved from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

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ABAGAI, ROSE TAKAI DATE/SIGN

CERTIFICATION

This Thesis entitled “AN ASSESMENT OF THE CURRENT ECOLOGICAL STATUS OF KAGORO/TSONJE RIPARIAN FOREST, KAURA LOCAL GOVERNMENT AREA OF KADUNA STATE” by ABAGAI ROSE TAKAI meets the regulations governing the award of the degree of Master of Science in Educationnal Biology of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This research work is dedicated to God Almighty, the giver of wisdom, knowledge and understanding. To Him be the glory. The research is also dedicated to my beloved of blessed memory, Mr. D.H. Kazah (Father), Mr. Alhamdu Haruna (brother), and Mrs. Deborah S.T.Y Kukah (friend).

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To God be the glory.

Abstract

The current ecological status of the Kagoro/Tsonje riparian forest was assessed and information was gathered on the flora and bird fauna, water quality parameters and soil status. Other data collections were phytoplankton types and population. Physiocochemical properties of the soil were tested .Modified Whittakker plots were used to evaluate woody species for density, diversity and similarity measure. One metre by one metre quadrats were used to evaluate herbaceous plants for same parameters in addition to dry matter determination. Density and diversity of algal groups in the water were determined using methods described by APHA., while physicochemical parameters of water were tested instrumentally and by laboratory procedures. Results showed that the population of the woody plants in this riparian forest had declined within the period of one year of study. The forest had a woody population of 336 plants in the encroached area per hectare and 97 woody plants in the farmed area per hectare before the farming season. After the farming season, the population of woody plants decreased to 121 and 31 respectively. As a result of the disturbances of the forest, the important Avian species Vannellus supercilliosus, Chrysococyx flavigularis, Cassypha natalensis and Camphephage quiscalina which made the forest to be known for its ornithological importance were not sighted at the time this study was undertaken. The result of the water analysis showed abundance of phytoplakton and Baccillariophyta as the highest algal division at all seasons. The population of this division in the wet season was higher than the dry season [119 and 36] respectively. This trend was similar for Chlorophyta, Cyanophyta and Euglenophyta. Soil particle size of the riparian forest showed a non significant ($P > 0.05$) difference between farmed and encroached forest segments indicating the variability of soils in a riparian area. The organic carbon content also showed a significant ($P < 0.05$) difference.

TABLE OF CONTENTS

CHAPTER TWO

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

CHAPTER SIX

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE

1.0 INTRODUCTION

The Kagoro forest comprises of four forest reserves and areas of communal land near Kagoro in Southern Kaduna State of Nigeria. It is located between Jama'a and Kaura Local Government on latitude $9^{0}31`542``$ and $9^{0}33`509``$ N and longitude $8^{0}22`.244``$ and $8^{0}22`262``$ E. The reserves are situated in the Kagoro Hills, (a western extension of the Jos Plateau) which rises to over 1,300m and dominates the landscape (Birdlife, 2008,Ezealor, 2002). The area is about 1754 acres (approximately 710 hectares) and is drained by numerous steams which empty into the Sanga River (Benjaminson, 1971, Ezealor, 2002). The vegetation of the forest is a moist type and occurs mainly in river and stream valleys. As a result of the relatively higher annual average rainfall of 1556mm of this area, forest outliers also occur outside of the riparian formations.

The riparian vegetation created by these numerous streams is important to the environment, biodiversity conservation and obviously the people of Kagoro for the following reasons:

It sustains the stream environment, enhances the hydrologic cycle, purifies the atmosphere of some pollutants, and creates conducive habitats of diverse types

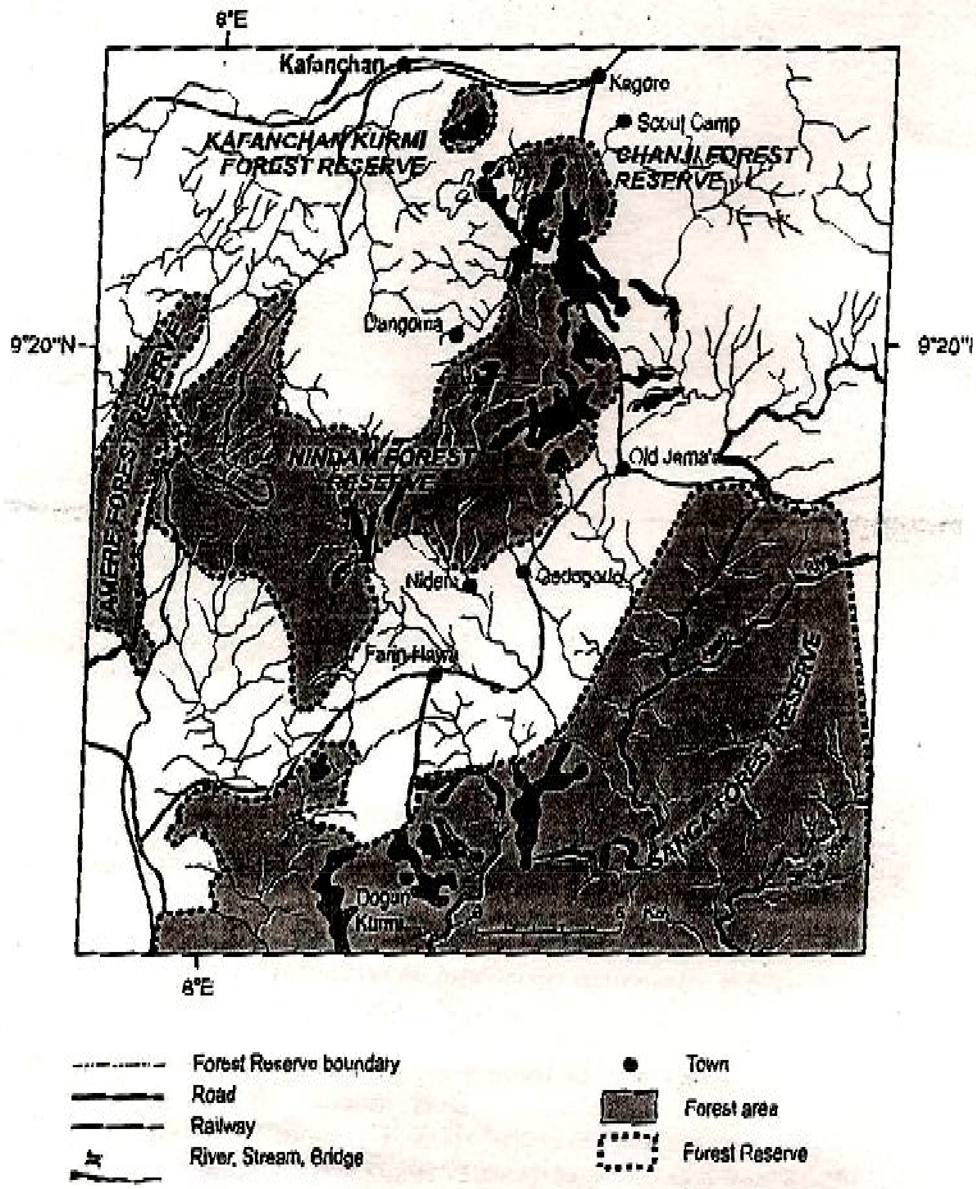

Fig. 1: Map Showing Kagoro/Tsonje Forest

for increased flora and wild stock interaction (Austin, 2008). It creates a microclimatic effect distinct from surrounding areas. This particular importance may have accounted for the Kagoro/Tsonje forest being the only known site of habitation within Nigeria for the purple-throated Cuckoo-Shrike *Camphephage quiscalina* (Abalaka, 2008). It is also one of the two localities where the Redcapped Robin-chat *Cassypha natalensis* and the Yellow-throated Cuckoo *Chrysococyx flavigularis* have been recorded. Another important bird species recorded as associated with vegetation was Brown chested wattled plover *Vanellus supercilliosus* (Abalaka, 2008, Birdlife, 2008, Ezealor, 2002). The higher rainfall averages over the Kagoro region made the Kagoro forest a close similitude of the moist lowland forest. It was physiognomically an extra zonal formation of the moist lowland forest in the guinea savanna region. The diverse habitats possible in that ecosystem coupled with adjacent moist deciduous forests of guinea vegetation presented a possibility of high density and diversity of fauna and flora.

Due to the intensive farming activities of the people of this region, woodlands have become restricted to ridge mountain tops as previously forested parts have been cleared for agriculture. The patches of Forest in this area typify the ecological phenomenon called forest fragmentation which is tending towards decimation.

1.1 Statement Of The Problem

The observed vegetation changes in and around the Kagoro/Tsonje forest have become a matter of concern. Several reasons such as slash and burn agriculture, indiscriminate logging, poaching, livestock grazing, forest fires among others, can be adduced for these changes. A new dimension to these changes is the deliberate destruction of these resources by two neighboring communities, the Kagoro and Ninzam people who deliberately maintain activities within the forest in order to assert ownership of the resource.

The complete disappearance of what used to be known as the Kagoro/ Tsonje forest is therefore a disaster waiting to happen. Unfortunately, not much had been documented with respect to the biotic and abiotic component of the forest community. As such, if a reconstruction be desired it may almost be impossible without a good knowledge of these factors of the Kagoro/Tsonje forest.

1.2 Justification

Though it is well known that the Kagoro/Tsonje forest is being degraded, the level of destruction and the major factors have not been assessed. Research is therefore required in order to create a base-line information in this ecological environment called Kagoro/Tsonje forest. It will also go a long way to assess the current ecological status of the components of the forest. It is also possible that the visible presence of research activities around the forest will create awareness of the importance of this resource to the peoples of Kagoro.

1.3 Aim of The Study

The aim of the study is to determine and record the current state of the ecological components of the Kagoro/Tsonje riparian forest.

1.4 Objectives

- To determine the current flora and bird fauna of the Reserve Forest.
- To determine the current availability and states of surface water of the Forest.
- To determine the soil/ physicochemical properties of the Reserve Forest.
- To determine the current activities causing degradation in the Forest.

1.5 Hypotheses

- The current vegetation and bird fauna of the forest are not typical of a virgin moist riparian Forest.
- The streams of Kagoro forest are not affected by the disturbances in volume of water, chemical and physical properties.
- The soils of Kagoro forest are not typical of the organic loamy soil of the Riparian forest type.
- There are no significant degradation activities challenging the integrity of the Kagoro riparian forest.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

A riparian zone is the interface between land and a flowing surface water body. Plant communities along the river margins are called riparian vegetation characterize by hydrophilic plants. Riparian zones are significant in ecology, environment management and civil engineering due to their role in soil conservation, their biodiversity, and the influence they have on aquatic system. They occur in many forms including grassland, woodland, wetland or even areas of sparse vegetation. In some regions, the terms riparian forest, riparian buffer zone or riparian strip are used to describe a riparian zone. (Wikipedea, 2008).

