School of Biological Sciences

College of Science

UC
UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Nigerian Montane Forest Project

Contents

Introduction

Late 2004/ 2005 has been a busy year for the Nigerian Montane Forest Project. In November 2004 three students from the University of Canterbury, New Zealand arrived at Ngel Nyaki to begin research projects. One as an MSc thesis, and two as volunteers in ongoing research projects (page 9).

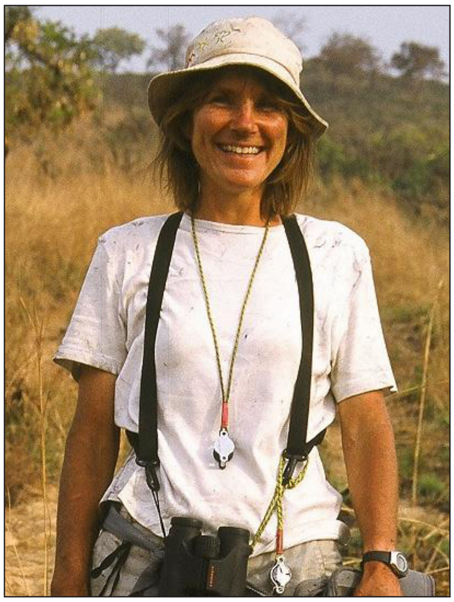
For a week in November 2004 and another in January 2005 **Hazel Chapman** was able to stay with major sponsors **Nexen Nigeria**, **Robert Warren** and **Phil Hall** in Lagos, and start a sponsorship drive. It was invaluable to have a base to work from, and led to relationships beginning with several Lagos based companies / groups.

Very exciting news has been the building of the field station at Ngel Nyaki. Three years after initiating the Nigerian Montane Forest Project (NMFP), we now have a permanent presence at Ngel Nyaki! The research station, funded by Nexen Nigeria will enable us to conduct year-round fieldwork, even in the difficult conditions of the rainy season, and to maintain computer, laboratory, and library facilities that will enhance on-site research (page 6).

All this activity has meant that we have added four permanent employees to our group, two research assistants and two watchmen for the field station.

Other highlights of the year have been several good sightings of the chimpanzees, and the fact that baboons and other wildlife appear to becoming less shy (suggestive of less hunting).

We have had visits from people from several different countries including the UK, Italy, Germany and the USA. Equally important have been visitors from our neighbouring Gashaka Gumti Primate Project. Next year we shall be able to offer visitors accommodation in the field station.



Dr Hazel Chapman
Director
Nigerian Montane Forest Project

Project Partners

Nigerian Conservation Foundation (NCF)

Nigerian National Parks

Taraba State Forestry

Federal University of Technology, Yola (FUTY)

Major Sponsors

Nexen Nigeria
Chester Zoological Society
American International School, Lagos

Members of the Yelwa football team supported by Nexen Nigeria

Students from the American International School, Lagos

Grants

UC Research Grant 'The role of primate frugivores in seed dispersal and seedling survival of African montane forest trees'.

Rufford Small Grant 'Seed dispersal and the long term survival of Nigeria's Montane Forests'.

Additional Support

School of Biological Sciences, UC
Leventis Foundation
DHL Nigeria
American Womans Community, Lagos
Phil Hall
Robert Warren
Daubeny Herbarium, Oxford
Royal Botanic Gardens, Kew

Jim and Betty Chapman
Gerald Cuthbert
Frank Sin
Larry Field
Melanie Massaro
Laura Sessions
Matt Walters

Personnel

Full-time Staff

Four field assistants, **Misa Zubairu, Augustine Ntim, Musa Amadu** and **Usman Usuf** and two watchmen, **Bobo Zubairu** and **Hadija Dauda**.

Students

PhD (FUTY) **Stephan Gawaisa**; MSc (FUTY) **Jerome Ihuma**; MSc (UC) **Arne Mattheius**.

Volunteers

Josie Beck (UC); **Sarah Luxton** (UC)

Patrollers

2 people from Yelwa; 2 from Ndombo Ngishi; 2 from Dujere.

Associate Supervisors

Dr Akosim (FUTY); **Professor Dave Kelly** (UC).

New Collaborations / supervisors 2005/6

Dr Jenny Brown statistician (UC); **Mr Duke Knoop** butterfly expert (Israel); **Dr Jon Lovett** Climate change and montane forest diversity (University of York); **Dr Richard Vokes** Anthropologist (UC); **Dr David Zeitlin** Social Anthropologist (University of Kent).

Tony Disley, Jerome Ihuma and Misa Zubairu

Field station

1st January 2005 saw the start of building at Ngel Nyaki, thanks to financial assistance from **Nexen Nigeria**. The builder came from the nearby village of Kakara, but all the rest of the labor was carried out by the local people of Yelwa.

The Yelwa youth group, below, began work early on New Years morning, and they began the building process by making the mud blocks. This was hard work as all the water for the mud had to be carried to the site from a nearby stream in jerry cans. The building was completed by local builders, carpenters and brick layers. The timber was sawn on site from *Eucalyptus* from the Yelwa plantation. A bridge was especially constructed to allow a vehicle to cross the Mao Jigerwal from Yelwa, carrying sand and cement.

The field station comprises a laboratory, library, office, 4 bedrooms and a living /dining room. There are wide verandas facing west and north - west towards the forest (see above). The kitchen, bathroom and toilet are separate from the main buildings.

The building is currently being fitted out with furniture. It is planned to have wiring installed this dry season so that we can use a generator for light and laptop use. Solar panels will be installed in the future when funding permits.

On Friday, 29 April 2005 The Junior High Senate and National Junior Honor Society of the American International School in Lagos joined together to hold a walk-a-thon to raise money towards books for the library of our new field station. The students walked for an hour, followed by a pool party! The walk-a-thon raised 48,000 naira (£200). In addition the Junior School raised another £200 in another fund raiser.

Yelwa Youth Group

Making mud bricks

Sawing timber on site

Research Projects

Plant species inventory

Plant collecting has continued during 2005. We now have over 700 collections, mainly trees, from the mountain forests of Taraba State. Our Ngel Nyaki collections have been identified initially by botanists at the Forest Herbarium Ibadan. However some of the tree species are unknown to Nigeria, and therefore not held at Ibadan. For this reason we have sent duplicates to the Royal Botanic Gardens, Kew. Martin Cheek, an expert on Cameroon montane forest vegetation and Dr William Hawthorne from the Daubeny Herbarium, Oxford have offered to help identify these species. Hazel plans to visit the UK in 2006 to do this.

Misa, Hazel, Abubakar and Augustine

Phenology

A knowledge of community wide timing of plant reproductive cycles, such as fruiting and flowering, underpins studies of animal behavior, seed dispersal and pollination biology.

During 2003/4 500 trees were identified (or collected for future identification), labeled and quantitatively scored on a monthly basis for the abundance and timing of production of new leaf, flower buds, flowers, immature fruit, mature fruit and deciduousness. For ease of scoring these first 500 trees were situated along either the forest edge or stream sides, where the crown of trees was easily visible. During 2005 we cut eight parallel trails through the forest from East to West, each up to 2 km long. Along these trails we randomly labeled an additional 500 trees over 30 cm DBH and named (or collected for identification) them. We therefore now have 1000 labeled trees throughout all the main vegetation types at Ngel Nyaki, and each tree quantitatively scored on a monthly basis.

This data is currently being entered into a spreadsheet and analyzed in collaboration with Dr Jenny Brown, a statistician from UC, and Ms Carla Meurk, a postgraduate student at UC. We shall continue to collect the data on an annual basis for the foreseeable future.

In April 2005 we began an additional collaborative phenology project with Professor Volker Sommer and Andrew Fowler of UCL. The aim of this work is to investigate the influence of food abundance and availability on primate behavior, in particular its role in the evolution of patriarchal vs matriarchal societies. Our results will contribute to a larger research program involving the Gashaka Gumti chimpanzees and the Congo bonobos.

To make our work directly comparable with the Gashaka Gumti and Congo sampling, at Ngel Nyaki we have cut two transects through the forest from north to south, each 4km long. On each transect all trees with a DBH of >30cm, and within 5 m of the centerline were labeled and their DBH recorded, a total of 1000 trees. In this case trees are monitored on a fortnightly basis, with emphasis on fruit abundance and ripeness.

Research Projects

The influence of frugivore communities on forest fragments in Ngel Nyaki Forest Reserve.

Jerome Ihuma MSc student, FUTY See Appendix 1.

Jerome Ihuma, with a scholarship from the **Chester Zoological Society,** is carrying out the thesis part of his MSc project at Ngel Nyaki. Jerome is committed to lectures at FUTY most of the time until October 2005, when he will spend three continuous months in the field. However, the Project has financed his travel to Ngel Nyaki for a few days each month, so that he can carry out observations all year round.

Jerome is building on the bird identification skills he learnt from Tony Disley in 2004 (NMFP 2004 report) and is building up a good data set, comparing the bird faunas of the main forest and neighboring riverside fragments. Of interest is the fact that the rare white crested Tuaracos rarely enter the main forest, and only ever at the forest edge. They are common however in the tree- species depleted riverside fragments. This information should be used as leverage for the inclusion of the fragments in the future buffer zone plans for Ngel Nyaki proposed by NCF, RSPB and NMFP.

The role of putty nosed monkeys (*Cercopithecus nicitans*) in seed dispersal

Stephen Gawaisa PhD student FUTY. See Appendix 2.

Guenons (*Cercopithecus* monkeys) are one of the most widely distributed and frugivorous primate genera in Africa. However because they have been considered to be seed predators, they have been largely ignored in terms of seed dispersal studies. Recently however work in Rawanda and Kibale, Uganda has indicated that guenons may in fact be important in seed dispersal, especially in degraded areas. As Ngel Nyaki and other Nigerian montane forests have high numbers of *C. nicitans*, and as Ngel Nyaki has a lot of degraded forest, it is important to know what role this species plays in seed dispersal.

During 2005 Stephen Gawaisa has been working on his project proposal (Appendix 2) and carrying out field work at Ngel Nyaki.

Stephen and Musa Amadu (field assistant) have semi-habituated a troop of putty nosed monkeys with a home range close to the eastern edge of Ngel Nyaki forest. For five days every week the monkeys are observed from 6.30 am -12 pm, and 3.30 pm -6 pm. Their feeding habits and food species are recorded (Appendix 2). Work is also underway to extract seed from dung and compare its germination with seed of the same species that has been a) chewed and spat out, and b) not handled by monkeys at all.

Frugivores and seed dispersal

Hazel Chapman, Misa Zubairu and Augusine Ntim

Nigeria's montane forests, as is the case with most tropical forests, are loosing their wildlife at an unprecedented rate. The long term consequences of this loss of wildlife on plant biodiversity are an unknown. Seedlings of some tropical tree species survive well under the crown of the parent tree, and therefore may not depend on dispersal for long term survival. Other species appear to need dispersal of seed away from the parent tree in order to germinate.

While these questions have been asked of forests in Kibale National Park, Uganda, no one has addressed them in Nigeria. In order to make a comparison with the Kibale study, we followed the methods of Chapman & Chapman (1995).

Seedlings, saplings and poles growing directly under the canopy of six adult trees of twenty species will be identified and their height measured. The species were chosen to incorporate common canopy/ sub-canopy trees:

Species	Method of seed dispersal	Number of trees under which seedlings/poles have been counted and measured to date
Beilschmiedia mannii	animal	6
Celtis gomphophylla	animal	1
Chrysophyllum albidum	animal	1
Dasylepis racemosa	animal	6
Deinbollia pinnata	animal	1
Diospyros monbuttensis	animal	1
Garcinia smeathmannii	animal	1
Isolona mailtlandii	animal	6
Hannoa klaineana	animal	1
Macaranga occidentalis	animal	1
Newtonia buchananii	wind	6
Olea capensis	animal	6
Parkia filicoides	animal / explosive	1
Polyscias fulva	animal	1
Pouteria altissima	animal	6
Rothmannia urcelliformis	animal	1
Santiria trimera	animal	1
Strombosia scheffleri	animal	1
Tabernaemontana contorta	animal	1
Trichilia sp	animal	2
Vitex doniana	animal	1
Zanthoixylum leprieurii	animal	7

Data collection will be completed during November / December 2005 and analyzed early 2006.

Reference: Chapman & Chapman (1995) *Conservation Biology* **9**:675-678

This project is supported by a 2005 **Rufford Small Grant** Award to Hazel Chapman.

Testing the Janzen Connell hypothesis in montane forest

Arne Mattheius MSc student, UC See Appendix 3.

According to the Janzen-Connell hypothesis, seedling recruitment around tropical trees is more likely away from parent trees because of density- or distance-dependent predation or pathogen attack on seeds and seedlings. This is expected to lead to a more regular distribution of conspecific adults than would be expected by chance, and to favour coexistence.