Klapproth and Johnson (2008), defines a riparian area as that area of land located immediately adjacent to streams, lakes or other surface waters. The area occupied by a riparian system has the characteristics of a flood plain. The boundary of the riparian area and the adjoining uplands is gradual and not always well-defined. However, riparian areas differ from the uplands because of high level of soil moisture, frequent flooding and the unique assemblage of plant and animal communities found there. Through the interaction of their soils, hydrology, and biotic communities, riparian forest maintain many important physical, biological and ecological functions and important social benefits (Klapproth and Johnson, 2008). The importance of riparian forest in the functioning of river ecosystems and biodiversity protection is recognized all over the world by numerous Researchers. The rapid changes in land cover all over the world have led to the destruction and fragmentation of riparian slopes in most places where they occur. Their abusive over use is widespread and growing hence, they are classified as endangered ecosystems (Natta *et al.,* 2002). Riparian forests are often small in area, but are of extreme ecological and economic value for local people. The Kagoro/Tsonje forest was gazetted in 1954, as Kagoro native authority forest and published as NRLN 18 of 1954 on page B. 53 of the supplementary Northern Region gazette No 18 of July 29, 1954. The reserve was carved to cover an area of 2.75 sq miles and contained two major streams. These were Abum stream and Rafin Tabo stream. There were other drainage channels that took off from Abum stream and transverse several sections of the Reserve Forest (see map on page 9). The Abum stream and tributaries appeared to have taken their origin from the adjacent hills and from there flowed into the low lying area that was the major concentration of the forest ecosystem. The consequence is that, relief rains due to the adjacent higher elevations watered the low lying forest which was also supplied with water from the Abum and Rafin Tabo streams. This made the Kajoro/Tsonje forest a typical wet forest similar to the low land moist forest of Southern Nigeria.

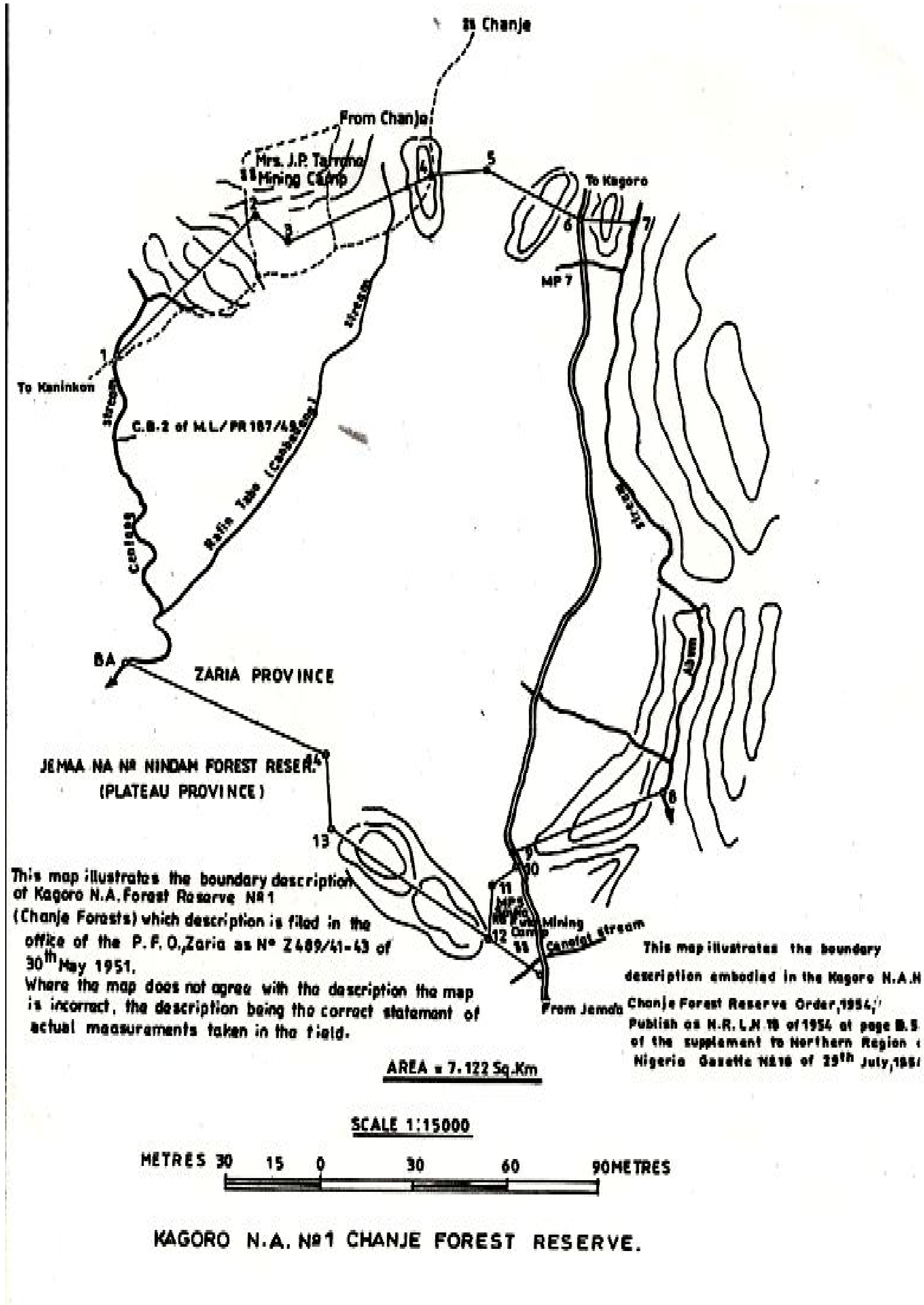

Fig.2: Map of boundary description of Kagoro N.A. Forest Reserve No.1

2.2 Riparian Plant Communities

Riparian areas support some of the most diverse and productive of all plant communities. This is primarily as a result of the rich soils and abundant moisture. They have readily available water and productive soils. As such they support a greater plant biomass than is usually found in upland areas, resulting in forests with a wide variety of species and complex vertical structure (LaRue *et al.,* 1995).

The diverse plant community is hence subject to regular ecological disturbance. These disturbances could be both chronic (predictable, occurring monthly to yearly) and episodic (not predictable, usually occurring decades or centuries apart). They take the form of floods, fires, wind and pests and are capable of producing large-scale changes in the plant community, or smaller patchy clearings scattered about the flood plain (Gregory *et al.,* 1991, Bohlen and King, 1996),and are capable of producing large-scale changes in the plant community, or smaller patchy clearings scattered about the floodplain. Disturbances contribute to the highly variable topography, hydrology and soils found in riparian area. It is not uncommon to find deep deposits of soil and gravel, rock outcrops, spring seeps, muddy areas all within the same floodplain. This range of physical habitats, each support a distinct vegetation and hence contribute to species richness and high diversity of flora and fauna that can be found in Riparian areas.

2.3 The Soils Of Kagoro/Tsonje Forest

The Kagoro/Tsonje forest reserve soils were reported as clay-loam to clay and all layers commonly contained many fine mica corns. They were also said to be soft and crumbly, non-sticky nor plastic when wet. The upper 4 inches layer were reportedly dark brown, from 4 to 11 inches the soil was a dark yellowish brown, from 11 to 29 inches the colour was strong brown and from 29 to 65 inches, it was pale yellow to yellowish brown. The soil was on the whole classed under Ferruginous Tropical soils on crystalline rock (Benjaminson, 1971). Further more, the same author found the soils chemical characteristics as having a low pH of 4.9 in the surface area which rises about 1 pH unit in subsequent layers. The saturation percentage indicated a heavy soil type, except for the upper layers where the content of exchangeable potassium was very high. The organic matter content was high down through the profile and so was the content of total Nitrogen. Carbon to Nitrogen ratio (C:N) was 10 to 5 in the surface layer, deceasing with the depth. Despite these characteristics, rapid ecological processes in Riparian strips make soils in riparian areas to be highly variable, resulting from a combination of local soils weathered in certain places, deposits of sediments from storm events, and accumulation of organic debris (Lowrence, *et al.,* 1985).

Scientists in Southern New England have observed that riparian soils vary considerably in a distance of as little as 30 feet (Gold and Goffman, 1995).Riparian forests with organic soils have great potentials to enhance water quality, by infiltrating a large amount of surface runoff, adsorbing nitrogen and other contaminants and supplying carbon needed to fuel microbial processes. A recent study in the Midwest USA concluded that the major factor influencing the movement of nutrients and herbicides through the soil was its organic carbon content (U.S.D.A.A.R.S. 1995).

2.4 Riparian Animal Communities

Riparian areas provide critical habitats for many types of wildlife because of their diverse productive and complex structure of their plant communities, as well as proximity to water. The wildlife may be permanent resident of the riparian area or occasional visitors that use the area for food, water or temporary shelter (Klapproth and Johnson 2008). Food availability varies with the type of vegetation in the riparian area, but includes fruits, seeds, foliage, twigs, buds, insects and other invertebrates. Trees and shrubs produce a variety of food that are eaten by many animals and may be especially important source of nutrition during the dry season period. Grasses and herbaceous vegetation provide seeds and forage both within the riparian area along the forest border. (Klapproth and Johnson, 2008).

The stream environment provides moving water for many animals to drink, feed, swim and reproduce. Water is also available on the moist vegetation and in the shallow wetland pools and backwater common to many riparian areas. These areas, both permanent and temporary, are especially important for amphibians and macro invertebrates (Clark, 1978).

The main attribute believed to attract livestock to riparian areas are similar to those that attract wildlife. These include availability of water, shade, thermal cover and quality and variety of forage (Kaufman and Kruger 1984, Brady *et al.,*1985). Riparian areas provide a sheltered environment for many species of animals to feed, rest and reproduce. Animals use these areas to seek shelter from extremes of weather and to escape predators and human activities (Compton *et al*., 1988, Johnson and Beck, 1988). Riparian areas may also provide important travel corridors for some species and are frequently used as stop over points for migratory birds (Klapproth and Johnson 2008). Decrease in the quality and quantity of riparian ecosystems have therefore contributed to the widespread elimination of several avian species (Goldwasser *et al*., 1980, Gaines and Layman 1984, Serena,1982, Gray and Graves 1984). The distinct rainy and dry seasons in Nigeria have necessitated migratory life of several species of animals. Riparian strips are stop over sites for species to rebuild body fat reserves for the onward journey (Skagen *et al*., 1998). The Kagoro/Tsonje forest is a breeding area for *Vanellus supercilliosus* (nest recorded in 1987 and 1997) and is one of the two localities from which *Chysococcyx flavigularis* has been recorded in Nigeria (Ezealor 2002, Birdlife, 2008).

2.5 Aquatic Communities

Ecologically, riparian streams contained massive accumulation of woody debris that created a complex constricted aquatic environment (Harmon *et al.,* 1986). This channel constrictions cause frequent flooding and develops a complex network of channels and wetlands (Everest *et al.,* 1985). The removal of forest can affect the stream environments in many ways, including loss of food, habitat and water quality. The location of forested buffers around streams can help restore these habitats. Riparian forests influence the aquatic community through their effect on food availability, habitat diversity, stream flow, light intensity, water temperature and chemistry. These factors determine the productivity and variety of plants, micro-organisms, invertebrates, and fish found in the stream.

Riparian forests provide food for stream organisms in the form of twigs, branches, bark, leaves, nuts, fruits, flowers and insects falling from the forest cover. Streamside forests also influence the stream community by modifying the level of nutrients and dissolved organic matter leaching from the surrounding (Sweeny, 1993).

Deciduous forest bordering streams, deposit large amounts of organic materials into the streams, mostly during leaf fall and as buds burst and flower (Moss, 1988). This rich organic material complex is slowly broken down by aquatic microorganisms and stream invertebrates to products which form the base of the food chain for large aquatic organisms such as fish.