The Janzen-Connell hypothesis has never been tested in African montane forests.

Ngel Nyaki chimpanzee survey

Josie Beck Volunteer UC

In order to obtain an estimate of the chimpanzee (*Pan troglodytes* subsp. *villerosus*) population/s at Ngel Nyaki, and to compare their nest sites with the chimpanzee populations in Gashaka Gumti National Park, we carried out a nest census following the line transect methods of Plumptre and Reynolds (1996), and used the same data sheets as the Gashaka Gumti Primate Project use in their chimp surveys (Andrew Fowler pers. com).

10 parallel transects, each 2km long, were cut through the forest running from East to West (the same transects as used in the phenology study). In order to avoid bias in relation to chimpanzee ranges we located the position of each transect by dividing the upper (eastern) forest edge into ten strips and randomly placing one transect in each strip.

We measured the distance to each nest from a marker tree on the transect line with a tape measure. We also recorded the species of tree in which nests were found, nest height (using an abney level), nest age, whether it was open or covered, proximity of nest to water, and the topography (valley vs ridge vs river bed) (after GGPP).

Musa, Misa and Josie - chimp watching!

We used the marked nest counts technique after White 1994 (Plumptre & Reynolds 1996): We first walked each transect and marked each nest we found within 20m of the transect line. We marked the nest by tying a piece of liana around the tree, and mapping it. We then re-walked each transect every two weeks, marking all new nests we found and measuring their distance to the marker tree. We carried out a very thorough initial count, and assumed that all nests had been marked before regular counts started.

We will combine all counts from each transect to calculate one nest density estimate which we will divide by the time in days between the first walk of the transect and the last. We were confident that the time between each subsequent count was before the minimum time for a nest to disappear. Thus it should be possible to estimate a measure of density by dividing the count by the number of days elapsed (Plumptre & Reynolds 1996). However, this measure of chimpanzee density is only a rough estimate (Sommer pers.com.) and the real interest in our data may be in comparing nest heights at Ngel Nyaki (where there has been hunting) with nest heights in Gashaka Gumti National Park. It will also provide information on whether or not the chimps nest in fruiting trees, and whether or not vicinity to water plays an important role in choosing a nest site.

This data is currently being analysed. Preliminary results show that up to twenty new nests can be built over a two week period in any one nesting site. Nests are typically high up in the canopy, and are not necessarily in fruiting trees. A wide range of tree species are used to build nests in, but the most common are *Beilschmiedia mannii, Dasylepis racemosa, Isolona mailtlandii, Macaranga occidentalis, Santiria trimera* and *Trichilia* sp.

We found groups of up to 30 nests at a time, of mixed ages.

We saw the chimps three times in eight weeks. Once a party of seven chimps were was watched for 50 minutes. The chimps are heard frequently throughout the forest.

Plumptree & Reynolds (1996) *International Journal of Primatology* **17**:85-99

Patrollers

In April 2005 the **Leventis Foundation** gave us funds to employ 4 men to patrol Ngel Nyaki. We chose to employ young people from each of the three villages closest to Ngel Nyaki, two from Yelwa, and one each from Ndongo Ngishi and Dujere.

Patrolling began in May 2005, and so far has proved successful. Two of the new patrollers were previously hunters, and one is the son of the Chairman of Ndongo Ngishi. While the NMFP patrollers have no legal authority to apprehend hunters or gatherers, their presence in the forest does appear to be reducing the number of hunters. Clearly a combination of our being in the area, and formal patrolling on a daily basis is reducing hunting pressure on the reserve. Baboons which two years ago were very shy and hard to see are now happy to feed while being observed (from a distance). Red backed duikers are also more visible than they were.

Community Projects

Conservation Club

Jeshua Ntim, a teacher at Maisamare Secondary School is working with us to establish a Conservation club at the school. The idea is that students from the NMFP will go to the school and talk with the pupils about what is going on at Ngel Nyaki. At the same time we will invite pupils from the school to visit us in the field and see what we are doing. We plan to teach them bird and tree species, and explain why a healthy future for their forest is so important to them.

Woman's group basket business and the American Woman's Community

The American Woman's Community (AWC) in Lagos is working with us to help the local women sell their Mambilla baskets. The AWC first bought baskets from the women and then raffled them at their AGM in May – all proceeds going back to the Yelwa ladies. In addition the AWC volunteered to man a stall to sell more of the baskets for the women at the May Lagos Trade Fair .

The AWC has also proposed that the NMFP be their NMF project as the designated recipient for the 2006 Small World Fund Raiser. We haven't heard the outcome yet, but it all sounded hopeful.

Visitors 2005

Richard Barnwell, WWF International, visited the project in November 2004. Richard was accompanied by **Ibrahim Inahoro** and **Abdullahi Zabudum**, both of the Nigerian Conservation Foundation (NCF).

NCF, the Taraba State Forest service and NMFP are project partners in a 9,000,000 Naira allocation from the Taraba State Government for the protection of the sanctuary through the mobilisation of the currently unpaid and moribund team of forest guards responsible for the management of the area.

Dr Roger Wilkinson Head of Conservation and Science, and **Mark Pilgrim** , Chief Curator, Chester Zoo visited us in January 2005. They were accompanied by **Professor Volker Sommer** of the Gashaka Gumti Primate Project. Our visitors spent a day at Ngel Nyaki, meeting with students and volunteers and saw the building of the field station in progress.

Kathy and Jason Heiser, and **Malcolm and Robert Warren** from Lagos visited the Project between March 22 & 23rd, 2005. Kathy and Jason have helped the Project enormously through organizing the fund raising events of the American International School. Kathy introduced me to the American Woman's Community in Lagos. Robert Warren also helps the Project by providing accommodation and transport in Lagos. Such help is invaluable!

Malcolm Warren, visiting from Italy, and his brother **Robert**, spent time butterfly collecting. Their collections included a rare (perhaps new) species and a very unusual mutant!

Malcolm and Robert Warren with Kathy and Jason Heiser, with members of the project, Easter 2005

Outputs 2005

Presentation to 3 classes at the American International School, Lagos

Presentation to the MSc class of the Leventis Ornithological Conservation Institute in Jos

Presentation to the School of Biological Sciences, UC

Chapman, H. M. African montane forests- a review (in prep for *Biotropica*)

Sessions, L. The Nigerian Montane Forest Project *Chronicle* magazine September 2005

DRAFT

Appendix 1

PROJECT PROPOSAL

The influence of frugivore communities on forest fragments in Ngel Nyaki Forest Reserve, Taraba State

IHUMA JEROME OBO

M.TECH/FR/04/368

SUBMITTED TO THE DEPARTMENT FORESTRY AND WILDLIFE MANAGEMENT. FEDERAL UNIVERSITY OF TECHNOLOGY, YOLA

MAY, 2005

CHAPTER ONE

INTRODUCTION

1.1 THE BACKGROUND OF THE STUDY

Forest fragmentation and the activities which support or discourage processes of forest segregation are the main focus of some scientists. Ecological rehabilitation assumes a key role in ameliorating fragmentation effects, as a means of creating, directing and accelerating succession processes across degraded areas of the landscape (Brown and Lugo, 1994; Goosem and Tucker, 1995; and Lamb et al. in press). Although, the causes of such fragmentation are known. According to Chazdon (2003), land use increases with growing human populations, deforestation and it's negative effects are likely to worsen, nevertheless, forest exists as a whole, patches or corridors where animals inhibit permanently or migrate in and out. The forest fragments which are in isolation from the main forest interacts directly or indirectly with each other through the mechanisms of seed dispersal. Frugivores may be the major interractant.

The pulp of fleshy fruits, with the soft, edible, nutritive tissues surrounding the seeds, is a primary food resource for many frugivorous animals, notably mammals and birds, but also reptiles (Howe, 1986). Defining the level of frugivory is very important, at least three basic types of frugivory can be difined, relative to their potential consequences for seed dispersal. First Legitimate dispersers swallow whole fruits and defecate or regurgitate seeds intact. Secondly, pulp consumers tear off pulp pieces while the fruit is attached to it's peduncle, or they mandibulate the fruits and ingest only the pulp by working the seed (s) out. Finally, seed predators may extract seeds form fruits, discard the pulp, crack the seed and ingest it's contents or can swallow whole fruits and digest both pulp and seeds. From the plant's perspective, these categories define a wide gradient of seed dispersal 'quality' (snow, 1971; Mckey, 1975; Howe, 1993; Schupp, 1993), from Frugivores that deliver seeds unharmed (dispersers) to those that destroy seeds (granivores), with no clear cut limits between them (Jordano and Schupp, 2000). Most references to frugivorous animals will be birds and mammals that behave as seed dispersers.

However, to discourage land degradation and forest fragmentation, sustainable forest restoration and management require a thorough understanding of the influence that habitat fragmentation has on the processes shaping genetic variation and its distribution in the tree populations. (Bacles, CFF, A.J Lowe et al. 2004). Effective seed dispersal by frugivores is probably helping to maintain high levels of genetic differentiation between them (Baches, CFF, A J Lowe, et al 2004). However, identifying the rate – limiting step(s) of successions in highly degraded lands is necessary to develop techniques for facilitating the recovery process and restoring biodiversity and ecosystem services (Macmahon 1987).

1.2 STATEMENT OF THE PROBLEM

Many years of indiscriminate exploitation of Ngel Nyaki forest resources and poor land-use resulted in the fragmentation of the forest with large land areas formerly covered with forest converted to grassland. Although, global estimates vary widely; it is unquestionable that tropical forests are being cleared at a staggering rate (Myers 1989; food and Agricultural organization 1993). Tropical deforestation also has profound effects on carbon cycling (Houghton 1995), the hydrological cycle (Lean and Warrilow 1989; Shukla et al. 1990),and the conservation of biodiversity (Wilson 1988).

Again, Natural forest succession on human-distrubed land is often slow because the resources necessary for succession are depleted. In many cases the overriding factor impeding forest recovery appears to be lack of forest seeds (Nepstad et al, 1991; Aide and Cavelier 1994; Holl in Press). In such land scapes, forest succession may be dependent on arrival of seeds from off-site, many of which are dispersed by fruit eaten animals. However, there is dearth of information on the frugivore communities of West Africa and their role in forest regeneration, similarly, nothing is known about the influence of fragmentation on these communities.

Human disturbance to these areas often depletes resources needed for natural regeneration (eg seed bank) and forest succession may depend on arrival of wind or animal dispersed seeds (Da Silva et al. 1996, Nepstad et al, 1996). In many tropical regions, frugivorous birds and mammals are the predominant dispersers of pioneer wood plants, playing an important role in their early establishment (Uhl et al 1981, vierira et al. 1994, Da silva et al. 1996). Therefore, this study aims at investigating gene flow within the forest fragments, between the forest fragments and finally between the forest fragments and the main forest.

1.3 OBJECTIVES OF THE STUDY

The general objective of this study is to investigate the best method of forest succession on human-disturbed land. Since previous research works have shown that frugivirous birds and mammals are the main seed dispersers that help to maintain high levels of genetic differentiation within and between forest fragments (Bacles, CFF, AJ Lowe, et al 2004), the current study is planned with the aim of obtaining a more precise picture of how frugivores and forest fragments interdepends or interact to yield a successional vegetation or regeneration of plant species in a degraded land. The study's objectives are:

1. Indentification of frugivores present in the main forest, and fragments of forest (A, B and C).
2. To produce the species list of plants of the main forest and the forest fragments (A B and C).
3. Identification of plants whose fruits are eaten by the frugivores and determine what proportion of the total species they constitute.
4. Determination of fruit size, colour, seed number and type
5. To determine the height of region of the tree utilized by the frugivore species
6. Acertain what stage of ripeness the fruits are at the time of utilization
7. Determination of seedling regeneration in each plot.

1.4 HYPO THESES

The hypotheses are:

HA: There is variation in plant species composition between the forest fragments (A, B and C) and the main forest

Ho: There is no variation in plant species composition between the forest fragments (A, B and C) and the main forest

HA: There is variation in Frugivore diversity between the forest fragments (A, B, and C)

HO: There is no variation in frugivore diversity between the forest fragments (A, B and C)

HA: There is variation in frugivore diversity between the forest fragments (A, B and C) and the main forest

HO: there is no variation in frugivore diversity between the forest fragments (A, B and C) and the main forest.

1.5 SIGNIFICANCE OF THE STUDY

The overall benefit of this research project will be enhanced if biodiversity

of Ngel Nyaki forest reserve is protected and conserved. In order to fulfill conservation and ecosystem functions, rehabilitation of degraded areas is important. Ngel Nyaki forest reserve is currently beset with problem of fragmentation and consequent loss of biological resources, without doubt, this project will offer some antidote to these ills by understanding environmental processes. A protected and conserved area offers water-shed protection, support for traditional livelihood, conservation of potentially valuable genetic resources, natural laboratory for research, education and support for rural development.

These functions are the basis of any meaningful advancement in our

agricultural system and technology which affect individual directly or indirectly. Environmental protection and conservation strategies that will enhance such benefits mentioned will be suggested and recommended.

1.6 THEORETICAL FRAMEWORK

Biological information (Biodiverity) as suggested by (McClanahan 1986) is the cause of ecological succession and dispersal of biodiversity entails spatial dependency, while its introduction and development are time-dependent processes. As seeds are not in themselves mobile, their movement must be effected by dispersal vectors, whether abiotic (eg wind) or biotic (eg frugivorous vertebrates). An understanding of dispersal is needed to asses recruitment limitation in plant communities and to predict population response to global change (Schupp 1990. Ribbens et al 1994, Pitelka et al 1997, Clark et al 1998).

Another fundamental goal of plant population ecology is to understand the consequences for plant fitness of seed dispersal by animals. Theories of seed dispersal and tropical forest regeneration suggest that the advantages of seed dispersal for most plants are escape from seed predation near the parent and colonization of vacant site, the locations of which are unpredictable in space and time (Daniel and Douglas 1998). Dispersal is summarized "by seed shadow" describing the density of juveniles with distance from the parent.

These theories formed the appropriate bases for examining the frugivore communities and their influence on forest fragments.

1.7 SCOPE AND LIMITAITON

A complete assessment of the influence of frugivore communities on

forest fragments in Ngel Nyaki forest Reserve will be impossible because of the diversity in population of both frugivore and plant species. Any references to frugivore in this project will be birds, and mammals. Other limitations include.

1. Nocturnal frgivores other than bats will not be considered in this study
2. Conclusion, recommendation and suggestion on this research work will only be based on eight months of filed work.
3. Only plants in fruit as at the time of this research work will be considered.
4. Only seedlings saplings and poles will be considered as evidence of regeneration.
5. Sampling plots will only be in areas that are accessable.
6. Errors in data collection due to seasonal variation and changes will be ignored.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 FOREST FRAGMENTATION

Deforestation represents one of the planet's most significant environmental and economic problems (FOA, 2001 NASA, 2003) as land use increases with growing human populations, deforestation and it's negative effects are likely to worsen (Chazdon, 2003). Forest fragmentation is one of such negative effects, nevertheless, the crisis is particularly severe in wet tropical regions where soil fertility is generally poor (Aber and Melillo, 1991); and erosion is severe (Lal, 1986; Carpenter et al; 2001; Khamsouk and Roose, 2003; Angima et al; 2003).

Due to deforestation and fragmentation, tropical forests are increasingly sharing edges with disturbed vegetation seed dispersal between these habitats has important implications for future vegetation composition and structure (Nina 2002). Lack of input of forest seeds is one of the most intractable barriers to reestablishment of forest in cleared or degraded areas (Nepstad et al, 1991; Aide and Cavelier 1994; Dasilva et al. 1996; Nepstad et al, 1996; Holl 1999, Holl et al, 2002).

2.2 REGENERATION

Consequently, several practices have been implemented to expedite the processes of regeneration in tropical ecosystems (Uhl and Jodan 1984, Janzen, 1988a, b, Uhl 1988, Virgilio et al. 1997). One of approach that has been frequently proposed is the natural regeneration that involves protection of the deforested area from further disturbance to allow natural successional processes to restore forest communities (Fournier 1977, Lamb et al. 1977). The natural recovery of an ecosystem usually takes very long. One of the causes of such delay is the low availability of propagules and non-available of suitable microhabitat for plant establishment (Janzen 1988a b, Uhl 1988). Again, restoration time of natural forests may be reduced by introducing seeds or propagules of certain species that modify the environment and facilitate establishment of other species (sun et al, 1995). Planting particular trees is another technique that usually accelerates natural regeneration. There are several plant species that tolerate and ameliorate the adverse conditions prevailing a degraded ecosystem (Lamb et al 1997). Other species not only tolerate such conditions but accelerate the colonization process by attracting seed dispersing animals. (Lugo 1988, Lugo et al. 1993, Parrota 1992). Additionally, trees that ameliorate poor soil would be attractive for farmers to plant by providing indirect economic benefits (Diaz –Pena, 1995). Some legumes (family: fabaceae) improve degraded soils by increasing soil nitrogen (Fenchel et al. 1998). A growing number of studies suggest that woody legumes aid forest regeneration Tarrant, 1961; MacDicken, 1994; Franco and Defaria; 1997; Gathumbi et al, 2000, perhaps through their effect on soil nitrogen.

Another suggestion was, reforestation of late succession, high – diversity ecosystem may, at times be accelerated by planting desired species. (Michanahan 1986a, 1998b). Yet tree planting is expensive in human energy and money and may not produce the same ecosystems (in terms of diversity and ecological processes) that result from natures self organization. Consequently, at times it may prove beneficial to enhance the attractiveness of disturbed sites to animals that disperse propagules of late-successsional species. Bird perches (such as snags) provide such a service (DeBusshe et al, 1982; Mcdonnell and Stiles 1983; Brown and archer 1987; MCChanahan and Wolfe 1987) and may prove useful in accelerating forest recovery, particularly in highly fragmented forest landscapes.

Another source of impediments faced by restoration ecologist as they attempt to coax or retain processes that regulate natural communities is, even when habitats are well prepared and species choices carefully made, successful restoration can be delayed or prevented by local environmental changes, such as altered hydrologic patterns (Zedler, 1988), competition from invading weeds (Bradshaw 1983) or herbivove damage (Archibold 1979 Anderson 1989). When change is anticipated as apart of restoration planning however, the out come can be directed in favourable ways. For example, natural succession can be initiated and promoted during land reclamation and habitat restoration (Uhl 1988, Bradshaw 1989; Mayer 1989; Luken 1990). Restoration planners can draw from a wealth of knowledge on the ecological processes that accompany successional change, in particular the role of plant reproduction and dispersal during secondary succession (Archibold 1979, Uhl et al, 1982; Mcclanahan 1986, aber 1987, Janzen 1988a, 1988b; Nepstad et al 1991). During secondary succession, animals continuously transport seeds of woody species into open areas (Johnston and Odum 1956; Smith 1975; Guevara et al. 1986; Hoppe 1988; Saulei and Swaine 1988). Stimulating natural succession by attracting dispersers might be a poor technique when it leads to the unmanaged spread of weedy aliens (Robinson and Handel 1992).

2.3 FRUGIVORY

Total frugivory among mammals is non-existent.

Among bats only

pteropodids (old world bats) and phyllostomids (new world bats) can be considered largely frugivorous (Gardner, 1977; Marshall, 1983; Fleming 1986) supplementing fruit food with insects (courts,1998) and or leaves (kunz and Daiz 1995). Considering primates, fruit is the most widely used type of food, found in the diets of 91% of species examined to date (Harding, 1981; Hladik, 1981), and certain frugivorous forest ungulates, such as brocket deer (Mazama Spp) and African cephalophines (Cephalophus Spp), can include up to 85% of fruit material in their diet (Dubost,1984 Bodmer, 1989, 1990).

Birds are not left out of frugivory, 17 families of birds (15.6%) can be considered as strictly frugivorous but at least 21 families (19.3%) consume a mixed diet with a large proportion of animal prey, and 23 families (21.1%) mix, roughly equal proportion of fruits and other material in their diets (Snow, 1981). Basically, two kinds of birds' fruits can be recognized (whitemore, 1999). Non-specialist frugivores feed on fruits with watery, sugary flesh and small seeds, which provide only part of their diet, mostly carbohydrates. eg Trema. By contrast, fruits evolved for dispersal by specialist frugivorous birds provide a high quality diet, rich in fats and proteins, the seed is large and many one drupe (whitemore, 1999). Other specialist bird fruits are brightly coloured, dehiscent and arillate.

There is a prime distinction, that the birds and monkeys favoured brightly coloured fruit with succulent pulp or arillate seeds, whereas the ruminants and large rodents favoured larger, indehiscent, fibrous fruits. Apart from strong smell, there are no well-defined characteristic syndrome for mammal dispersed fruits (whitemore, 1999).

2.4 SEED DISPERSAL

Recent research suggests that colonization can potentially be limited by

poor seed set from pollen limitation at low plant population density (mcClanahan 1986; Jennersten 1988; Worthen and Stiles 1988; Allison 1990). Large distances from seed sources (McChanahan 1986a, 1986b, Hughes and Fehey 1988), a lack of dispersing organisms or dispersal site, or high post dispersal motality (Janzen 1970; Clark and Clark 1984; Goldbery 1985; Sork 1987; Louda 1989). These limitations on plant colonization process can potentially determine species composition, rates of vegetative development, and ecosystem process (Vitousek and Walker 1989). Recruitment and colonization limitations are likely to be particularly important in highly fragmented landscapes where forest partches are small, distances to seed sources are great, and seed tank storages have decayed or, in the case of primary succession, not developed.

However, the importance of seed dispersers/dispersal cannot be overemphasized. Many tropical trees bear fruits adopted for consumption by animal, and many tropical animals depend on fruits for food for at least part of the year (Howe 1984). Local extinction of a fruit-eating bird, bat or primate might, for instance, reduce recruitment of fruiting trees dependent upon it for reproduction, and consequently increase the chanced of local extinction of the focal trees, of other animals that eat their fruits and ultimately of other trees dispersed by members of the initial assemblage (Howe 1976). The general consequence would be a widening circle of extinctions, precipitated by the disappearance of one "pivotal" species (Howe, 1977).

2.5 IMPORTANCE OF SEED DISPERSAL

Again, seed dispersal determines the spatial arrangement and physical

environment of seeds and thus is an important step in the reproductive cycle of most plants (Harper, 1977; Wilson, 1992; Howe and Smallwood 1982; Herrera, Jordana, Lopez-sora and Amat, 1994; Schipp and Fuentes, 1995). Three non-exclusive advantages have being proposed (Howe and Smallwood 1982, Howe, 1986).

- Escape form high seed or seedling mortality under and near the parent tree (escape hypothesis).
- Colonization of unpredictable, ephemeral, or newly created sites (Colonization hypothesis).
- Directed dispersal to particular favourable microhabitats (Directed dispersal hypothesis).

The escape hypothesis (Janzen, 1970 Connel, 1970) is expected to be an advantage for most plants and is supported by numerous studies showing density- or distance- dependent mortality near parent tree (Wilson, 1992; How and Smallwood 1982, Clark and Clark 1984, Wills, Condit, Hubbell and Foster 1997). However, colonization or directed dispersal also could be important for the seeds that do escape such mortality. The colonization hypothesis is most relevant when suitable sites for establishment are unpredictable or randomly distributed. Alternatively, directed dispersal can result if the plant attracts dispersers that deposit seeds non-randomly in suitable locations, thereby increasing plant fitness.

CHAPTER THREE

3.0 METHODOLOGY

3.1 STUDY LOCAITON

Ngel Nyaki Forest Reserve is located towards the western escarpment of mambilla plateau. The plateau is between longitude 11000- and 11030- East, and latitude 6030- and 7015- north. It is drained by numerous water courses which unite to form the main rivers to discharge eventually into the River Benue. Ngel Nyaki Forest Reserve. Can be reach on foot form Yelwa village through mayo jigawal, from where it is less than an hour's walk to the upper edge of the forest. It comprises approximately 46km2 of impressive submontane to mid altitude forest, lying between 1400 – 1500m (Chapman and Chapman 2001).

The single path down a spur in the forest leads to Gidan Sabo and Dujere, at a lower level of the plateau (Chapman and Chapman 2001). Forest vegetation is continued to the South – West facing slope where mist may lie for days, and sometimes week at times. In forth night from late July to early August 1976, the nist lifted twice for an hour. The trees never ceased dripping (Chapman and Chapman 2001). Heavy rainfall is recorded between April to October while dry seasons commences form November to March.

3.2 DIVERISTY AND CONSSERVATION STATUS

According to Chapman and Chapman (2001) Ngel Nyaki is the most

diverse forest on mambilla plateau. Over 146 vascular plant species were collected, many of which were trees, and (near-) endemic to the Afromontane Region of white (1983), Dowsett – lemaire, 1989).

Also, four tree species are Red Data listed and several tree species were

new to West Africa and others to Nigeria (Chapman and Chapman 2001). The high floristic diversity is reflected in high number of primates and other animal species (Hall, 1970; Dunn, 1993). There is a small, but thriving population of Red Data listed Chimpanzee (Pantroglodytes subspecies vellerosus), as well as putty – nose monkeys (Cercopithecus nictitans, subscpeices martini and black – and – white colobus (colobus guereza occidentalis (Dates, 2000 pers.comm.). The forest is also rich in bird life, more than 200 species were documented in 2003.