The environment of larger streams is very different from that of headwater streams. Where streams are deeper and wider, sunlight penetrates the forest canopy and filamentous green algae and rooted aquatic plants become more common (Cummins, 1974, Wallace and Benke, 1984).These aquatic plants begin to replace organic debris as the food source for aquatic microorganisms and invertebrate. However, the interaction between the riparian area and the streams remains. Small fish find refuge along the margins of streams and depend on insects and plant materials from the surrounding forest for food (Manci, 1989). During flood events, organic debris is washed from the riparian area into the stream, providing an important surge of nutrient and dissolved carbon for plant growth. The productivity of mid-order stream is also influenced by the quality of water, nutrients and organic matter they receive from up stream reaches. Much of the worlds freshwater fish production occurs in mid- order of large rivers (Gregory *et al.,* 1991). In larger rivers and lakes however, plant material input from riparian forest ecosystem is still less important than planktonic algae in fish diet[Weslsch,1991]. Ahle and Jobsis, (1994), however said that the connection with the surrounding riparian area is still of great importance in supporting fisheries primarily due to the influx into the stream of large amounts of organic matter, nutrients, small organisms and plant debris. These get flushed into the river channel when high flow collects them and receding water deposits same on the channel. Because of the increase in available food and the expansion of the physical habitat, fish experience accelerated growth and improved condition during high water period. Flood-plain areas may also provide permanent habitat for some fish in isolated pools and small back-water channels (Everest *et al.,* 1985). The many still water spots possible in riparian ecosystems are excellent habitats not just for some fish but several other aquatic organisms. Thus the riparian ecosystem has several different habitats suited for aquatic organisms at different stages of their life cycles, shallow water patches for newly hatched fishes which are protected from aquatic and aerial predators due to canopy cover. This way fish juvenile survival rate increases in a riparian forest ecosystem.

Trees increase the diversity of stream habitat when they fall into streams. Large woody debris is important to stream communities because it can slow the force of storm waters, trap leaves twigs, seeds and other important food items, supply cover, and create various small habitats such as deep pools and still backwaters. Logs provide escape cover to fish, an area for invertebrates to colonize, resting and sunning areas for reptiles, amphibians, birds and mammals. Fish also find habitat in overhanging roots and stream side vegetation.

Like fish, aquatic invertebrates also require a variety of habitat that the Riparian ecosystem can provide. They may live on either inorganic (sand, gravel) or organic (leaves, woody debris, tree roots) substrates. This way, riparian forests support not just a large benthic population of aquatic organisms but through diversified habitats, a large sum total population of aquatic organisms within its course (Sweeny, 1993).

The breeding biology and physiology of organism in riparian ecosystems are also influenced by the riparian ecosystem. Clark (1978) report that aquatic snakes and other reptiles become dormant during low water levels in aquatic ecosystems, while high water levels may initiate breeding in several riparian dwelling organisms.

Stream velocity affects oxygen level in streams, the retention of organic materials and the ability of aquatic organisms to move up and down the stream. Loss of forest vegetation can affect streams and aquatic communities by increasing the intensity and frequency of flood events and the degree and duration of low flow conditions during droughts. Canopy over streams exerts tremendous influence on algae production and other aquatic plants. Depending on the season, light intensity in a shaded area of a stream can be 30 per cent to 60 per cent less than that of un-shaded areas (Sweeney, 1993). Stream temperature which is also an important water variable to the aquatic bio communities is influenced by riparian tree canopy. This variable alters the physical and biological characteristic of the stream. Higher stream temperatures can reduce the stream's oxygen carrying capacity, increase rate of organic matter decomposition and influence the rate at which nutrients are released from suspended sediments (Brown and Krygier, 1970, Sweeny, 1993). Cummins (1974) observed that even slight increases in stream temperature produced significant growth of filamentous algae. Brown and Krygier (1970) observed a positive correlation between increased water temperature in a stream and growth of parasitic Bacteria. While raised water temperature in a stream can favor certain organisms, the same condition is capable of causing migration of others to cooler environments the consequence is a shift in community structure (Karr and Schlosser, 1978). Minshall, (1978) found that both species diversity and total numbers of benthic organisms decreased significantly as forest cover was removed from stream banks primarily as a result of increasing water temperatures. Temperatures affect benthic organisms by influencing respiration, feeding, growth rates, adult size, fecundity and timing of reproduction (Cummins 1974, Sweeney, 1993). McCormick *et al*., (1972), found that the optimal range of temperature for growth and survival of young brook tout lies between 12.2^0C and 16^0C.

Removal of stream side vegetation can cause increases in daily and seasonable temperature variation. Small shallow streams are especially vulnerable to increase in stream temperature due to their small volume (Brown and Krygier, 1970). However, the stream will most quickly respond when shading is restored (Karr and Schlosser, 1978).

2.6 Effects of Riparian Cover On Stream Water Chemistry

The chemistry of water strongly affects the richness and abundance of aquatic organisms (Clark, 1978). The stream environment is adversely affected by extremely high or low nutrients or pH level, low dissolved oxygen concentration, high sediment loads or high toxic chemical content. Sedimentation is considered a major factor in the decline of aquatic life due to its effect on stream water quality (Karr and Schlosser, 1978). Sedimentation affects aquatic life by decreasing light penetration, reducing dissolved oxygen level, and by introducing toxins into the stream (Chen *et al.,* 1994). These effects reduce the food base, impair especially fish feeding due to reduced hunting success, and reduced reproductive success (by covering spawning grounds and eggs, preventing the emergence of newly hatched fry, limiting the availability of oxygen to incubating eggs and reducing water flow and removal of wastes), (Karr and Schlosser, 1978). Aquatic insects are also affected as they loss food and consequently die off (Chutter, 1969).

Nutrient enrichment is also a serious problem in streams and lakes with consequences on aquatic communities through direct toxic effect and by inducing excessive growth of algae and other aquatic plants. Nutrients are essential elements for aquatic ecosystem, but in excess amounts, they can lead to many changes in the aquatic environment and reduce the quality of water for human uses (Dupont 1992). Some nutrients inputs into surface water are entirely natural, such as nutrients contained in plant material or naturally eroding soils (Clark *etal.,1985*). However, most nutrients in surface waters today result from human activities such as crop fertilizers, township sewages and manure. (Klapproth and Johnson, 2008).

In rural ecological setting, agricultural lands are the primary source of nutrient inputs into streams contributing nearly 70% of total load of Nitrogen and Phosphorus each year to the aquatic ecosystem. (Chesters and Schierow, 1985). These two nutrient elements are of particular concern in the aquatic ecosystems. Riparian forests buffers remove nitrogen and nitrate ($N0_3$-N), Phosphorus and other nutrients hence are therefore crucial in forestalling eutrophication that can result from mineral enrichment of water bodies, (Klapproth and Johnson, 2008). They also protect stream water quality as they reduce the amount of sediments, and other contaminants that enter the stream.

2.7 Impact of Human Activities In Riparian Areas

Intensive human activities in Riparian areas can lead to serious losses of streams habitat and water quality. Natural drainage is interrupted as riparian soils become compacted. Other effects are increase in sedimentation rates, solar radiation and altered streams channels. Examples of habitat alteration that occur from riparian degradation include the removal of stream side vegetation, removal of woody debris and boulders from streams through sand mining, streams channelization, and in extreme cases, damming and dredging (U.S.E.P.A 1995). Streams can also be degraded by activities in the surrounding watershed which are often not unconnected to agricultural production or animal rearing/grazing. One natural result of cultivation around a watershed/riparian environment is forest clearing to increase drainage, reduce competition with crops for moisture and sunlight. Other reasons for clearing include weed management allowance for use of farm machinery and wildlife extraction (Osborne and Kovacic, 1993). Such clearance and weed control is often done with chemical herbicides. These do not only remove the plants but find their ways into stream channels causing damage to non target organism. Livestock can be particularly damaging where they have unrestrained access to streams (Kauffman and Krueger, 1984, Kasi and Botter, 1994). Livestock erode the stream bank as they climb in and out of the streams, causing the stream to become wider and shallower. Grazing the riparian area alters the riparian plant community.

Impacts to riparian vegetation induced by livestock can basically be separated into four areas; compaction of soils, which increases runoff and decreases water availability to plants; herbage removal which lowers vigor and changes competitive interactions among species; physical damage to vegetation by rubbing, tramping and browsing; and changes in the fluvial processes, which may lower water table and /or cause a decline in invasion sites for woody vegetation (Glinski 1977, Severson and Bolt 1978, Kauffman and Krueger 1984, Brady and Patton 1985). Reproduction of tree population as affected by browsing on young plants (Glinski 1977, Kauffman **and** Krueger1984). Without population recruitment of young trees, riparian forests will develop unstable age structures and may eventually be eliminated. This would greatly affect the long-term suitability for the wildlife species that utilize their communities, coarse woody debris inputs will be decreased and the hydrologic properties of the stream will therefore be altered. This in turn would further affect the composition and structure of riparian vegetation (Kauffman and Krueger 1984).

Stream water quality is also impaired (as stream becomes shallower and vegetation decreases) and manure is deposited or washed into stream, introducing organic matter, nutrients and pathogenic organism (Overcash *et al.* , 1983, Oakley *et al.*, 1985). As riparian watersheds give way to urban and pre urban developments, the vegetation is removed and the watershed becomes covered by roads, farm lands and buildings. Changes in the vegetative cover in the watershed can cause changes in the amount and timing of water flows in stream channels (Chesters and Schierow, 1985, Guldin, 1989, Booth and Reinelt, 1994).

2.8 Importance of Riparian Forest

The first globally important aspect of forests is that they are a global carbon sink that ameliorate the effects of elevated atmospheric carbon dioxide. They are refuge for biodiversity, accommodating zonal as well as rare and threatened species (Sayer and Byron 1997). Locally, riparian forest provides many cultural benefits. When leaves fall into a stream they are trapped by woody debris (fallen trees and limbs) and rocks where they provide food and habitat for small bottom-dwelling creatures such as insects, amphibians, crustaceans and small fish. Survival of this creature is critical to the aquatic food chain and of course the nutrition of people within the Riparian catchments area (Austin, 2008). The leaf canopy of a mature forest provides shade that keeps the water cool during the warm times, and insulation that keeps soil and water warmer during cool times. It also retains dissolved oxygen and encourages the growth of diatoms, beneficial algae, and aquatic insects. The canopy improves air quality by filtering dust from the wind.

Forests, are also important in the maintenance of an attractive environment, provision of opportunity for out door recreation, provision of habitat for wildlife, watershed function, general conservation including minimizing of soil erosion, laboratory for ecological teaching and research and the production of wood for various use (Aweto 1990).

Fertilizers and other pollutants that originate on land are taken up by plant root in the riparian areas. Nutrients are stored in leaves, twigs and roots instead of reaching the stream. Plants take up Nitrogen from the soil and through a process called de-nitrification, bacteria in the forest floor convert excess harmful nitrogen into gas, which is released into the air. (Austin, 2008)

Forests act to facilitate these processes by stimulating microbial activity and contact between biologically active soil layers and ground water.

Active nitrate uptake by forest vegetation throughout the biologically active soil layers can provide long term sequestering of nitrate and other nutrients in woody biomass. Since the growth rate of a forest tends to be limited by nitrogen, forest can respond to a nitrogen subsidy in the soil by both increased growth rate and the luxury of increased nitrogen uptake. Such a response will reduce the amount of nitrogen available to enter stream water.

Rain and sediments that run off the land in sheet flows can be slowed and filtered in the forest, settling out sediments, nutrients and pesticides before they reach streams. Water in-filtration in forest soils is often 10-15 times higher than grass turf and 40 times higher than a plowed field. Wooded stream corridors provide the most diverse habitats for fish, mammals and other wildlife. Woody debris provides cover for fish while preserving stream habitats over time. Forest diversity is valuable for birds.