Ngel Nyaki was formally gazetted a local authority Forest Reserve under Gashaka – mambilla Native authority Forest order of April 1969, but at present it is under the management of Taraba State Government and Nigerian. Conservation Foundation (NCF).

3.3 EXPERIMENTAL DEISGN

3.3.0 THE MAIN FOREST

This is the bulk of the primary or secondary forest where the study will be carried out. This will be denoted as (MF) with the plots of (50 x 50) m randomly selected denoted as a1 MF and a2MF2 respectively.

3.3.1 THE FOREST FRAGMENTS

Three forest fragments at different distances/area will be considered for

the study. The fragments will be denoted A, B and C. Two plots of (50 x 50)m will be sampled and named b1A1, b2A2 for fragment A, C1B1, C2B2 for fragment B and d1C1, d2 C2 for fragment C respectively.

MATERIALS/INSTRUMENTS

Instruments to be used for data collection includes: binocular, Telescope, caliper, measuring tapes, secateur, field data sheets, pencil, clinometers, Geographical Position system (G.P.S) Birds of Western Africa (Test book).

3.4.0 DATA COLLECTION TECHNIQUES

Data collection in the main forest (MF) and the fragments of the forest A,

B and C will be based on observation and documentation. Data will be collected on frugivore identification. Plant species list, frugivores feeding behavour, fruit size, colour seed number and type. Also to be documented are Height or region of the plant species utilized by frugivore, state or stage of fruit, and finally regeneration.

3.4.1FRUGIVORE IDENTIFICAITON

This is to identify the frugivores present in the main forest (MF) and each

of the forest fragments A, B and C generally. This will be done by observation (Walk/Watch). See appendix one for field data sheet.

3.4.2 PLANT SPECIES LIST

Two plots of (50 x 50)m will be made on the main forest (a1MF1, and a2

MF2) and in the fragments of the forest b1A1, b2A2; C1 B1; C2B2, d1C1, d2C2 for fragment A, B and C respectively. Plant species in these plots will be enumerated in an anti-clockwise direction girth and height of 3cm and 2m and above will be considered respectively. Unknown plant species will be collected and pressed for identification see appendix two for field data sheet.

3.4.3 FRUGIVORES FEEDING BEHAVOUR

Plant whose fruit are eaten by frugivores will be identified. This will be

done by watching focal plants in the main forest (MF) and fragments of forest A, B and C to see what feed on their fruits. Monitoring will be done by sitting at about 20m from the focal plant (plant in fruits) and watch, document the which frugivore comes to feed. See appendix three for field data sheets.

3.4.4 DETERMINAITON OF FRUIT SIZE, COLOUR SEED NUMBER AND TYPE

This will be done by measurement and observation. Caliper will be used

for diameter measurement. Colour will be by visual appreciation counting the seed and identification. See appendix four for field data sheets.

3.4.5 HEIGHT/REGION OF TREE UTILIZED

This will be done by observation and categorization; between 0 – 3m will

be low 3m – 7m middle and 7m and above will be denoted top. This will be deduced from field sheets on feeding behavour. See appendix five for field data sheets.

3.4.6 STAGE OF FRUIT RIPENESS.

This will be down by collecting samples of fruits at the time of utilization

and observe them to know the stage of ripeness see appendix six for field data sheet.

3.4.7 REGENERATION

In the plots of (50 x 50)m transect sampling will carried out. Strips at

interval will be made. Seedlings, saplings and poles will be documented base on individual plant species. This will give the evidence of regeneration. See appendix seven for field data sheets.

3.5.0 METHOD OF DATA ANALYSIS

Statistical methods of data analysis such as percentages, least significant difference will be used. However, analysis of variance, will be used to test the hypothesis.

CHAPTER FOUR

4.0 EXPECTED RESULT

It will be expected that there will be direct gene flow between the forest

fragments and the main forest.

APPENDIX ONE

FRUGIVORE IDENTIFATION

Date:______________ Session:__________Location:_______________

S/No	Frugivore Species	Time	Activity	Fruit	Tree	Position
Eg 1.	Double-toothed barbet	9.00	Sitting	No	Syzygium	top

APPENDIX TWO

PLANT SPECIES LIST

Date:______________ Session:__________Location:_______________

S/No	Name of Plant Species	Fruit	DBH	Height	Next Neighbor Distance

APPENDIX THREE

FRUGIVORE FEEDING BEHAVIOUR

Date:______________ Session:__________Location:_______________

S/No	Frugivore	Time	Tree	Activity	Position	Ripe

APPENDIX FOUR

FRUIT DATA

Date:______________ Session:__________Location:_______________

S/No	Tree Species	Diameter of Fruit(km)	Length of Fruit (km)	Colour	Seed No	Seed Type	Ripe

APPENDIX FIVE

HEIGHT OR REGION OF TREE UTILIZED BY FRUGIVORE

Date:______________ Session:__________Location:_______________

S/No	frugivore	Tree	Time	Activity	Position	Ripe

APPENDIX SIX

STATE OF FRUIT

Date:______________ Session:__________Location:_______________

S/No	Frugivore SPP	Time	Tree	Activity	Position	Ripe

APPENDIX SEVEN

REGENERATION

Date:______________ Session:__________Location:_______________

S/No Tree/Plant Name No of Seedlings No of Saplings No of Poles Total

DRAFT

Appendix 2

PROJECT PROPOSAL

The role of putty nosed monkeys (*Cercopithecus nicitans* in seed dispersal at Ngel Nyaki

Stephen Gawaisa

CHAPTER ONE

INTRODUCTION

Montane forests which occur above 1500 metres are different both in character and composition from lowland forest. At higher altitudes on forested mountains in the tropics, the hot, sticky humidity of the lowland rainforest gives way to a cooler dampness. As the climate changes, so do the flora and fauna. These montane forests are generally further subdivided into recognizable bands: low montane forest, upper montane forest, and subalpine forest. Due to the high humidity and low temperatures these forests are often engulfed in mist for much of the year and are known alternatively as cloud forests. Epiphytic plants such as orchids and lichens are abundant. Tree species are numerous among which are Albizia gummifera, Symphonia globulifera, Syzygium guineense, Polyscias fulva, Aningeria altissima, Entandrophyragma angolense, Schefflera abyssinica, and Ficus species. Light is not excluded and a lush ground vegetation is found in which tree fern Cynthia manniana is dominant (Beazley, 1990; Chapman, 2004).

In Africa montane forest are scattered over the continent, notably in Ethiopia, Rwanda, Burundi, Democratic Republic of Congo, Kenya, Tanzania, Cameroon, and Nigeria. In Nigeria, montane forests can be located on the Obudu Plateau, Mambilla Plateau and Jos Plateau. African montane forests are of high conservation priority because of their complex origin and evolutionary history (Chapman et al., 2004). There are many satellite populations of many species of flora and fauna restricted to African mountains. They harbour many International Union for the Conservation of Nature and Natural Resources' (IUCN's) Red Data List of endangered species of plants and animals especially primates and are Important Bird Area (IBA) (Chapman, 2004). They provide many social, economic and environmental benefits. In addition to timber and paper products, forests provide wildlife habitats and recreational opportunities, prevent soil erosion, landslides and flooding, help to provide clean air and water and contain tremendous biodiversity (Encarta website, 2003). Montane forests area also important against global climate change. The deforestation of lands and depletion of the ozone layer as a result of large quantities of carbon dioxide being released into the atmosphere have caused changes in regional and global climatic conditions. Some of these conditions are drought and global warming which adversely affect man and the resources he depends upon (Ijomah and Akosim, 2000). The species most at risk are in montane, alpine and coastal habitats, where the scope for ecological adaptation to rapid climate change is most limited (WWF,1990). Another reason for conserving the montane forests is their potential as a genetic storehouse for the development of medicine and agricultural products (Nason, 1992). Many plant and animal species are useful either for the manufacture or testing of drugs (Ijomah and Akosim, 2000). The genetic resources contained in the forests are the common heritage of humankind, and may well prove to be vitally important to the future welfare of human race.

Montane forests are important for watershed conservation. The future water resources of rivers and seas depends on the conservation of thickly forested mountains. However, there are some factors that militate against the sustainability of these resources. These include the fact that national development objectives give insufficient value to natural resources, coupled with the fact that living natural resources are exploited for profit and not for meeting the legitimate needs of the people. Other factors are inadequate trained manpower and lack of incentives. Conservation activities by most organizations focus too narrowly while conservation programmes and projects are given inadequate financial allocations and funding. Similarly, poor planning and implementation of projects have negative impact on the ecosystem. This is compounded by obsolete legislation. As the population grows the demands for all human necessity also increase. These demands include food and timber to build more houses for the growing population. This results is clearing of bush and felling of trees, a situation which leads to the destruction of the ecosystems and the extinction of plants and animals.

Conserving biological diversity needs to address both proximate and ultimate causes. The complex threats to biodiversity call for a wide range of responses across a large number of private and public sectors. Since government policies are often responsible for depleting biological resources, policy changes are often the necessary first step toward conservation. National policies dealing directly with wild lands management or forestry, or influencing biodiversity indirectly through land tenure, rural development, family planning and subsidies for food, pesticides or energy can have significant impacts on the conservation of biodiversity. National and sub-national conservation strategies can often provide the mechanism for carrying out such reviews.

Protecting species can best be done through protecting habitats. Most national governments have established legal means for protecting habitats that are important for conserving biological resources. These can include national parks and other categories of protected areas, local laws protecting particular habitats, regulations incorporated within concession agreements, planning restrictions on certain types of land and customary law protecting sacred grooves or special sites. The responsibility for such management is often spread widely among private and public institutions. While the accomplishments to date are impressive, the amount of habitat protected needs to be increased if these areas are to make the necessary contribution to conserving biological diversity, these new areas may need more flexible approaches to management than is usual in national parks.

In addition, protected areas will succeed in realizing their conservation objectives only if they become parts of larger regional schemes to ensure biological and social sustainability, and to deliver appropriate benefits to the rural population. Ex situ conservation programmes which supplement in situ conservation in propagation of threatened and rare species of plants and animals are particularly important for wild species whose populations are reduced in numbers, serving as a backup to in situ conservation and as a major repository of genetic materials for future breeding programmes. It also provides important opportunities for public education. Biological diversity is threatened by various forms of chemical pollution, but the greatest threat may be climate change due to deforestation and burning of fossil fuels. Therefore new forms of management intervention will be required to maintain system deemed desirable.

Local communities which form the foundation for the sustainable use of biological resources need to be more involved in the management of biological resources and to benefits from their sustainable use. They should also be given particular attention in all conservation programmes and be closely associated with the authorities responsible for management of biological resources. However, the tension between local interest and national interest in conservation requires great sensitivity campaigns and education to create awareness for the need to conserve natural resources can be carried out through the use of media agencies. In the process, direct campaign is launched against illegal and indiscriminate exploitation of natural resources.

While efforts are being made to influence the actions of both the public and private sectors in favour of biodiversity conservation, a more challenging approach involving the understanding of the complex connections among natural resources needs to be explored. Animals especially primates contribute significantly to the maintenance of forest structure through complex interactions with the plants. Most of the woody plants in tropical forest are dispersed by animals (Sun et al., 1997). The importance of frugivores on plant regeneration and forest dynamics in these ecosystem is well appreciated and has been studied extensively in recent decades (Howe and Smallwood, 1998; Estrada and Fleming, 1986; Fleming and Estrada, 1993). A question central to evolutionary and ecological consequences of seed dispersal is how effective animal frugivores are as dispersers (Wheelwright and Orians, 1982; Murray, 1983). The study of vertebrate seed dispersal in the tropics is complicated by the tremendous diversity of vertebrates involved. In the tropics these range from some of the smallest vertebrates such as terrestrial rodent and passerines to some of the largest such as hornbills, apes and elephants (Gautier Hion et al., 1985; White et al., 1993 Graham et al., 1995; Whitney et al, 1998). It is therefore, unlikely that animals as diverse as these desperse seeds in comparable ways (Howe, 1989; Schupp, 1993). Thus understanding the ecological and evolutionary forces that produce and maintain forest diversity requires detailed information on individual dispersers (Graham et al., 12995; Sun et al., 1997; Kinnaird, 1998) such as primates.

Primates comprise a large proportion of frugivore biomass in tropiucal forests (Kaplan and Lambert, 2002) and are recognized as important seed dispersers for tropical plants (Dew and Wright, 1998; Voysey et al., 1999; Wrangham et al., 1994,). Zhang and Wang, 1995).. they are known to highest and defecate or spit large numbers of seeds (Corlett and Lucas, 1990; Stevenson, 2000; Wrangham et al.,1994). Thus they are likely to play a role in seed dispersal and tropical forest regeneration (Chapman, 1995). By moving seeds away from the parent plant, primates can influence seed deposition patterns of tropical plants that likely contribute to forest structure (Paulsen et al., 2001). But a quality of a particular seed disperser for a plant species depends on: 1) the number of seeds dispersed, 2) the germination potential of the seed after handling or gut passage, and 3) the suitability of the microsite where the seed is deposited for germination (Chapman, 1995; Schupp, 1993). However, there have been relatively few studies on seed dispersal by one of the most widely distributed fongivorous genera of primates in Africa (Cercopithecus), while little is known of how individual tropical frugivores impact forest structure and consequently on natural regeneration of forest lands. It is likely that focusing on individual dispersers may shed some light (Holbrook and Smith, 2000).

Commonly known as guenons, Cercopithecus monkeys were believed to be mainly seed predators (Rowell and Mitchell, 1991) until recent studies documented that they defecate seeds in viable condition (Fairgreves, 1995; Kaplan and Moermond, 1998; Lambert, 1999). They possess cheek pouches, a characteristic of the Cercopithecianae (the Old World sub-family to which they belong) (Heagle, 1999) and they typically spit seeds (Kaplan and Lambert, 2003). Guenons eat more foliage and have longer gut retention times then their New World frugivorous counterparts (Lambert, 1998). They tend to be both arboreal and terrestrial and may be important in the generating old farm sites (Kaptan and Lambert, 2002).

1.2 STATEMENT OF THE PROBLEM

The contribution of animals and birds in natural forest regeneration has been conducted (Kaplan and Lambert, 2002; Chapman and Onderdonk 1998; Silva et al., 2002; Holbrook and Smith, 2000; Poulsen et al., 2001, Stevenson, 2000). Seed dispersal by Cercopithecinae primate as a means of forest regeneration have relatively been studied elsewhere in East Africa (Kaplan and Lambert, 2002), and West Africa (Martin, 1991). However, seed dispersal by Putty-Nosed monkeys in Nigeria and particularly in Nigerian montane forest is yet to be investigated.

The collection of many aspects of behavioural ecology data requires patient observation and study of primates over long periods of time in order to understand the seasonal changes in the behaviour and behavioural changes through the life time of primates (Albernethy, 1994). Unfortunately because collection of data requires such large investment of time, the behavioural ecology of most primates in Nigerian montane forest is still poorly understood and the effectiveness of our management of them often remains guess work (Albernethy, 19994). Successful conservation requires details on diet, home range, social system and breeding behaviour of individual species (Kilner, 2000; Sutherland, 1998).

1.3 PURPOSE OF THE STUDY

The broad aim of this study will be to investigate the interactions between Cercopithecus nicitans and plants in a montane forest ecosystem.

The specific objectives will be.

1) To determine the status and distribution of Putty-Nosed monkeys in the study area.

2) To identify feeding patterns of Putty-Nosed monkeys including plant species used, parts used and the temporal variation in the use and availability of food resources.

3) To investigate daily ranging patterns of Putty-Nosed monkeys and microsites where ingested seeds are deposited.

4) To assess the contribution of Putty-Nosed monkeys to the natural process of montane forest regeneration.

1.4 NULL HYPOTHESIS

1. Status and distribution of Putty-Nosed monkeys do not influence seed dispersal.

2. Putty-Nosed monkeys feeding pattern has no effect on seed dispersal.

3. Putty-Nosed monkeys do not defecate far away from the feeding parent tree.

4. Putty-Nosed monkeys do not contribute to natural forest regeneration.

1.5 SCOPE OF THE STUDY

Collection of data on the feeding behaviour of primates in a montane forest requires heavy investment in materials and time over long periods. For this reason the study will only cover Putty-Nosed monkeys confined to Ngel-Nyaki Forest Reserve for a period of twelve months. This will allow for a detailed survey on a single group of Putty-Nosed monkeys to be carried out. Other factors limiting the scope of the study include logistics, funds and personnel. The undulating and rugged nature of the terrain makes accessibility difficult especially during the rainy season. There may also be variation in weather conditions which will be beyond the control of the researcher.

1.6 SIGNIFICANCE OF THE STUDY

The study is intended to investigate the role of Putty-Nosed monkeys as seed dispersal agents and how they contribute to the natural process of montane forest regeneration in Nigeria. This study will not only be of great benefit to Ngel Nyaki and Taraba State but also of tremendous importance to states and Federal Ministries of Environment, Agriculture, Universities and Non-governmental Organizations involved in biodiversity conservation programmes in Nigeria and other related parts of Afrotroprics. It will also contribute important and new information about feeding behaviour of Putty-Nosed monkeys that exist in montane forests of Nigeria. Such information is fundamental to promote the conservation of the species and to understand their responses to changes in their natural habitat as a result of human activity.

CHAPTER TWO

2.1 LITERATURE REVIEW

2.1.1. GENERAL INTRODUCTION OF PRIMATES

The primate order, to which we belong, comprise 185 species worldwide divided among 11 families and 56 genera (Estes, 1991). There are four major branches of the primate tree: prosimians (lower primate), New World monkeys, Old World monkeys and hominoids. Monkeys and apes show obvious simian characteristics and have diverse and complex social systems (Alden et al., 1995). Primates have a rounded skull with relatively small brain; forward directed eyes for stereoscopic vision. Hands and feet (except in humans) are adopted for grasping (Alden et al., 1995). Most primates are arboreal and diurnal.

Their food consists of fruits, flowers, leaves and insects.

Africa and Asia have 51 and 52 primate species respectively. Seventy-eight of these belong in one family the Cercopithecidae. The African branch is dominated by forest guenons (Cercopithecus species) (Estes, 1991). The family Cercopithecidae includes all monkeys of the Old World: totaling some 74 species in 2 subfamily, the Cercopithecinae and Colobinae. Tropical Asia is a stronghold of Colobine monkeys and macaques, while tropical Africa is a stronghold of guenons and baboons. The split between the two contiments is approximately half-and-half: 35 Asian and 39 African species (Estes, 1991).

The genus Cercopithecus includes 20 species or half of Africa's complement of Old World monkeys. They are closely related that probably most could hybridize (Estates, 1991).

2.1.2 DISTRIBUTION

With the exception of a few macaques and langurs that have adopted to temperate Japan and China, primates are confined to the tropics and the majority live in rainforest (Jolly, 1985). They inhabit a wide variety of habitat types, which include semi-arid deserts, savannas, woodlands and forests as well as areas cultivated by humans (Hacker et al., 1998). They are either adopted for terrestrial or arboreal, diurnal or nocturnal life. Some primates make use of various canopy strata, whereas others use more specific areas (Estes, 1991).

2.1.3 ECOLOGY

Different primates can share a forest by partitioning its resources and their time in such away that no 2 species have precisely the same diet or regularly complete for the same foods at the same time and places. Some primates range from top to bottom, but many live and forage within just 1 or 2 tiers.

2.1.3.1 SEPARATION BY SIZE AND DIET.

The ecological separation of primates is effected first of all by differences in size. All primates need protein for growth and tissue replacement, carbohydrates and fats for energy, vitamins and trace elements. But size largely predominates the animal's primary food source (Estes, 1991). The stable food and main source of energy for many primates is fruit, which amounts to one quarter (1/4) of the food (Jolly, 1985). Some subsist on new leaves, buds, shoots and seed pods, which are an alternative source of protein and edible gum for carbohydrates. Some eat foliage as the main source of food e.g. colobine monkeys which have ruminant like digestive system. Others still depend on insects and other small vertebrates (Estes, 1991).

2.1.3.2 SEPARATION BY SPACE AND TIME

Though niche separation allows different species of primate to occupy the same habitats and use different resources at different times, competition do occur for edible and palatable foods (Martins, 1991). Competition occurs with herbivores and leaf-eating ants. Frugivorous bats, squirrels and birds may also be significant competitors (Cowlishaw and Dunbar, 2000). Primates are preyed upon by a number of taxa includsing birds, cats, reptiles and other primates, for example, colobus is preyed upon by chimpanzee.

2.2 PUTTY-NOSED GUENON (CERCOPITHECUS NICITANS)

2.2.1 APPEARANCE: A large arboreal monkey with a long tail and dark, grizzled olive green fur on the back, crown, cheeks and base of the tail. The limbs and far half of the tail are black or dark gray. The monkey's most striking feature is a pure white nose spot which stands out against the dark face. It is about 43-70cm in length. The tail is between 56-100cm long, and weighs between 42-6.6 kg. (Alden et al., 1995).

2.2.2 HABITAT AND DISTRIBUTION

The Putty-Nosed guenon is found on Bioko Island and on the main land from north of Congo and Itimbiri rivers west to Nigeria and in patches, on to Siera Leone. The monkey is found in all evergreen forests, from lowland to montane, primary, secondary and narrow galleries and patches. It is uncommon in swamp or mangrove forests. Competing primates usually limit the Putty-Nosed range rather than plant content.

2.2.3 SOCIAL STRUCTURE AND FOOD.

The Putty-Nosed monkey lives in groups of 12-30 females who defend a territory and are accompanied by a single male. Troops of up to 60 have been reported. Resident males advertise their status and presence with a deep, resonant, booming calls. They eat fruit, seeds, flowers, foliage and invertebrates (Alden et al., 1995).

2.3 FRUGIVORY

The pulp of fleshy fruits is a primary food source for many frugivorous animals especially mammals and birds, but also replities, (Howe, 1986). Animals regurgitate, defecate, spit or otherwise drop undamaged seeds away from the parent plant. These animals are the seed dispersers that serve to establish dynamic link between the fruiting plant and seed-seedling bank in natural communities (Jordano, 2002). Seed dispersal and seedling establishment represent the most critical and sensitive stages in the life of the plant (Terborgh, 1990). Frugivory is, therefore, a central process in plant populations where natural regeneration is strongly dependent upon seed dissemination by animals.

Frugivory appears to be a feeding mode that is open to many types of organisms. No special adaptations are necessary to consume fruit, but certain morphological, anatomical and physiological characteristics determine an animals ability to rely extensively on fruit food (Jordano, 2000). Frugivores have potentially disparate effect an seed and seedling survival (Howe, 1986, Levey, 1987). Seeds may be digested scarified or discarded unchanged, singly or in large or small clumps near or far from the concentrations of seeds (Howe, 1990). Jordano (2000) defined 3 types of frugivory relative to their potential consequences for seed dispersal:- 1) legitimate dispersers swallow whole fruits and defecate or regurgitate seeds intact, 2) Pulp consumers tear off pulpy pieces or they mandibulate the fruits and ingest only the pulp by working the seeds out, 3) seed predators may extract seeds from the fruits, discard the pulp, crack the seed and digest both pulp and seeds. However the frugivore behaviour either as a seed disperser, pulp consumer or seed predator in a particular interaction with plant is dependent on frugivore ecomorphology, behaviour and fruit characteristics of the plant in the specific situation (Jordano, 2000; Jordano and Schrupp, 2000).

2.3.1 FRUGIVORY SIZE AND FORM

Body mass is a major determinant of intensity of frugivory. The relative importance of fruit in the diet of Mediterranean passerines is strongly correlated with body mass (Jordano, 1987: Herrara 1995). For example, smaller birds, such as those in the genera Phylloscopus, Saxicola, Hippolais and Aerocephatus. sporadically consume fruits. Fruit makes up 30 – 70% of diet volume among medium sized Phoenicvrus, Luscinia, Sylvia and Erithacus and more than 80% in the larger species (Sylvia atricapilla, S. Borin, Turdus spp. and Sturnus spp. (Jordano, 2000). A similar relationship for eastern North American frugivorous birds was found (Katusic-Malmborg and Wilson, 1986).

Body-size affects frugivory intensity by limiting the maximum number of fruits that can be swallowed or otherwise processed in feeding bout and the maximum amount of pulp that can be maintained within the gut since gut capacity is correlated with body mass. For example, average number of fruit ingested per feeding visit to Prunus mahaleb plant is 1.5 for Phoenicurus ochrurois (16.0g), 9.0 for Turdus viscivorus (107.5g) and 21.0 for Columba palumbus (460.0g) (Jordano and Schupp, 2000). Therefore, body size alone sets an upper limit to the potential maximum number of seeds that a given frugivove can disperse after a feeding bout (Schupp, 1993).

Body-size differs markedly among species showing different types of frugivory, and influences fruit and seed handling prior to ingestion or immediately after it. Usually, small species tend to be pulp consumers rather then legitimate dispersers. Thus fruit and seed swallowing among frugivorouns primates is restricted to large hominoids and cebids (Carlett and Lucas, 1990). Smaller species either spit out seeds e.g. cercopithecines (Kaplin and Moermind, 1983). Although some small species, such as Saguinus, can swallow very large seeds (Garber, 1986).