Riparian forest also creates condition that lead to sustained yield of higher quality water (Rawat *et al.*, 2008). By shading streams filtering run off, enhancing stream habitat, and stabilizing stream hydrodynamics, riparian forest allow the healthy natural tendencies of the stream system to take hold and function. Improved water quality is achieved as fundamental reorganization of the ecosystem occurs, creating healthy natural tendencies over time.

Riparian forests help dampen peak water discharges during storms, while maintaining more baseline water flow during dry times. Forests help create stable channels that carry water more efficiently while reducing suspended sediment loads. Improved hydrologic functions are achieved as stable natural stream channel dimension, pattern, and profile are restored over time.

Riparian forests sustain the stream environment by controlling water temperature, light, habitat diversity, channel morphology, food webs and species diversity of the stream systems. Riparian forests act as solar energy collectors and pumps, collecting and transforming this energy into useful forms and spreading it around the ecosystem. Riparian forest remove, sequester, or transform nutrient, sediments and other pollutants.

Microbial processes also immobilize pollutants in riparian forest buffers. Microbes may take up dissolved nutrients as do plants. Later, these nutrients may be mineralized following the death and decomposition of microbial cells. This process is similar to the release of nutrients by plants following litter falls. Over time, a net storage of immobilized nutrients occurs in forest ecosystems that are accumulating soil organic matter. If managed to encourage the accumulation of soil organic matter, riparian forest can support significant long term nutrient storage by immobilization. There are many different microbial degradation mechanisms that operate in forests, these include aerobic, anaerobic, chemoautotrophic and heterotrophic pathways. The wide ranging and diverse environments, in riparian forest can support these mechanisms at many locations.

CHAPTER THREE

MATERIALS AND METHODS

3.1 STUDY AREA

The study was carried out in Kagoro/Tsonje forest between latitude $9^0 31`542``$ and $9^0 33`509``$ N and longitude $8^0 22`.244``$ and $8^0 22`262``$ E. The forest is made up of two components, the encroached forest, where exotic species like *Gmelina arborea* and *Tectona grandis* were planted alongside the indigenous species like *Albizia zygea, Milletia thoningii, Nuclear diderricchii* and the second component mainly a natural forest which had been seriously farmed at the time of this study. The forest is located in Kagoro, Kaura Local Government area of Kaduna State, Nigeria. It is about 2km from the Kagoro town along Kafanchan – Jos road. The study covered a period of one year spanning both dry and wet seasons. The vegetation of the reserve is a mosaic of savanna and forest. The forest occur mainly in river and stream valleys but also elsewhere from the rivers, as a consequence of the relatively high annual rainfall of about 1550mm.[Ezealor 2002, Birdlife 2008].

3.2 Vegetation Study

The forest vegetation was investigated after a reconnaissance survey. The method of investigation of the woody vegetation was the $1/10^{th}$ of a hectare technique of Modified Whittaker, (1960). This involves three plot sizes of 100 metres by 100 metres. Three such plots were laid each in the encroached and farm segments of the Reserve Forest.

The following evaluations were done:

- The specie composition of all woody species in the plot.
- Total count of all woody density of species
- Basal area of species of the woody tree stems of the studied plots was determined using the formula

$$BA = \pi r^2$$

Where BA = Basal Area

π = pi, $^{22}/_{7}$

r = radius of bole

The unit of Basal area is (m^2).

The herbaceous vegetation was evaluated in 1 metre by 1 metre quadrates and five quadrates were randomly placed within the area of 100 metres by 100 metres. From these, the following data were generated:

- Total herbaceous species identification
- Total number of each species
- Dry matter evaluation by the harvest method

Harvest was done in cloth bags and weight was taken using Hanson small scale.

3.3 Avian Study

The bird fauna was surveyed by the assistance of an ornithologist through the use of binoculars and field identification guide of Borrow and Demey (2001). The binoculars was used to sight birds and the field guide was used to identify birds sighted.

3.4 Water Samples

Water samples were collected at one point from all identifiable streams in the forest using clean plastic water bottles. A preservative, Lugol's reagent was added to one of a set of two samples per point to fix algae for subsequent study. The Physicochemical characteristics of water and Pytoplankton from the streams of Kagoro forest were sampled using methods described by APHA [1998] during two field visits, once in the wet season and the other in the dry season. Samples were selected along the stream course that stretches through the forest.

3.5 Soil Samples

Soil samples were also collected at three points per plot within each 100 metres by 100 metre plot using soil auger. The soils were sampled at 0 – 30cm depths. The following data was generated from the samples.

- Textual properties using the hydrometer
- The macronutrient composition of the soil using the ammonium acetate ($NH_{40}AC$) method for cat ion determination.

Soils were dispersed in Ammonium acetate (NH_4OAC)

- Chemical properties
- pH determined by pH meter
- Electrical conductivity (EC) determine by conducting meter.
- Exchangeable bases by NH_4 OAC meter
- Organic carbon
- S.A.R was calculated from values of Na^{2+}, Ca^{2+} Mg^{2+} using the formula below:

$$\frac{Na^{+}}{\frac{\sqrt{Ca^{2+} + Mg^{2+}}}{2}}$$

3.6 Flora And Fauna Analysis

The vegetation populations of the woody and herbaceous species were evaluated for diversity using the Shannon –Weinner (1949) mathematical index.

H´	=	$\sum^{s}$ (pilnpi)
H´	=	Diversity index
i	=	1
s	=	Total no. of species
Pi	=	frequency of the ith species out of a total N.
Lnpi	=	logbase$_n$ of Pi
		(Huston, 1994).

The dry matter yield percentage (%) was evaluated using the formula;

$$DM\% = \frac{\text{wt of dry sample}}{\text{wt of wet sample}} \times \frac{100}{1}$$

Where:

DM% = Dry Matter Percentage (%)
Wt = Weight

Bird species check list was constructed from the birds encountered.

3.7 Data Analysis

The means of variables of soil and water samples between encroached and farmed areas of the forest were tested for similarity or differences by using the one way analysis of variance (1- ANOVA).

CHAPTER FOUR
RESULTS

4.1 Density of Woody Plants In Areas 0f Riparian

Table 1 presents the results of woody plant population in the studied plots. Results show that the encroached area had three hundred and thirty six (336) plants per hectare while the farmed area had ninety seven (97) plants per hectare by April (before the farming season). After the farming season in September, the tree numbers per hectare in encroached and farmed area were one hundred and twenty one (121) and thirty one (31) per hectare respectively. The average for both encroached and farmed areas of the forest were 229 and 64 respectively (Table 1).

4.2 Basal Area (Stem Cover)

The effective stem cover of woody plants per hectare is also presented in Table 1. The result shows that the stem cover in the encroached forest was 40.67% of the total sampled area while that of farmed area was 4.4%.

Table4.1: Trees Density in Encroached and Farmed Areas of Kagoro/Tsonje Forest Reserve.

	Species	Encroached Area April		September		Farmed Area April		September	
		Pop.	BA	Pop	BA	Pop.	BA	Pop	BA
1	*Adenodolichos paniculatus*	22	38.48	-	-	-	-	-	-
2	*Albizia zygia*	86	588.86	-	-	3	0.72	-	-
3	*Anogeissus leiocarpus*	1	0.08	3	0.72	-	-	-	-
4	*Anthonotha macrophylla*	-	-	3	0.72	-	-	-	-
5	*Anthocleista vogelli*	-	-	4	1.27	-	-	-	-
6	*Treculia africana*	1	0.08	-	-	-	-	-	-
7	*Chlorophora excelsa*	1	0.08	-	-	-	-	-	-
8	*Cola millenii*	4	1.27	-	-	2	0.32	-	-
9	*Ceiba pentandra*	-	-	-	-	1	0.08	1	0.08
10	*Cola gigantea*	-	-	-	-	1	0.08	4	1.27
11	*Cussonia barteri*	-	-	1	0.08	-	-	-	-
12	*Detarium microcarpum*	1	0.08	-	-	-	-	-	-
13	*Dichrostachys cinerea*	-	-	2	0.32	-	-	-	-
14	*Desmodium velutirium*	-	-	3	0.72	-	-	-	-
15	*Dalium guineense*	-	-	3	0.72	2	0.32	-	-
16	*Dennettia tripetala*	-	-	-	-	-	-	4	1.27
17	*Erythrophleum suaveolens*	1	0.08	1	0.08	-	-	-	-
18	*Eupatorium odorata*	10	7.95	-	-	-	-	-	-
19	*Entandrophragma angolense*	-	-	2	0.32	-	-	3	0.72
20	*Ficus sycomorus*	6	2.86	1	0.08	1	0.08	-	-
21	*Ficus ingens*	-	-	-	-	-	-	1	0.32
22	*Gmelina arborea*	188	2812.74	87	602	6	2.86	7	4.00
23	*Hymenocardia acida*	-	-	1	0.08	-	-	-	-
25	*Khaya ivorensis*	1	0.08	3	0.72	3	0.72	-	-
26	*Lophira alata*	-	-	2	0.72	-	-	-	-
27	*Milletia thonningii*	2	0.32	-	-	1	0.08	-	-
28	*Musa sapientum*	-	-	-	-	76	424.73	-	-
29	*Malacantha alnifolia*	-	-	1	0.08	-	-	1	0.08
30	*Sarcocephalus latifolius*	2	0.32	3	0.72	-	-	-	-
31	*Nuclea diderrichii*	1	0.08	-	-	-	-	-	-
32	*Parkia clappertoniana*	1	0.08	1	0.08	-	-	-	-
33	*Rauvoulfea caffra*	-	-	-	-	-	-	1	0.08
34	*Terminalia sp*	1	0.08	-	-	-	-	-	-
35	*Triplochiton scleroxylon*	-	-	-	-	1	0.08	3	0.72
36	*Vitex doniana*	7	4.00	-	-	-	-	6	2.86
	Total	336	3457.44	121	609.43	97	430	31	11.4

4.3 Woody Plant Wildling Population

The woody plant wildling population in the encroached forest was eighty seven (87). This number was dominated by *Desmodium velatinum* with 19 wildings in twenty five square metres ($25m^2$), *Millettia thonningii* with 15 wildlings, *Eupatorium odoratum 10,Mucuna pruriens 6,Lophira lanceolata 5, Nuclea latifolia, Anthocleista vogelii, Prosopis africana, Vitex doniana, Bridelia ferugenea, Khaya ivorensis, Daniellia oliveri, Anogeisus leiocarpus 2, and Cussonia barteri, Milicia exalsa, Tripochiton sclereoxylon, Terminalia avicennoides, Dalium guineense at 1* wilding each. In the farmed forest, the wildling population was fourteen (14). This number was dominated by *Albizia zygia* , *Cola millenii ,* with 3 wildlings each in twenty five meter square ($25m^2$), *Daniellia sp*, *Anthocleista vogeili* at 2 wildlings each and *Milletia thonningii, Tripochiton scleroxylon, Ficus sycomorus, Ficus benjamina* at 1 wildling each. (Table4. 2).