Many ungulates swallow whole fruits and defecate seeds (Merz, 1981; Short, 1981; Lieberman et al., 1987; Sukumar, 1990; Chapman et al., 1992; Fragoso, 1997) and others spit out seeds (Janzen, 1918c; 1982). Seed spitting is a common behaviour among primates, especially cercoprithecines, which use cheek pouches to store food and later spit out the seeds (Corlett and Lucas, 1990; Tutin et al., 1996; Kaplin and Moermond, 1998). New World apes (ceboids) and Old World hominoids swallow and defecate most seeds intact (Rogers et al., 1990; Tutin et al., 1996; Wrangham et al., 1994; Corlett, 1998). However, some species mash fruits or tear off pulp pieces and can spit or destroy seeds (Teborgh, 1983). Colobines and some cercopithecines destroy must seeds they consume (Davies et al 1988), but some Cercopithecus can disperse relatively large seeds by dropping or defecating them unharmed (Kaplin and Moermond, 1998).

2.3.2 FORAGING FOR FRUITS SEED DISPERSAL

Most seed movement away from the parent trees is a direct consequence of movement patterns by frugivores which take place on a habitat template with numerous microhabitats, patches, safe sites for seed deposition (Schupp, 1993). Thus differences in frugivore activity have profound effects on the conditions under which seeds and seedlings must survive and consequently should influence the evolution of tree demographies (Howe, 1990). According to Jordano and Schupp (2000), two main aspects of frogivory influence the resulting seed dispersal. They are the seed processing behaviour and the ranging behaviour of the frugivore. The former determines the number of seeds that are transported and delivered unharmed in conditions adequate for germination, while the later defines the potential range of microsites that will incercept delivered seeds. Similarly, Howe (1990) pointed out that frugivores have potentially disparate effects on seed and sedling survival. Seeds may, therefore, be digested, scarified or discarded unchanged singly or in large or small chumps, near or far from other concentrations of seeds.

Frugivory influences on plant fitness and recruitment goes beyond seed delivery. For every dispersal episode, it matters how many and where seeds reach the ground and the particular mix of seed species delivered (Jordomo, 2000). Ranging behaviour of frugivores have been studied in detail (Gautier-Hion et al., 1981; Hladik, 1981; Terborgh, 1983; Fleming, 1988; Murray, 1988; Chavez-Ramire and Slack, 1994; Sun et al., 1997).

2.4 SEED DISPERSAL

Seed dispersal determines the spatial arrangement and physical environment of seeds and thus is an important step in the reproductive cycle of most plants (Schupp and Fuueness, 1995; Wenny and Levey, 1998). Seed dispersal and sedling establishment represent the most critical and sensitive stages in the history of plants. Since tropical forests are one of the world's most diverse plant communities, it can be anticipated that the process of seed dispersal and seedling establishment in them will accordingly be diverse (Terborgh, 1990).

2.4.1 SEED DISPERSAL BY BIRDS

Dispersal effectiveness can be divided into two components: the quality of seeds dispersed and the quality of dispersal for each seed (Harrera and Jordano, 1981). Two elements however, according to Schupp, (1993) affect the quality of seed dispersal: (1) the probability of the ingested seed to be dispersed away from the parent tree and (2) the distance seeds are dispersed.

4.4.1.1 GUT RETENTION TIME

Levey (1986, 1987) found that the time interval over which seeds are defecated by frugivourous birds is shorter for large than small seeds. He attributed this to the fact that large seeds can be easily separated from the pulp. Similarly Levey and Grajal (1991) found that the gut retention times of large seed tend to be shorter than those of small seeds. Murray (1988), also found differences in passage rates among fruits of similar size and texture in three species in the families of Muscicapadae, Capitonidae and Ptilogonatidae and suggested that some fruits with the shortest seed passage rates contain chemical laxative.

Sun et al., (1997), however, found no correlation between seed size and either the time internal over which seeds were defecated or the gut retention time in Ruwenzori Turaco (Musophaga johnostoni) in the Ngungwe Forest Reserve, a tropical montane forest in Rwanda. They attributed the descrepency between their study and other studies to two factors: (1) differences in pulp texture and chemicals among fruit species and (2) the small number of fruit species included and the uneven distribution of seed sizes tested. In a study of two species of Ceratogymna hornbills in the Dja Reserve, Cameroon, Holbrook and Smith (2000) collaborated Lavey (1987) that seed passage rates increased with bird mass.

2.4.1.2 SEED SHADOW

The seed shadow of a tree is often assumed to be highly leptokurtic, with the majority of seeds being deposited under the parent tree (Harper, 1977; Fleming and Heithaus, 1981). However, results of a study conducted by Sun et al., (1997) suggested that most seeds ingested by turacos may be deposited away from the parent and that the highest concentration of seeds was not located under the parent tree. A study by Holbrook and Smith (2000) on hornbills suggested that seed shadows exhibited long thin tails. The long tails suggest that hornbills seed dispersal may have impacts on plant community structure and may contribute to increased gene flow (Schupp, 1997; Hamllton, 1999; Shilton et al., 1999). Long distance dispersal by hornbills may also facilitate the dispersal of rare species and colonization to gabs or more suitable germination sites (Holbrook and Smith, 2000). Several other studies have noted that seed shadow distributions deviate from a negative exponential curve (Murray, 1988; Wilson, 1993; Sun et al., 2000). Hornbill seed shadows estimated in Dja Reserve, Cameroon (Hilbrook and Smith, 2000) are very similar to those described by Sun et al., (1997) for turacus in the African montane forest of Rwanda.

2.4.2 SEED DISPERSAL BY MAMMALS

2.4.2.1 UNGULATES

Seed dispersal by ungulates have been studied for many decades. For example, Martin (1991) reported that duikers, bushbucks and bongos consume a great deal of fruit but that they usually destroy the pits and their seeds. Some of the pits, however, were spat out during cud-chewing and others passed through the intestines of larger rummants unharmed. He noted that seed dispersal by ungulates is not very efficient. The bush pig and giant forest hog can crack even hard nuts with their powerful jaws, thus eliminating the plant's chances of reproduction.

Elephants are known to disperse large numbers of seed with intact shells and may transport them over long distance before depositing them in their dung. Waithaka (2001) showed that elephants are important agents of seed dispersal for many plant species in a study conducted in Aberdare and Tsavo National Parks in Kenya.

The potential for elephants to disperse seed in the Aberdares was high. A hundred dung piles produced 422 seedlings, an indication that the number of seed dispersal in this manner was quite large, considering that there were over 4000 elephants in the area (MGM Environmental Solution, 1999) and each defecates roughly 17 times a day (Barnes and Jenzen, 1987). By extrapolation, elephants in Aberdares have a potential of planting 272,000 viable seeds daily in the park (Waithaka, 2001). On the other hand, Waithaka (2001) found such dispersal on a much lower scale in Tsavo.

Other studies showed a similar situation. For example, Muoria et al., (2001) showed that seed or fruit remains were recovered in 64.5% (n=736) of all elephant dung piles examined in Arabuko – Sakoke Forest, Kenya. 82% (n=311) of the dung piles at Lope Reserve, Gabon, contained fruit remains (White et al., 1993). In that study, elephants fed on fruits of 72 plant species. Merz (1981) found that elephants at the Tai National Park, Ivory Coast, fed on fruits of 44 plants species. Short (1983) documented a large scale migration of elephants in response to seasonal fruiting patterns. At Santchou Reserve, West Cameroon, 65% of all dung piles examined (n=250) had some traces of fruits with 22 plant species being recorded (Tchamba and Sene, 1993).

2.4.2.2 PRIMATE AND SEED DISPERSAL

Early studies of tropical fauna recognized that primates contitute a large proportion of the frugivore biomass in tropical forests (Eisenberg and Thorington, 1973). That they eat large quantities of fruits and that they defecate or spit out large numbers of seeds (Estrada and Coates-Estrada, 1984; Corlett and Lucas, 1990; Rowell and Mitchell, 1991). Recently, these initial impressions that primates move large numbers of seeds have been quantified by studies conducted in South American forests (Garber, 1986; Julliot, 1996), Central American forests (Estrada and Coates – Estrada, 1984, 1986; Chapman, 1989), and African forest (Gautier – Hion, 1984; Gautier Hion et al., 1986; Wrangham et al., 1994; Chapman and Chapman, 1996; Lambert, 1997). These studies have revealed interesting differences between primate communities. For example, in Kibale National Park, Uganda, 98.5% of chimpanzee fecal samples contain seeds, with an average of 22 large seeds (> 2mm) per defecation (Wrangham, 1994). The number of large seeds dispersed by the chimpanzee populations is estimated at 369 large seeds km2/day (Chapman, 1996). Lambert (1997) recently extended this analysis and assessed fruit removal rate of redtail monkeys (Cercopithecus ascanius), the blue monkesy (C. mitis), and mangabeys (Cercocebus albigena) in Kibale. He found that in a single day, these animals removed approximately 34,000 fruits/km2 and dispersed 446 seeds/km2. The frugivorous primate community at Kibale with a biomass of 575kg/km2, defeated approximately 815 large seeds/km2/day. A primate community in northern Costa Rica (Ateles geoffroyi, Alouatta polliata, Cebus capucinus), having a biomass of 426 kg/M2, dispersed approximately 5600 large seeds/Km2 chapmen 1989). Similarly, a group of howler monkeys Alouatta seniculus in French Guiana has been shown to disperse more than 1,000.000 seeds /year from approximately 100 plant species (Julliot, 1996).

2.4.2.3 GERMINATION POTENTIAL OF PRIMATE DESPERSED SEEDS

Evidence suggests that most primate-dispersed seeds are capable of germination. Chapman and Onderbonk (1998) pointed out that when researchers extracted seeds from primate dung and attempted to germinate them in controlled settings, results often indicated that the passage of seeds through the frugivore gut improved the rate of germination and reduced dormancy to germination. Similarly, Lieberman et al. (1979) germinated seed from 59 plant species collected from baboon dung in Ghana and found that ingestion improved germination success over that of fresh seeds in three of the four species tested. Garber (1986) planted seeds defeated by Sagiunus mystax and S. fuscicollis and found a 70% germination success rate. Estrada and Coates –Estrada (1991) documented that the germination success of seeds from dung of howlers (Alouatta palliota) at Tuxtlas, Mexico was 57%, an increase of 22% over control seeds collected from the tree. Passage through the gut of chimpanzee improved the rate of germination and reduced dormancy to germination in all ten fruiting tree species tested in the Kilbale National Park, Uganda (Wrangham et al., 1994).

2.4.2.4 QUANTITY OF SEED DISPERSED BY CERCOPITHECUS MONKEYS

The number of seeds dispersed is a product of the number of seeds handled and the probability of the handled seeds being dispersed (Schupp, 1993). Guenons handle seedin a variety of ways ranging from spitting, dropping to swallowing and defecating them or place them in their cheek pouches and remove them later to consume the pulp and drop or swallow the seeds (Kaplin and Moermond, 1998; Lanbert, 1999).

Cheek pouches are an important component of seed handling in guenons (Rowell and Mitchell, 1991; Lanbert, 1993). Fairgreves (1995) documented 14 tree species whose seeds were spat from blue – monkey cheek pouches after the pulp had been removed (seed size ranged from 3 to 30mm). In a study conducted in Kilabe forest, Uganda, seed spitting was the most common pattern of seed handling year round. The spat seeds had usually been stored in cheek pouches (Lambert, 1999). Cercopithecus monkeys tend to spit seeds greater then 10mm under canopies of fruiting trees, thus speicies with large seeds may have a low probability of dispersal by guenons (Kaplin and Lanbert, 2002). However, fruits of these species may be placed into cheek pouches and thereby dispersed 50m or more from the parent tree (Rowell and Mitchell, 1991). Similarly, Lambert (1999) found that while the majority of seeds in cheek pouches were spat under the parent tree (83.3%), some seeds (16.7%) were spat as far as 100m from the parent tree.

Guenous also defecated both large and small seeds intact. For example, in the Nyungwe Forest, all mountain – monkey dung collected (n=58) and blue – monkey (n=50) contained intact seeds. Blue and mountain monkeys dispersed a mean of 2.3 and 6.4 seeds >2mm respectively per dung sample (Kaplin and Lambert, 2002). However, Fairgreves (1995) found a mean of 6.12 seeds >2mm per blue monkey dung sample in the Budongo Forest, Uganda, and a Maximum of 92 seeds >2mm of a single plant species in a single dung sample. He also found that 55% of the Kibale redtail dung sample (n=135) contained seeds most of which (84%) were small sized Ficus spp.(-2mm). Blue-monkeys in the same area, on the other hand, had seeds >2mm in only 16% of their dung samples.