Table4. 2: Wildlings Population of Kagoro/Tsonje Forest

	Species	Encroached		Farm	
		April Pop.	Sept. Pop.	April Pop.	Sept. Pop.
1	*Vitex doniana*	2	1		
2	*Mucuna pruriens*	6			
3	*Eupatorium adoratum*	10			
4	*Anogeissus leiocarpus*	2			
5	*Nuclea latifolia*	4			
6	*Lophira lanceolata*	5			
7	*Uvaria chamae*	4			
8	*Millettia thonningii*	15	1	1	
9	*Prosopis africana*	3			
10	*Desmodium velutinum*	19			
11	*Cussonia barteria oliveri*	1			
12	*Daniella oliveri Anthocleista*	2		2	
13	*Anthocleista vogilli*	3		2	2
14	*Milicia excelsa*	1			
15	*Albizia zyggia*		1	3	1
16	*Triplochiton scleroxylon*	1		1	
17	*Ficus sycamorus*				1
18	*Ficus benjamina*			1	1
19	*Cola mellenii*		2	1	3
20	*Allophyllus. spicatus*		1	3	1
21	*Dicrostachys cinerea*		1		
22	*Artocarpus heterophylus*		1		
23	*Alcornea laxifloria*		1		
24	*Adenodolichos paniculatus*		1		
25	*Senegalium sengar*		1		
26	*Hymenocadra acida*		1		
27	*Entandioprhagma angolense*		1		
28	*Ficus sur*		1		
29	*Alchornea cordifolia*		1		
30	*Bridelia ferugirea*	2			
31	*Annona senegalensis*	3			
32	*Khaya ivorensis*	2			
33	*Dalium guinense*	1			
34	*Terminalia avecennoides*	1			
	Total	**87**	**15**	**14**	**9**

4.4 Dry Matter Yield

The above ground dry matter yield of herbaceous components in the forest was evaluated in late rainy season (September). Result shows that, the encroached forest yielded 1.4 tons of grass per hectare and 106 kg of forbs per hectare while in the farmed forest, grass yield was 1.3 tons and 95.98 kg of forbs per hectare. Table 4.3

Table 4.3: Herbage Yield of Kagoro/Tsonje Forest

Grass	2.7 tons
Forbs	201.98 kg

Table4. 4: Population of Herbaceous Plants in Encroached and Farmed Areas of Tsonje/Kagoro Forest Reserve.

Species (Grasses)	Encroached					Farmed					Total
	1	2	3	4	5	1	2	3	4	5	
Andropogon tectonum	-	2	-	-	1	-	-	-	1	7	11
Axonoplaus compressus	1	-	-	-	-	-	-	-	-	-	1
Heteropogon contortus	1	-	-	-	-	-	-	-	-	-	1
Pennisetum pedicelliatum	-	51	-	4	-	1	-	-	-	-	56
Rottboellia exaltata	-	-	23	3	3	-	-	-	3	7	39
Setaria pallidefusca	-	-	-	-	1	-	-	-	-	-	1
Forbs											
Ageratum conyziodes	-	-	-	4	-	22	54	10	40	22	152
Anthocleista dijalonensis	-	-	-	-	-	-	-	1	-	-	1
Anthocleista vogelli	-	-	-	-	-	-	-	-	-	4	4
Anthonatha macrophylla	-	-	-	-	-	-	2	-	-	1	3
Calopogonium mucunoides	1	7	1	-	2	-	-	-	-	-	11
Eupatorium odoratum	-	-	2	11	-	-	-	-	-	-	13
Cola millenii	-	-	-	2	-	-	-	-	-	-	2
Crotalaria lachnosema	-	1	-	-	-	-	-	-	-	-	1
Danielli oliveri	-	1	-	-	-	-	2	-	-	-	3
Desmodium velutinum	-	3	-	-	1	-	-	-	-	-	4
Dichrostachys cinerea	1	-	-	-	-	-	-	-	-	-	1
Eupatorium odoratum	-	-	-	-	-	1	3	-	-	-	4
Eriosema psoraleoides	1	-	-	-	-	-	-	-	-	-	1
Fleurya aestuans	-	-	-	-	1	-	-	-	-	-	1
Gloriosa superba	-	-	-	-	-	-	-	1	-	-	1
Hypoethes cancellata	-	-	-	-	-	-	-	16	-	12	28
Melastomastrum capitatum	-	-	-	-	-	-	-	-	6	-	6
Momordica balsamina	-	-	-	-	-	-	-	11	-	-	1
Morus alba	-	-	-	-	-	-	1	-	-	-	1
Mucuna pruriens	1	-	-	-	-	-	-	-	-	-	1
Nephrolepis biserrata	-	-	1	-	-	-	-	-	-	-	1
Paulinia pinnata	-	-	-	-	-	-	-	1	-	-	1
Phyllanthus muellerianus	-	1	1	2	-	-	-	-	-	-	4
Pouzolzia guinenses	-	-	-	2	-	-	-	2	4	-	8
Physalis micrantha	-	-	-	-	-	-	-	-	1	-	1
Senna mimosoides	-	-	-	-	2	-	-	-	-	-	2
Stylosanthus hamata	1	-	-	-	-	-	-	-	-	-	1
Synedrella nodiflora	-	-	-	-	-	4	-	-	6	11	21
Tephrosia bracteolate	5	-	-	-	-	-	-	-	-	-	5

4.5 Avifauna Occurence In Kagoro/Tsonje Riparian Forest

A total of thirty nine bird species were encountered in the riparian forest in the two visits pooled together. The list is presented in table 5. This list shows that *Camphehaga quiscalina* was no longer encountered as well as *Cassypha natalensis, Chrysococyx flavigularis* and *Vanellus supercilliosus*.

Table4. 5: A Checklist of the Bird Diversity of Kagoro Forest

S/N	NAME OF BIRD	SCIENTIFIC NAME
1.	Grey Hornbill	*Tockus nasutus*
2.	Yellow frauted-Tinker bird	*Pogoniulus chrysoconus*
3.	African green fruit pigeon	*Treron calvus*
4.	Senegal coucal	*Centropus senegalensis*
5.	Scarlet chested – Sunbird	*Chalcomitra senegalensis*
6.	Red-Shouldered cuckoo-shrike	*Campephaga phoenicea*
7.	Black-faced Quail finch	*Ortygospiza atricalis*
8.	Red-Bulled five – finch	*Lagonosticta senegala*
9.	Morning Dove	*Streptopelia decipiens*
10.	Grey-Backed Cameroptera	*Camaroptera brachyura*
11.	Olive Sunbird	*Cyanomitra olivaceus*
12.	Klaas's Cuckoo	*Chrysococcyx klass*
13.	Didric Cuckoo	*Chrysococcyx caprius*
14.	Broad-billed Roller	*Eurystomus glaucurus*
15.	Amethyst Sunbird	*Chalcomitra amethystina*
16.	African Thrush	*Turdus pelios*
17.	Common Bulbul	*Pycnonotus barbatus*
18.	Long-Tailed Shrike	*Corvinella carvina*
19.	Pin-Tailed Whyddah	*Vidua macroura*
20.	White-helmeted Shrike	*Prionops plumatus*
21.	Black-Shouldered kite	*Elanus caerulus*
22.	African Golden oricle	*Oridus auratus*
23.	Paradise flycatcher	*Terpsiphone viridis*
24.	Village weaver	*Ploceus cuculatus*
25.	Black-necked weaver	*Ploceus nigricollis*
26.	Abyssinian roller	*Coracias abyssinicus*
27.	Cattle Egret	*Bulbulcus ibis*
28.	Black – Kite	*Milvus nigrans*
29.	Lanner Falcon	*Falco biarmicus*
30.	Double – spurred francolin	*Francolinus bicalcaratus*
31.	Red-eyed Dove	*Streptopelia senutorquata*
32.	Vinaceous Dove	*Streptopelia vinacea*
33.	Laughing Dove	*Streptopelia senegalensis*
34.	Namaqua Dove	*Oeria capensis*
35.	Black-Billed wood Dove	*Turtur abyssinicus*
36.	Grey-Plantain – eater	*Crinifer piscator*
37.	Narina's Trogon	*Apaloderma narina*
38.	Tropical Boubous	*Laniarus aethiopicus*
39.	Stone Patriach	*Ptilopachus petrosus*

4.5 Water Physicochemical Parameters

The reactivity (pH) in either the wet or dry season was in the neutral range (7.18 in wet season and 7.13 in dry). There was no significant difference in pH of water between seasons. Dissolved oxygen was also high for either season with no significant difference between seasons.

Only nitrate nitrogen was significantly higher and statistically different between seasons with dry season being higher than wet season (See Table 6).

Table4.6 Mean (SE) Physicochemical Characteristics of Water Samples from the Streams of Kagoro/Tsonje Forest

Physicochemical Characteristics	Wet Season	Dry Season
pH	7.18^{a} (0.07)	7.13^{a} (0.05)
Dissolved Oxygen (mg/I)	13.78^{a} (0.68)	13.43^{a} (0.40)
Total Hardness (mg/1)	1.19^{a} (0.11)	1.07^{b} (0.07)
Total Alkalinity (mg/1)	8.56^{a} (1.22)	6.83^{b} (0.31)
Phosphate – phosphorus (mg/1)	0.56^{a} (0.09)	0.72^{a} (0.08)
Nitrate – Nitrogen (mg/1)	0.32^{b} (0.05)	0.62^{a} (1.10)
Electrical Conductivity (uScm1)	137.87^{a} (15.41)	110.66^{a} (15.30)

Means with the same superscript across the table are statistically not significantly different ($p > 0.05$)
Means with different superscripts are statistically significantly different $p<0.05$ (a>b).
Values within parenthesis are standard error

4.6 Algal Groups and Populations With Seasons

The Bacillarophyta were the highest algal division at all seasons. The population of this division in the wet season was significantly higher than its population in the dry season (119 and 36 respectively). This trend was similar for Chlorophyta, Cyanophyta and Euglenophyta. Indeed the Euglenoids were not encountered in samples of dry season (See Table 7). Some of the encountered algae species are presented in plate 1 to 6. Some of these are oligotrophic others are Eutrophic species and other mesotrophic.

Table4. 7 Mean Phytoplankton Abundance (no.cells/1) of Water Samples from the Streams of Kagoro/Tsonje Forest

Phytoplankton	Wet Season	Dry Season
Bacillariophyta	119^{a}	36^{a}
Chlorophyta	11^{a}	7^{a}
Cyanophyta	10^{a}	3^{a}
Euglenophyta	2^{a}	0^{b}

Means with the same superscript are statistically not significantly different ($p > 0.05$)
Means with different superscripts are statistically significantly different ($p<0.05$ (a>b).

Table4. 8: Algae Species Encountered in Riparian Stream Course

Bacillariophyta	Chlorophyta	Cynophyta	Euglenophyta
Achnanthes inflate	*Ankisrodesmus falcatus*	*Borzia sp*	*Euglena grocilis*
Actinocyclus sp	*Closterium sp*	*Oscillatoria spp*	*Phacus sp*
Asteironella sp	*Desmatractum sp*	*Sacconema sp*	
Chaetoceros sp	*Hydrodictyon sp*	*Spirulina major*	
Coconies placentula A-V.H.	*Mougeotia sp*		
Cymbella cistula A-V.H.	*Mycanthococcu sps*		
Denticula elegance A-V.H.	*Netrium sp*		
Diatomella sp	*Scenedesmus sp*		
Epithemia zebra A-V.H.	*Selanastrum sp*		
Fragillaria sp	*Spirogyra sp*		
Frustulia rhomboids A-V.H.	*Ulothrix sp*		
Melosira mumuloides			
Meridion sp			
Navicula petersenii			
Nitzchia sp			
Oplephora sp			
Pinmularia viridis			
Rhoicosphenia curvata			
Stephanodiscus sp			
Synedra ulna			
Tabellaria flocculosa A-V.H.			

4.7 Soil Physicochemical Characteristics

Texture

The soils in either the encroached or farmed segments of the forest were loamy. There was also no statistical difference between the soil particles for either segments of the forest (See Table 9).