Differences in seed spitting and defecation rates among sites were attributed to feeding behaviour differences among species of cercopithecus and different plysiological patterns or different plant species at the respective sites (Gautier – Hion et al; 1993; Tutin et al; 1996).

2.4.2.5 QUANTITY OF SEED DISPERSAL

Quantity of seed dispersal is a function of the treatment a seed receives in the mouth and gut and the quality of seed deposition (Schupp, 1993). Most seeds, regardless of guenon handling methods, are intact and viable following desposition (Chapman, 1995; Lambert, 1997; Kaplin and Moermond, 1998). Rowell and Mitchell (1991) suggested that guenons destroy most of the seeds thy ingested. However, on the contrary, Kaplin and Lambert (2002) demonstrated that guenons have the capability of dispersing a relatively large number of seeds away from the parent tree crowns through defecation, placement in cheek pouches and spitting.

1. According to Kaplin and Moermond (1998) and Lambert (2001), spat seeds are viable and for some plant species, removal of pulp by guenons may be beneficial even if the seeds are not carried away from the parent tree. For example, in Kibale Forest, redtail monkeys spat out cleaned seeds of Strychnos mitis fruit in a majority (80%) of the S.mitis fruit eating observations. In 83% of the S.mitis fruit eating events (FEE) redtail monkeys spat out seeds within 10m of the removal site and in 56% of the FEEs they moved <1m before spitting seeds. Most (83%) of S.mitis seeds spat out by redtail monkeys germinated, while only 12% of unprocessed seeds survived to germination .Of the processed seeds that germinated, 60% survived to seedling stage, whereas only 5% of the unprocessed seeds survived to seedling establishment.

CHAPTER THREE

MATERIALS AND METHODS

3.1 STUDY AREA

3.1.1 LOCATION AND SIZE

Ngel Nyaki Forest Reserve occupies an area of approximately 46km2 of impressive montane to submontane forest growing on volcanic creater. It lies between latitude 07' 27'N and longitude 11' 03E. The reserve is located towards the western escarpment of Mambilla Plateau of Taraba State in North Eastern Nigeria. It is about an hour's walk from Yelwa village which is situated between Serti and Gembu and about 60km west of Gashaka Gumti National Park (Fig. #).

3.1.2 TOPOGRAPHY

The region is a mountainous area which forms part of the Mambilla Plateau and the South Eastern Highlands of Nigeria. The mountainous terrain is characterized by step slopes, deep plunging valleys, precipitous escarpments and swiftly flowing rivers and streams. Altitude ranges from 1400 meters to 1700meters above sea level.

3.1.3 DRAINAGE

The region is a major catchment area for the River Benue and River Donga which rise from the Cameroon Republic and flow east to west. The Donga River empties eventually into River Benue which joins Niger River at Lokoja. The surface hydrology of the region is dominated by high rainfall regime of the highlands. These highlands are drained by a network of north-westerly or south-westerly oriented rivers. The north - westerly oriented rivers include Jigawal, Shina, Ngelforo, Hainare and Molirde which flow into Taraba River system and eventually into Benue

River. The south –westerly oriented rivers on the other hand are Gishi, Ngebe, Danko, Hara, Mbela, Akon and Dam which flow into Donga River system and then into Benue River.

3.1.4GEOLOGY

There are three main layers of rock to be found underlying the region (Dunn, 1998).

(i) Basement Complex: rocks underlying the lowland plains outcrop as isolated rocky hills and low ranges with serrated outline. In the highlands they form massive, step- sided-hills and mountain ranges with angular, structurally controlled drainage pattern. The rocks consist of scattered remnants of highly metamorphosed sedimentary rocks, and diverse, predominantly granitic plutonic masses, collectively known as the Older Granites. The oldest rocks comprise remnants of an ancient sedimentary series now almost entirely transformed into migmatites and granites. Biotite-gneiss and horn blende – gneiss are among the most frequently occurring types. The Older Granites vary considerably in structure, texture and mineralogy. They can be divided into three major divisions: syntectonic granites, which are by far the most extensive, fine-grained granites and basic and intermediate plutonic rocks. The granitic members are generally rich in potash. The Basement rocks have been intruded by dykes of varying composition which give rise to prominent linear features in the landscape. Considerable faulting and warping has affected these and this rocks in association with strong rectangular jointing give rise to the characteristically angular drainage pattern. Superficial deposits of concretionary ironstone occur scattered throughout the region, frequently forming resistant caps. They vary considerably in texture but are generally vesicular and contain colitic or pisolitic ironstone.

(ii) Volcanic rocks:- extensive tertiary volcanic rocks occur as highland plateaux in the Mambilla area. These and similar more recent formations occur as scattered local lava flows or plugs. They consist mainly of basalt with some trachyte, rhyolite, tuff and agglomerate.

(iii) Recent Deposits:- recent alluvium deposits poorly sorted sands, silt and gritty clays, may be found in several of the larger river valleys.

3.1.5SOIL

Most of the regions soils are Ferruginous Tropical Soils derived from crystalline acid rocks of Basement Complex. Many of them have sub-surface horizon with a high content of iron concretions and fossil ironstone occur in many areas, both in the highlands and in the lowlands. In the highland areas Humic Ferrisols occur derived from both basement and basaltic rocks. Rock outcrops and rock debris are associated with steep escarpments and are grouped together as undifferentiated Raw Mineral Soils. Lithosols and Lithic Soils are associated with isolated hills and inselbergs in the lowlands. Weakly developed soils also occur as Juvenile Soils on recent riverine alluvium and on lacustrien alluvium, mainly in conjunction with Mineral Hydromorphic Soils. Poorly drained heavy black clays occur in river valleys, depressions and other lowlying areas. Such soils are grouped together as Vertisols.

3.1.6CLIMATE AND SEASONS

The climate of the area is characteristic of montane and near temperate climatie. The rain bearing winds are from the south – west. The rainy season lasts from March to November. The annual rainfall exceeds 2000mm (Ezealor, 2002) with peaks in June, July and September. The start of the rains is often marked by furious squalls. The dry season lasts for about three months. The rains slacken off early in Movember and the dry season has usually begun by the second week of that month. The daily mean temperature does not exceed 300C. Locally reduced evapotranspiration and occult precipitation are caused by orographic cloud and mist (Chapman and Chapman, 2001). For weather data of the area, see Fig.#.

3.1.7 VEGETATION

The annual and seasonal distribution of rainfall and latitudinal and elevational temperature gradients largely determine the vegetation of and area (Alden et al., 1995). Ngel Nyaki Forest Reserve is the most plant rich montane forest on the Mambilla Plateau. The vegetation can be categorized into three: the grassland caps, the mid-altitude forest and wooded savanna or grassland. The reserve has over 24 Endangered plant species. These include the International Union for the Conservation of Nature and Natural Resources' (IUCN's) Red Data Listed such as Pouteria altissima, Lovoa trichiloides, Melletia conraui and Entandrophragma angolense (Chapman and Chapman, 2001). The forest has many tall emergents such as Newtonia buchananii, Entandrophoragma angolense and Pouteria altissima (Chapman and Chapman, 2001; Ezealor, 2002). The canopy is usually dense because of the profussion of lianas and other vines (Ezealor, 2002). Some of the grass species include Hyperrhania sp., Loudetia sp., Ctenium ledermannii and Sporobulus sp. In some places the forest has been greatly altered by human activities such as farming and grazing of domestic animals. Because montane forests tend to occur in isolated pockets and fragments interrupted by intervening lowland forest or savannas, they have given rise to a large number of endemic plant and animal species with restricted ranges. Such species need careful protection if they are to survive (Alden et al., 1995).

3.1.8VETEBRATE FAUNA

The diverse forest flora habitat of Ngel Nyaki is reflected in the high number of primates and other animal species and high avian diversity (Chapman et al., 2004). The reserve harbours a population of the rare endangered Nigerian Chimpanzee Pan troglodytes subspecies vellerosus (Chapman, 2004). Other species include Putty-Nosed monkey, Mona monkey, Baboon, Tantalus Monkey, Buffalo, Bushbuck, Blue duiker, Jackal, African Civet, Mongoose, Waterbuck, Red flanked duiker, hare and Giant Rat as well as squirel.

The area is classified as Important Bird Area (IBA) (Ezealar, 2002). Birds such as Turacos, Cameroon olive pigeon, double toothed barbet and green bulbul are common (Chapman 2004).

3.1.9. CONSERVATION ISSUES

Ngyel Nyaki Forest Reserve is administered by the Taraba State Government through Forestry Department, Sardauna Local Government and the local communities. However, since 1980's there has been very little patrolling and its prection has come primarily from local volunteer "informants". Although most of the forest is in good condition because access is difficult there has been some clear-cutting and burning by farmers these disturbed patches attract pastoralists who graze their cattle there. Hunting is wide spread. Many villagers exploit the forest for construction materials, fuel wood, medicine, food and water. Although legally protected as a state forest reserve, there were no active conservation initiatives until the birth of the Nigerian Montane Forest Project in 2004 (Ezealor 2002; Chapman, 2004).

3.1.10 LEGAL STATUS

Ngel Nyaki was legally gazetted as a forest reserve in 1969 by the then Gashaka – Mambilla Native Authority with the purpose of protecting its flora and fauna. It was designated as a Game Santuary in 1974 and gazetted as such in 1975. There appeared to be no active conservation initiatives (Ezealor, 2002) until the Nigeria Montane Forest Project came on board in 2004. Arrangements have been completed for the Taraba State Government to hand over the reserve to the Nigerian Conservation Foundation (NCF) for proper and better management. Already, the state government has released its counterpart funding to NCF as part of the agreement (Aji, pers. Comm., 2005).

To this effect, the reserve boundary has been re-demarcated and biodiversity survey and socio-economic studies carried out.

3.1.11 STUDY ANIMAL

Putty-Nosed Monkeys belong to the genus Cercopithecus, which contains the largest number of African primates. Most members of this genus live in forest habitat ranging from lowland rainforest to montane forest (Cords, 1987). This species associates with Mona Monkey during feeding.

3.2 STUDY DESIGN

A preliminary survey was conducted between October and November, 2004 to randomly select sites and a focal group of monkeys where intensive and detailed seed dispersal studies will be carried out. The study will focus on Putty-Nosed Monkeys at the montane forest habitat of Ngel Nyaki. The focal group will be followed daily during survey days for 8hrs. a day and 5 days a week. The survey will be conducted at approximately the same time each survey day.

All observations will be non-interactive (Altman, 1998). Any physical contact is to be avoided because of later problems such as overhabituation, which makes them prone to poaching. Data will be collected for a total period of twelve months (January, 2005 – January, 2006). The survey will span over both dry and rainy seasons (Appendix #)

INVESTIGATION I

Title: Determination of the status and distribution of Putty-Nosed monkeys in the study area.

OBJECTIVE

1. To determine the absolute population density estimate of Putty-Nosed Monkeys in the study area.

PROCEDURE:

Putty-Nosed Monkeys will be surveyed using modified line transects based on the distance sampling methods of Buckland et al. (1993) and described in detail by Whitney and Smith (1998) and Poulsen et al., (2001). To avoid disturbance associated with constructing transect grid, 3 of the already existing transects will be chosen randomly and then walked to census target species. The transect system traverses major habitats in the study area. The length of the transects ranges in distance from 3km to 4km. Each transect will be surveyed 20 times between the hours of 6.00am and 12 noon local time. At the start of each survey the following will be recorded: time (at the start and end of survey), date, location, weather and participating personnel (Appendix #). The transects will be surveyed in sequence so that all three transects will be surveyed before the first transect will be re-surveyed. During sequential samples along the same route, the direction of travel will be alterated so it will not be walked in the same direction in two consecutive surveys. This is to reduce potential biases resulting from differential habitat use by primates and from direction of travel by observers. The transects will be walked at a pace of approximately 1km/1.5hrs. due to the rugged nature of the terrain. For each Putty-Nosed group sighted, the following will be recorded: time, number of individuals actually seen and the total number or group size estimated when conditions prevented a complete count, category of detection (whether visual, audio-visual or by movement of disturbed vegetation), location of the observer along the transect, sighting angle, activity or behaviour of first individual animal detected (traveling, sleeping, resting, feeding, mating, fighting, standing, sitting, grooming or unclassified), sighting distance (S) from the observer to the first animal detected, perpendicular distance (P) from the transect to the first animal detected group spread, category of sighting (solitary, group or uncertain), and habitat type (Appendix #). Distances will be estimated to the center of the group (Whitesides et al., 1988) by eye to the nearest meter. Binoculars and telescope will be used for the survey. If the observers detected signs of animals they will not leave the transect in search of them, nor will they follow contracted animals away from the transects. Backward movement to confirm a sighting will be limited to 50m.