Chemical Constituents/Properties

Organic carbon percentage in the farmed area was higher at 1.35% compared to 0.51% in the encroached forest segment. The $pH_{(H20)}$ of soils in either segments were slightly acidic (6.05 in farmed segment and 5.7 in encroached), being more acidic in the encroached forest segment. Exchangeable sodium percentage (ESP) was higher in the encroached area than in the farmed area (11.45 and 6.8 respectively). The Sodium Absorption Ratio (SAR) for either soil segments was low and did not significantly differ from each other (0.4 for farmed area, 0.45 for encroached segment). For the macro nutrients however, soils in the farmed segment had significantly higher concentration of calcium (Ca^{2+}); magnesium (Mg^{2+}); potassium (K^{2+}) and sodium (Na^{2+}) than the encroached forest (See Table4. 9).

Table4.9 Mean (SE) Values for Physicochemical Characteristics and Textural Size of Soil Samples from Kagoro/Tsonje Forest

Physicochemical Characteristics	Farmed Area	Encroached	Mean Square
Ca	9.6^{a} (1.56)	1.95^{b} (0.32)	87.78**
Mg	4.7^{a} (0.17)	2.9^{b} (0.17)	9.38**
K	0.6^{a} (0.05)	0.30^{b} (0.01)	0.12**
Na	1.09^{a} (0.03)	0.65^{b} (0.00)	0.29**
SAR	0.4^{a} (0.03)	0.43^{a} (0.02)	0.00ns
ESP%	6.8^{a} (0.87)	11.45^{a} (1.01)	32.43*
EC	0.04^{a} (0.01)	0.1275^{a} (0.04)	0.00ns
Ph	6.05^{a} (0.09)	5.7^{b} (0.00)	0.18*
Organic Carbon	1.35^{a} (0.28)	0.51^{b} (0.12)	1.06*
Sand	58^{a} (2.31)	59^{a} (0.58)	1.50ns
Silt	22^{a} (1.15)	21.5^{a} (0.58)	1.50ns
Clay	20^{a} (1.15)	20^{a} (1.15)	0.00ns

Means with the same superscript across the table are statistically not significantly different $p > 0.05$

Means with different superscripts are statistically significantly different (* $p<0.05$, ** $p<0.01$, a>b).

Values within parenthesis are standard error.

** Highly significant

* Significant

NS – not significant

ESP – Exchangeable sodium percentage

EC – Electrical conductivity

SAR – Sodium Absorption Ratio

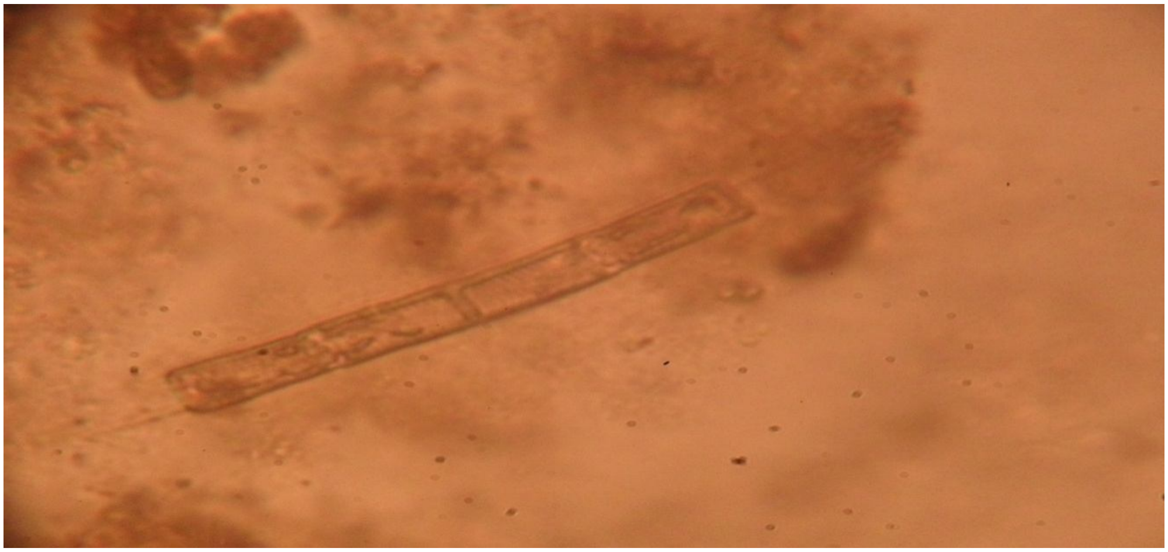
Plate I: Melosira granulate

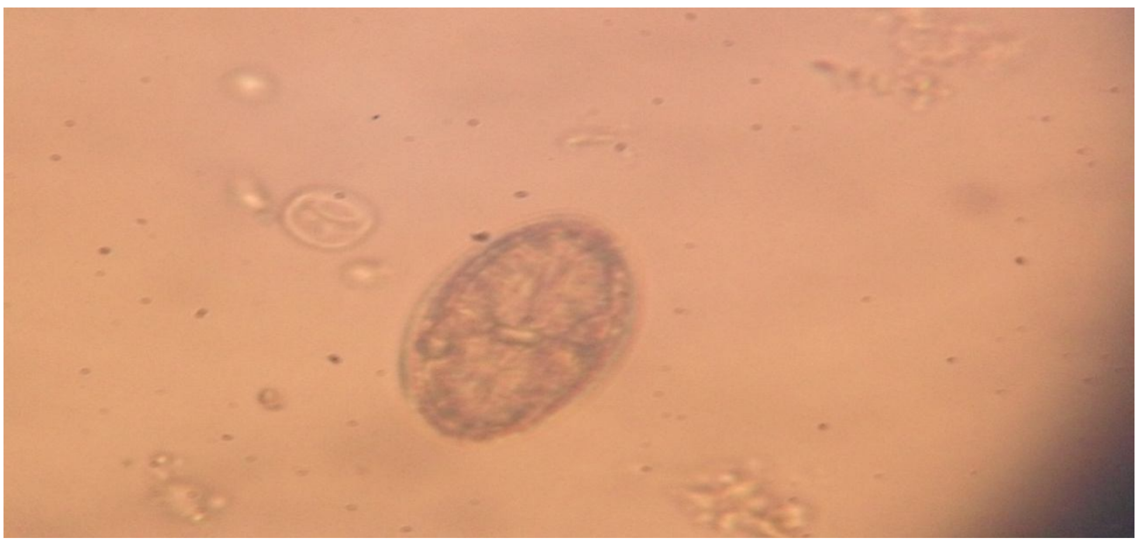
Plate II: Coconeis placentula

Plate III: Ulothrix **sp**

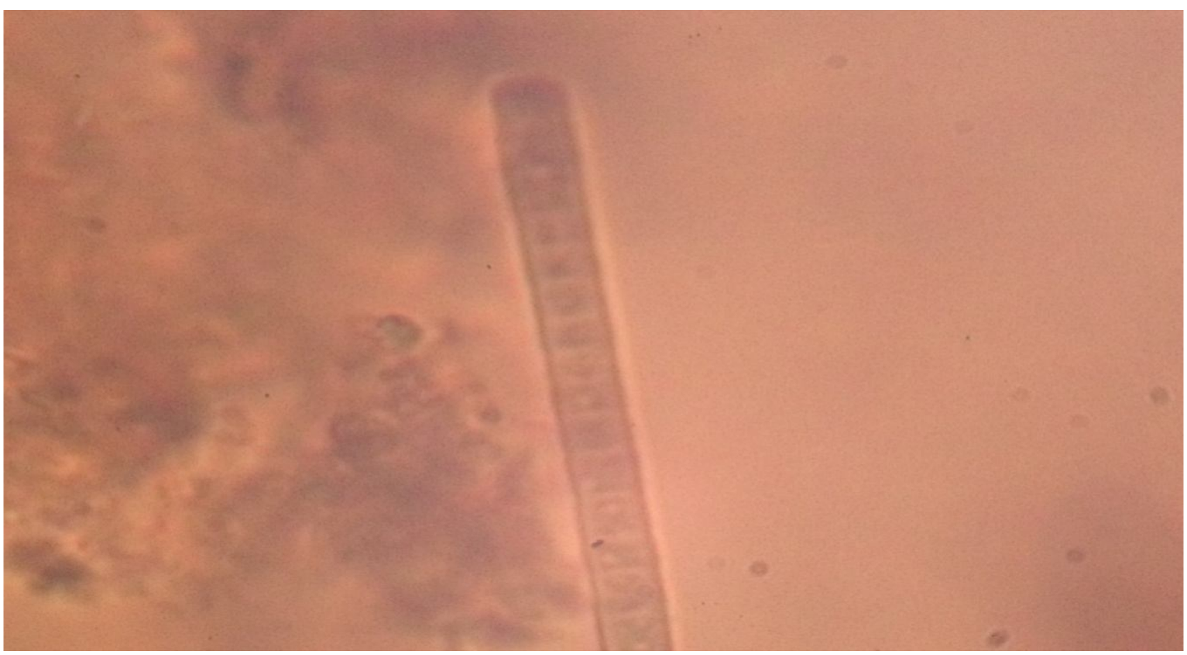

Plate IV: Oscillatoria **sp**

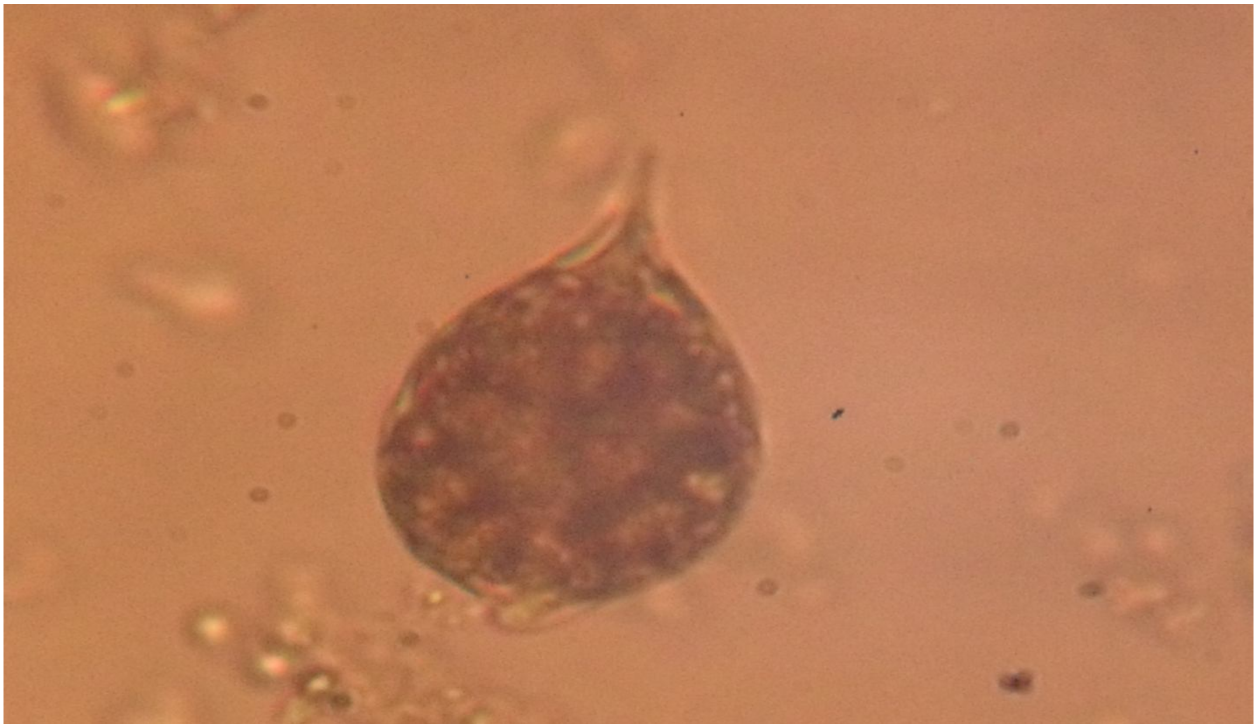

***Plate V: Phacus* sp**

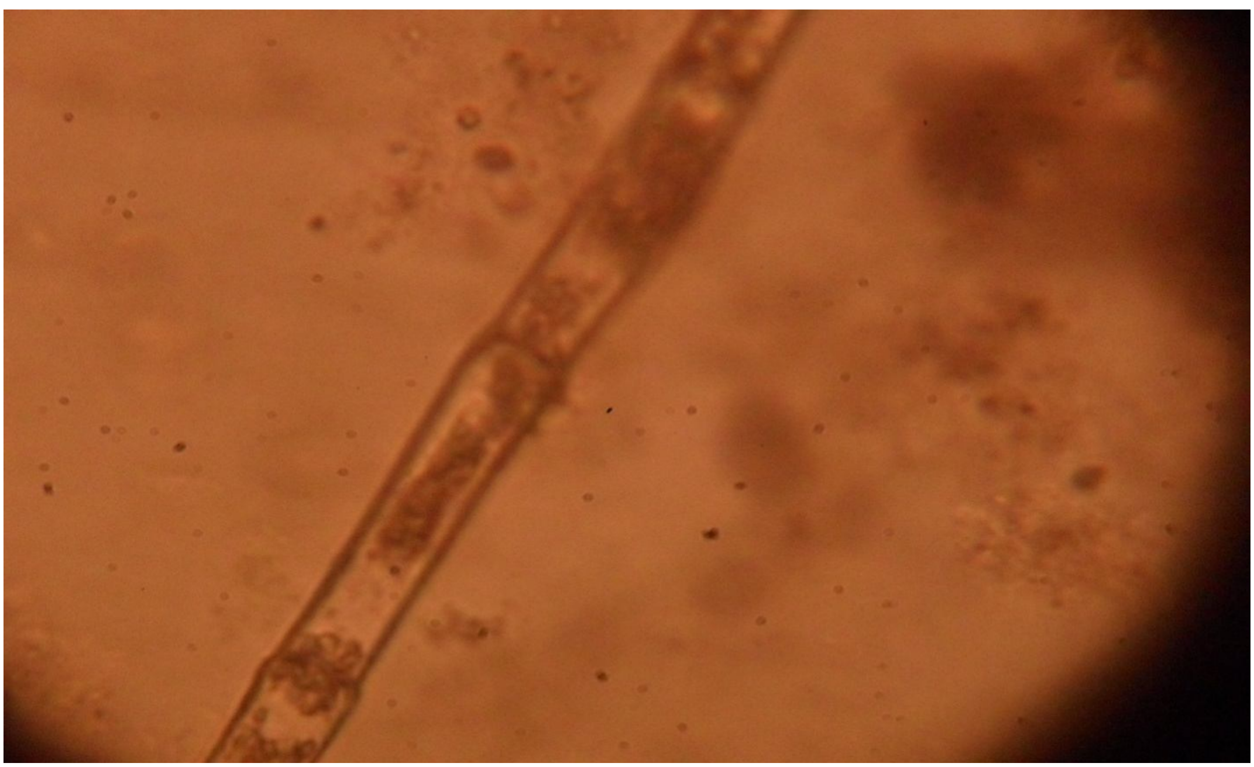

***Plate VI: Mougeotia* sp**

CHAPTER FIVE

DISCUSSION

5.1 Woody Plants Population

The decrease in tree number per hectare in both the encroached and farmed areas indicates that population of woody plants in Kagoro/Tsonje forest is apparently on a steady decline in all segments. The percentage drop in the encroached area was 36% (121 plants from 336). The drop in the farmed area was 32% (31 plants from 97).

The implication is that either through farming or fuelwood extraction (encroached), over exploitation of this once flourishing forest has reached a catastrophic state where as farming had decreased the plant population abinitio, wood exploitation from the segment termed encroached is particularly aggressive. It appears that fuel wood and timber exploitation pave way for farming. The activities are therefore in a kind of effective synergy against this once flourishing extra zonal low land rain forest type formation. Where as the exploitation is in tandem with the general devastation of similar such ecologies in Nigeria (Ezealor 2002,Oyebo 2006,) and world wide (Gregory *et al.,* 1991,Bohlen and King 1996).

The additional angle of competitive devastation of the forest resources by two adjacent communities in other to assert ownership over the land area is a worrisome dimension. Ignorantly, these activities have set in motion a process of ecocide due to habitat loss. This had already been observed by the bird check list which reveals that the area is no longer conducive for the bird species ,*Campephaga quiscalina, Chrysoccocyx flavigularis, and Vannellus supercilliosis.*

The massive disappearance of the woody plants of this ecosystem has had connotation for several other ecological processes such as the hydrologic cycle, (Austin, 2008), the nutrient cycle, thermal balance as well as pollutions from aerosols and sands.

There was however an observed resilience of the plants as several plots showed regeneration from seedlings through saplings. The possibility of such to recruit into the next adult generation is however doubtful as the pressures of over exploitation continue to buffet this ecosystem. If the encroached area remains unaffected, the over 101 saplings in twenty five square meters should recruit into adult plants. The farmed segment however had very low wildlings/sapling counts. Generally however the sapling layer was dominated by *Sarcocephalus latifolius, Milletia thonningii, Prosopis Africana, Albizia zygia, Cola millenii, Ficus sycamores, Ficus benjamina.* If undistributed, at least one percent of the lost forest cover should be potentially recovered by this recruit over a year in keeping with observations of Ojonigu *et al.,* (2010).

Woody stem cover was generally low, 14.4% in encroached area and 4.4% in the farmed area. This again shows the effect of intensive farming in woody species erosion in a forest ecosystem. The stem cover further shows that savannization of the ecosystem is complete in the farmed area while nearing completion in the encroached forest (Groomsbridge, 1992).

5.2 Herbage Biomass

Herbage yield in the encroached forest segment was 1.4 tons per hectare and 1.3 tons per hectare in the farmed area. The implication of this is that intensive farming of this ecosystem is not just dangerous to the woody vegetation, but it is also dangerous to the herbaceous cover. The likelihood of denuded ground from this exploitation is quite high. This will increase surface reflectance of insolution/radiation and hence cause subsidence that is depressed convection and hence reduced rainfall (Otterman, 1974)

5.3 Soil Physical Characteristics

The soils of this area irrespective of exploitation style still remained deep loamy. These would have no physical hindrance to plant growth or seedling regeneration currently. Indeed the free regeneration of the tree wildlings/saplings attest to this. Organic carbon percentage was however low in the encroached forest. This is because it was observed that after fuel wood/timber wood loggings, the exploiters often set fire on the vegetation hence mineralizing the litter. Fires were however excluded from the farmed segments which showed comparatively higher organic carbon content.

5.4 Soil Chemical Characteristics

The reactivity (pH) of the soils of either segments of the forest was not a problem. The exchangeable sodium percentage of the encroached segments was however very high at 11.45. The cause of this could not be ascertained however both this parameter and sodium absorption ratio did not predispose the soils to sodicity. Apparently mineral fertilizer use could have influenced the high values of macro nutrients in the farmed segment of the reserve. The appreciable amounts of macro nutrients in the soil are indicative of potential availability to plants demands. The textural class of the Forest was sandy loam, indicating that the soils of Kagoro/Tsonje Forest posses adequate porosity to encourage water infiltration with minimal run off. This quality of the soil will make the soil water potentially very available for good vegetation growth. The loamy character of the soils indicates that it has a good proportion of organic matter. From the analysis, organic carbon content was moreover in the medium range [1.35] in the farmed area of the Forest Reserve while in the encroached area it was low. It is not unexpected as the vegetation cover of the farmed area was cleared and ploughed into the soil as manure. The standing vegetation biomass in the encroached Forest however, sequestered much of the organic matter its above ground part. Only very little leaf and twig drops largely contributed to the organic matter in this section. The Exchangeable Sodium Percentage (ESP) in the soils of Kagoro/Tsonje Forest was 6.8 in farmed and 11.5 in encroached areas respectively. These figures are less than the 15% which according to the standard for rating of soils means that it has low level of sodicity. High sodicity brings about dispersal of soil and it easily exposes the soil to leaching and erosion (Odunze, *et al*, 2004). This will lead to low water infiltration. Sodicity occur naturally and can be increased by human activities such as irrigation.

5.5 Bird Fauna Occurrence Population

Ezealor, (2002) Birdlife, (2008) Abalaka (2008) reported that the Kagoro/Tsonje forest is seen, as being unique in the sense that only in this ecosystem was the people - throated cuckoo shrike *Campephaga quiscalina* encountered in Nigeria. It is also one of the two localities from which *Chrosyccocyx flavigularis* has been recorded in Nigeria. The site is a breeding area for *Vannellus supercilliosis*. (Nests recorded in 1987 and 1997). Lost of the Kagoro forest as a result of the disturbances may lead to the lost of some plant species and animals which may be endemic to the region. The important birds were not sighted at the time that this research was undertaken. It is probable that they have moved out of the habitat. Habitat structure is one of the factors that determine occupancy by an organism. If the preferred habitat of the organism is altered, it moves to an unknown destination and may face the risk of being attacked by predators. This agrees with Gray and Graves (1984), Glacier and Laymon, (1981), who state that decrease in the quality and quantity of riparian ecosystem have contributed to the widespread elimination of several avian species.

5.6 Physicochemical Characteristics 0f Riparian Stream Water

The dynamics of physicochemical characteristics of water in the streams flowing through the Kagoro forest may be attributed to the dynamic interactions between rainfall, evaporation, geology of the underlying bed rock, nature of the soil as well as human activities in the catchments of the streams.

The lack of seasonal variation in pH of the stream waters may be attributed to the relatively high total Alkalinity of the waters which adequately buffers slight fluctuations of hydrogen ion concentration that may result from uptake of Co_2 from the water by photosynthetic plants, dissolution of atmospheric Co_2 into the stream water by rain water and human activities that bring substances into the water such as agriculture.

The high dissolved oxygen (> 13mg/l) recorded in both seasons could be due to the reason that the streams are free flowing thus increasing the ability of atmospheric oxygen to dissolve into the water.

Total hardness is the measure of Ca and Mg ions dissolved in a water body. High concentration of these ions is usually responsible for the hardness of water. The low (<1.5mg/l) hardness of these waters is an indication of low chemical pollution.

Total alkalinity refers to the acid neutralizing capacity of a water body to contain variations in hydrogen ion concentration without a resultant change in pH. The major factors that affect the total alkalinity of a water body are the nature of the underlying bedrock and the nature of the soil in the catchment. The relatively high alkalinity of the water in the streams 8.56mg/l in wet season and 6.83mg/l in dry season) will be advantageous to aquatic plants against any wider fluctuations of pH.

$P0_4$ – P and $N0_3$ – N are limiting nutrients for the growth of phytoplankton and other aquatic plants. The higher concentrations of these nutrients in the dry season may be as a consequence of higher evaporation in the dry season than the wet season, inflow from agricultural areas (these nutrients are component of fertilizer) cow dung and detergents using in laundry. Any or all of these may have led to elevated concentration of these nutrients. Concentrations below 0.1mg/l and 0.090 mg/l for $N0_3$ – N and $P0_4$ – P are expected for natural unpolluted waters (UNESCO/WHO/UNEP/1996).The concentrations observed are capable of stimulating algal bloom.

The higher electrical conductivity observed in the wet season may be due to inflow of surface runoff carrying electrical conducting particles/elements.

These electrical conducting inputs include nitrates and other chemical substances that are required for plant growth.

5.7 Phytoplankton Abundance And Diversity

The abundance of Oligotrophic species such as *Achnanthes inflata, Synedra ulna, Asterionella* sp, *Fragillaria nitzchioides, Closterium reticulatum* and *Scenedesmus* sp is an indication of some relatively clean spots along the streams while the presence of organic pollution indicator species such as *Oscillatoria* and *Euglena* is a clear pointer to the increasing impact of human activities in the forests.

Changes in the seasonal phytoplankton abundance and diversity may be attributed to the changes in physicochemical characteristics of the water in the streams with seasons. Seasonal changes may result from inflow of nutrients and other elements necessary for phytoplankton growth in surface runoff during the wet season and concentration of these substances during the dry season due to evaporation. Similar results have been reported by Chia and Bako (2008). The greater abundance and diversity of phytoplankton in the dry season is an indication that the streams are cleaner in the dry season than the wet season. Tiseer *et al.,* (2008) and Davies *et al.,* (2009).

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

From the results obtained, the Kagoro/Tsonje riparian forest like other forests the world over is of both economic and environmental importance. However, human encroachment by way of settlement and cultivation is threatening the existence of the forest, if the current trend continuous unabated, the forest may disappear very quickly.

The vegetation of the forest has greatly reduced and loss of native riparian vegetation can result in loss of habitat for many animals. This has been shown in the disappearance of birds *Vanellus superciliosis, Chrsoccocysx flavigularis,* C*ampephaga quiscalina* that in recent past made the Kagoro/Tsonje forest to be of ornithological importance. At the time this research work these birds were not sighted either in the dry or rainy season.

The loss of the forest has also removed plant communities in many parts and the forest is replaced by open fields, shrubs or grass savannah of much less ecological value. The ecological consequences are serious both at local and regional levels with regard to the control of water sources, watersheds, water runoff and quality, mineral nutrient flows, stream bank erosion, floods etc.

The rate of disappearance of this important resource is evidence of serious environmental change. The implication of the deterioration of the forest on variables like local temperature, rainfall and erosion can at best be imagined but continually spell no good for the immediate communities.

This work reveals that Kagoro/Tsonje forest which was once an extra zonal lowland rainforest in this location has practically disappeared. The delineating drivers have been:

- Fuel wood extraction
- Slash and burn agriculture
- Community rivalry over ownership of the resource
- Uncontrolled lumbering activities
- Over hunting and fishing among other possible causes. The status of the forest as an Important Bird Area (IBA) is doubtful as the birds that warranted this were not encountered at the time of this research. The research further shows that the soil conditions of the forest area are suitable for forest regeneration. The water is adequate, portable and can sustain rural domestic use as well as wildlife use.

Effective conservation can best be achieved if the local communities are either collaborating or taking full responsibility. In the case of Kagoro/Tsonje forest however, community based management will have to resolve the problems of ownership first between the Kagoro and the Ninzam people. Initiatives have to be taken to raise awareness concerning their interest or benefit in protecting the forest. Active surveillance is more effective when it is community based, and there should be strict legislation to protect the forest from undue exploitation. Foresters, rural extension workers and NGOs, dealing with natural resource protection must promote local peoples rights and duties specified by the forest laws. The application of forest laws and good collaboration within local natural resources management will prove positive for forested areas.

The government should improve the energy sector of the economy particularly as it relates to the adequate provision and distribution of electricity. This will reduce the dependence on firewood and charcoal as sources of energy.

Land managers, scientists and biologists have much to offer by developing and implementation management techniques that insure the ecological integrity and sustainability of the forest.

6.1 Recommendations

Based on the findings of this research, the following recommendations are made:

1. Conservation plans should be made to restore the forest and this plan must involve the State and Local Government, the indigenes, traditional council and NGOs that are concerned with the environment.

2. Enrichment planting with indigenous forest plants should be undertaken and the issue of farming and grazing, felling of trees should be checked to allow the forest saplings to mature into natural forest plants.
3. New forest laws should be decreed. These laws should recognize the uniqueness of the Kagoro/Tsonje forest as a refuge ecosystem for plants and wildlife fauna of many kinds. A clear buffer zone of no anthropogenic activities should be demarcated at both sides of the forest.
4. Awareness should be created by way of seminars, workshops for the stakeholders such as the Traditional council and the Local Government on the importance of the forest and the dangers of loosing the forest.

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APPENDICES

Kagoro Forest

ANOVA summary for Bacillariophyta of Kagaro forest

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
SeasonS	5207.313	1	5207.313	6.710237	0.009985	3.868012
Phytoplankton	47383.19	21	2256.342	2.907563	2.74E-05	1.585979
Interaction	23431.35	21	1115.779	1.437812	0.097318	1.585979
Within	273160.9	352	776.0253			
Total	349182.7	395				

ANOVA for summary Chlorophyta of Kagaro forest

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Seasons	67.9596	1	67.9596	1.639376	0.202096	3.894838
Phytoplankton	301.2525	10	30.12525	0.726706	0.698636	1.884834
Interaction	603.1515	10	60.31515	1.454971	0.160026	1.884834
Within	7296	176	41.45455			
Total	8268.364	197				

ANOVA summary for Cyanophyta of Kagaro forest

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Seasons	242	1	242	2.386849	0.127291	3.990924
Phytoplankton	1022.889	3	340.963	3.362922	0.023976	2.748191
Interaction	608.6667	3	202.8889	2.001096	0.122691	2.748191
Within	6488.889	64	101.3889			
Total	8362.444	71				

Anova summary for Single Factor pH of Kagaro forest

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Dry	7	49.89	7.127143	0.038024
Wet	7	50.27	7.181429	0.020548

ANOVA summary pH of Kagaro forest

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Seasons	0.010314	1	0.010314	0.352195	0.563892	4.747225
Within Groups	0.351429	12	0.029286			
Total	0.361743	13				

Anova summary for Electrical Conductivity of Kagaro forest

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Wet	7	965.1	137.8714	1661.396
Dry	7	774.6	110.6571	1640.146

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Seasons	2592.161	1	2592.161	1.570273	0.234035	4.747225
Within Groups	19809.25	12	1650.771			
Total	22401.41	13				

Anova summary Single Factor Dissoved Oxygen of Kagaro forest

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Dry	7	94	13.42857	1.103214
Wet	7	96.48	13.78286	3.218724

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.439314	1	0.439314	0.203295	0.660113	4.747225
Within Groups	25.93163	12	2.160969			
Total	26.37094	13				

Anova summary for Single Factor Hardness of Kagaro forest

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Dry	7	7.5	1.071429	0.039048
Wet	7	8.3	1.185714	0.088095

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.045714	1	0.045714	0.719101	0.413034	4.747225
Within Groups	0.762857	12	0.063571			
Total	0.808571	13				

Anova: Single Factor for Alkalinity

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Dry	7	47.8	6.828571	11.96905
Wet	7	59.9	8.557143	10.48952

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	10.45786	1	10.45786	0.931302	0.353571	4.747225
Within Groups	134.7514	12	11.22929			
Total	145.2093	13				

Anova: Single Factor for PO_4-P

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Dry	7	5.05	0.721429	0.042481
Wet	7	3.92	0.56	0.060567

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.091207	1	0.091207	1.770194	0.208089	4.747225
Within Groups	0.618286	12	0.051524			
Total	0.709493	13				

Anova: Single Factor NO_3-N

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Dry	7	4.32	0.617143	0.063257
Wet	7	2.25	0.321429	0.015814

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
seasons	0.306064	1	0.306064	7.741463	0.016578	4.747225
Within Groups	0.474429	12	0.039536			
Total	0.780493	13				

Diversity Index in Encroached and Farmed Areas of Kagoro/Tsonje Forest Reserve.

Species	Encroached Area April Pop	Pi	Pilnpi	Sept Pop.	Pi	pilnpi	Farmed Area April Pop.	Pi	Pilnpi	Sept Pop	Pi	pilnpi
Adenodolichus paniculantus	22	0.065	-0.18	-			-			-		
Albizia zygia	86	0.26	-0.35	-			3	0.031	-0.11	-		
Anogeisus leiocarpus	1	0.003	-0.02	3	0.025	-0.09	-			-		
Anthonotha macrophylla	-			3	0.025	-0.09	-			-		
Anthocleista vogelli	-			4	0.033	-0.10	-			-		
Treculia africana	1	0.003	-0.02	-			-			-		
Chlorophora excelsa	1	0.003	-0.02	-			-			-		
Cola millenii	4	0.012	-0.05	-			2	0.021	-0.08	-		
Ceiba pentandra	-			-			1	0.010	-0.05	1	0.032	-0.10
Cola gigantea	-			-			1	0.010	-0.05	4	0.129	-0.26
Cussonia barteri	-			1	0.008	-0.04	-			-		
Detarium microcarpum	1	0.003	-0.02	-			-			-		
Dichrostachys cinerea	-			2	0.017	-0.07	-			-		
Desmodium velutirium	-			3	0.025	-0.09	-			-		
Dali.um guinense	-			3	0.025	-0.09	2	0.021	-0.08	-		
Dannettia tripetala	-			-			-			4	0.129	-0.26
Erythropleum suaveolens	1	0.003	-0.02	1	0.008	-0.04	-			-		
Eupatorium odorata	10	0.029	-0.10	-			-			-		
Entardrophragma angolense	-			2	0.017	-0.07	-			3	0.097	-0.22
Ficus sycomorus	6	0.018	-0.07	1	0.008	-0.04	1	0.010	-0.05	-		
Ficus ingens	-			-			-			1	0.032	-0.10
Gmelina arborea	188	0.559	-0.35	87	0.719	-0.24	6	0.062	-0.17	7	0.226	-0.33
Hymenocardia acida	-			1	0.008	-0.04	-			-		
Khaya ivorensis	1	0.003	-0.02	3	0.025	-0.09	3	0.031	-0.11	-		
Lophira alata	-			2	0.017	-0.07	-			-		
Milletia thonningii	2	0.006	-0.03	-			1	0.010	-0.05	-		
Musa sapientum	-			-			76	0.784	-0.19	-		
Malacantha alnifolia	-			1	0.008	-0.04	-			1	0.032	-0.10
Sarcocephalus latifolius	2	0.006	-0.03	3	0.025	-0.09	-			-		
Nuclea diderrichii	1	0.003	-0.02	-			-			-		
Parkia clappertoniana	1	0.003	-0.02	1	0.008	-0.04	-			-		
Rauvoulfea caffra	-			-			-			1	0.032	-0.10
Terminakia sp	1	0.003	-0.02	-			-			-		
Tridochiton scleroxylum	-			-			1	0.031	-0.05	3	0.097	-0.22
Vitex doniana	7	0.021	-0.08	-			-			6	0.194	-0.31
Total	**336**	**0.999**	-1.26	**121**	**1.001**	-1.15	**97**	**1.021**	-0.58	**31**	**1.00**	-2.1