Data analysis

From the transect data, densities of primate group will be estimated using the programme DISTANCE (Laake et al., 1993). DISTANCE models the distance from a transect to an animal using several density functions so that the density of animals in the study area can be estimated (Table #)

Objective (2):

To determine the distributional pattern of Putty-Nosed Monkeys in the study area.

Procedure:

Whenever a group of Putty-Nosed Monkeys are encountered along the transect, the location will be marked with a Global Positioning System (GPS). The time and habitat where they are located will also be recorded.

Data analysis

A map showing the distribution pattern of Patty-Nosed Monkeys in the study area will be produced (Fig. #).

INVESTIGATION II

Title: Identification of feeding patterns of Putty-Nosed Monkeys and the temporal variation in the use of availability of food resources.

OBJECTIVES:

1. To identify the type of food eaten by Putty-Nosed Monkeys in the study area.

2. To identify the parts of food plant eaten

3. To ascertain seasonal variation in the feeding habit of the monkeys.

PROCEDURE:

The focal group of Putty-Nosed Monkeys will be followed for 8hrs. each day of survey: 6hrs. in the morning from 6:00am – 12 noon, and 2hrs. in the evening from 4pm – 6pm local time. They survey will be conducted at approximately the same time each day of survey throughout the year. When the focal group is being followed, scan sampling method and fixed time – interval recording regime will be used. Each scan sample will last for 15 minutes beginning on the hour with an observation period of 5 minutes (Appendix #). Binoculars and telescope will be used for observation while GPS will be used to mark fruiting plants and microsites where ingested food are defected. During the observation period, the focal group will be scanned from left to right on the first scan then right to left next scan and so on. All feeding behaviour will be observed and recorded on a sampling protocol (Appendix #). Only one activity will be recorded for each member of the focal group seen during the scan period. Animals will be recorded as feeding if they are handling, pulling biting, ingesting, chewing food, and if they are feeding the plant part and plant species will be recorded. Phenology of plant parts production currently being undertaken by the Nigerian Montane Forest Project will be consulted. The abundance of plant part will be recorded using a score of 0 to 5 for each item. Scan sampling is chosen because it gives a representative cross-section of the activity budget (Nakawa, 2000).

DATA ANALYSIS

Graphs

INVESTIGATION III

Title: Investigation of the daily ranging patterns of Putty-Nosed Monkeys and microsites where ingested seeds are deposited.

OBJECTIVES

1. To produce a map showing the daily ranging pattern of focal group

2. To determine the average distance between the points of defecation and food plants.

3. To map out microsites used for deposition of ingested food.

PROCEDURES:

To determine the daily distance traveled by Putty-Nosed Monkeys, the focal group will be followed and their locations will be recorded with GPS at 6.00am and 6.00pm. Locations will also be marked during the days of survey between sleeping sites (6.00am – 6.pm) at the change in the direction of travel. This will be necessary as there will be every tendency that the group may not take a straight course, since they will be foraging for food randomly from the point of take off at 6.00am (after waking up) to 6.00pm when they retire for the day. Where foecal samples are encountered or when a member of group is observed defecating, the position in relation to the food tree and habitat will also be marked with GPS.

DATA ANALYSIS

Data from the survey above will be used for:

1. The production of a map showing the ranging pattern of the focal group (Fig. #)

2. The determination of the average distance between the point of defecation and the food trees (Table #)

3. The identification and mapping out of microsites for deposition of ingested food. (Fig. #)

INVESTIGATION IV

Title: Assessing the contribution of Putty-Nosed Monkeys to the natural process of montane forest regeneration.

Data will be collected on the quantitative and qualitative components of dispersal.

1. Quantity of seeds deposited in faecal samples.

OBJECTIVE I

To ascertain the presence of seeds in faecal dropping of Putty-Nosed Monkeys in the study area.

PROCEDURES:

Faecal dropping will be collected opportunistically when the monkeys are being followed. When an individual member of the focal group is observed to defecate, the faecal clump will be collected and preserved in a 95% E+OH of known volume in a screw top plastic containers which will be sealed with air-tight plastic bags. The date location, habitat and time of collection will be marked.

DATA ANALYSIS

Samples will then be taken to the field station for processing the faecal samples will be washed with water over a 1.5mm screen to ascertain the presence of seeds.

OBJECTIVE 2:

To determine the seed load of the faecal dropping and compare them to that of other primates.

PROCEDURE:

Faecal dropping will be collected when the monkeys being followed: the faecal clump will be preserved in ethanol in a screw top containers. The date, location, habitat and time of collection will be recorded. The faecal samples will be washed with water over a 1.5mm screen to extract seeds longer than 2mm. Seeds >2mm will be counted to know the exact number of seeds in a faecal clump. Seeds <2mm eg. Ficus seeds will be estimated to the nearest hundred seeds. The species of seeds will be determined by comparing them to a reference collection of seeds from identified fruits. Seeds that could not be identified will be assigned a temporary identification. Whenever other primate species are seen together with focal group, faecal samples will not be collected except a particular monkey is observed defecating.

DATA ANALYSIS

The number of seeds counted in the faecal samples will be compared to that of other similar primates where studies had been conducted elsewhere.

2) VIABILITY OF SEEDS

Quality of seed dispersal is a function of the treatment a seed receives in the month ond gut and the quality of seed deposition (Kaplan and Lambert, 2002).

OBJECTIVES 3

To evaluate the viability of seeds extracted from faecal droppings.

PROCEDURE:

The viability test of the extracted seeds from faecal dropping will be carried out by suspending them in a bucket containing water. Those which float may be considered unviable.

OBJECTIVE 4:

To compare the germination rates of ingested to un-ingested seeds.

PROCEDURE:

To assess whether Putty-Nosed Monkeys passed seed are viable, undamaged seeds will be extracted from faecal samples for germination trials, to compare germination rates of passed and non-passed seeds, seed of species from ripe fruits under the canopies of fruiting trees commonly found in the faeces will be collected. The seeds will be sown in replicates of 20-30 seeds in a complete randomized design. Both passed and non-passed seed will be sown and monitored under the same conditions (Table #)

DATA ANALYSIS

Analysis of variance (ANOVA) will be used to analyse the data.

3.3 EXPECTED RESULTS

It is expected that the outcome of this study may pave way to making recommendation to promote conservation management of the species and the forest restoration of the montane forest ecosystems.

DRAFT

Appendix 3

PROJECT UPDATE

Does the Janzen-Connell model for species diversity apply in montane african forests?

Arne Matthesius
0016470

Re-state the objectives of your research proposal.

To test the Janzen-Connell hypothesis in African montane forests by testing the following predictions:

1. Seed predation will be highest and seedling establishment and survival will be lowest under the parent tree. Germination will not vary with distance from the parent tree. This will be tested by sowing seeds at different distances from the parent to determine if seed predation decreases and whether germination, seedling establishment, and survival increase with distance from parent tree.

2. More conspecific seedlings and saplings will survive away from, rather than underneath the parent tree. In addition, herbivory will be highest under the parent tree, and decrease away from it.

This will be tested by measuring the distance from the parent tree of all conspecific seedlings and saplings: in order to determine their distribution at different ages (as estimated by height). From this data survival over time at different distances from the parent tree will be inferred.

Evidence of herbivory, fungal attack, parasites and other diseases of the conspecific seedlings and saplings will be recorded. From this data the frequency of herbivory and disease on seedlings and saplings in relation to distance from the parent tree will be assessed.

3. The degree of clumping of conspecifics in the forest is low.

The degree of clumping will be tested by measuring nearest neighbour identities and checking for pattern using the chi-square test.

Seedling/Sapling leaf area lost to herbivory is hypothesised to be greatest under the parent tree. (This would give indication as to whether herbivore activity is host specific or density dependant, supporting the hypothesis that herbivory strongly influences forest structure and thus potentially tree species diversity).

Methods (outline of experiments to be used to test hypotheses.):

Tests of the four hypotheses will run over five months and will be conducted as follows:

(1) Seeds of three tree species will be collected. Sixty seeds will be planted in 5x5m plots under (0-5m), at (10-15m) and at (20-25m) from the parent tree. This will be replicated twenty times for each species. The proportion of seeds germinated out of the total number planted at each distance from the parent will be determined. Germinated seeds and seedlings will be monitored (amount surviving) for all species and their replicates every two days for the first two months then fortnightly for two months and then once at the end of the last month. The amount of seeds lost to predation, seedlings killed by herbivory/disease or suffering from their effects or "other causes" at each distance from parent tree will be recorded.

(2) Seedling heights will be measured for five species, preferably the same five species chosen for experiment (1). Seedling heights will be used to estimate seedling age. Seedlings will be measured along continuous bands away from the parent (0-5m, 5-10m, … 20-25m). Twenty replicates will be carried out for each species. As seedling/sapling heights are being measured, notes will be taken on any seedling/saplings affected by herbivory, parasites, disease or mould and numbers affected at each distance from parent will be recorded (this will include those seedling/saplings recently killed for which the cause of death can be determined).

(3) In order to determine the degree of clumping of adult trees in the forest, firstly, as many adult trees as possible will be identified to the species level. As each adult tree species is identified, its nearest neighbours' species identity is also determined, and then that neighbours' nearest neighbours' species identity is determined as well. This will be repeated for all the trees that were identified. Once this data is collated, the pattern (degree of clumping) of adult trees in the forest can be determined using the Chi-square test.

(4) New or undamaged seedling/sapling leaves will be marked with twink away from and under the parent tree. After 4 months these leaves will be collected in a press and brought back to New Zealand, where leaf area lost under versus away from the parent tree will be determined.

List your progress towards achieving these objectives. & Have any of your objectives changed significantly? If so, please explain.

(1) Objective 1 and method 1 were changed soon after commencing the experimental work because it became obvious that differentiating planted seeds from those fallen naturally in the same season or germinating from seed banks would be difficult. Also, transporting water to the planted seeds into the forest over rough terrain was not practical. Another problem with the original idea of planting seeds was that it would provide data very similar to the measuring of abundance and height of seedlings at different distances from the parent (objective 2); because aside from having the same amount of seeds at each distance, there is no control over other factors governing germination, growth and survival. To overcome these problems I decided to set up a nursery with 600 seedlings of each of the 3 species. Seeds from three species have already been planted in containers, of which all have germinated and their seedlings are doing well. Once the seedlings have reached a height of about 10cm, and are strong enough, they will be planted out at distances close to 1m, 12.5m, and 25m from each of twenty parent trees of the 3 species. At each distance from parent tree, 10 seedlings will be planted in a row perpendicular to the measuring tape. At each side of a row, a wooden stake with coloured tape will be placed in order to easily find the rows for measuring seedlings over time. Coloured tape will be tied around stems to identify each seedling.

(2) Seedling heights have been measured for 20 trees of each of three tree species. No clear pattern of attack from disease, parasites or fungus on seedlings was observed, and due to a lack of expertise in identifying the presence of fungi, diseases or pathogens the proposed note taking concerning their frequency of occurrence (Methods (2)) was abandoned. Completion of seedling measurements for the remaining 2 species has now been moved to lowest priority of the four objectives for future work because 3 species may give enough of an indication as to whether there is any pattern of seedling survival (estimated by height) with distance from parent tree.

(3) No work has been done on the nearest neighbour identities. Upon returning to Ngel Nyaki in October, I plan to do 500 replicates. For each replicate the following will be determined: species identity, it's nearest neighbours' identity and that neighbours nearest neighbours' identity.

(4) Marking completely uneaten leaves with twink in order to find them again after four months (Methods (4)) was done for seedlings of the first species for which I measured seedling heights. It was then realised that calculating the leaf area lost after four months would be very difficult and / or inaccurate without knowing the leaf area before any herbivory had taken place. Therefore, the methodology of testing

this hypothesis was changed to visually estimating the percent of total leaf area for a seedling that had been eaten. This was done for a maximum of twenty seedlings at each distance in 5x5m plots at: 0-5m, 5-10m, 10-15m, 15m-20m, 20m-25m from parent tree for twenty parent trees of three species.

Have significant problems arisen? If so, please explain.

Objective 4. It is very difficult to visually estimate the total leaf area of a seedling lost to herbivory. The estimates that have been carried out for the three species may therefore be inaccurate and limit detection of the true underlying pattern. This data will nevertheless be analysed because it is useful in telling whether or not herbivory decreases away from the parent.

Another method to test this hypothesis has been devised (see below: (New herbivory test)), the data already collected can then be compared to the data that will be collected using the new method to determine if it yields similar results and how useful the data I have already collected will be.

New herbivory test: Work on this test will begin soon after arriving in Ngel Nyaki in October 2005. It involves taking digital photos of leaves of three different tree species' seedlings and marking those leaves for later identification. Two months later, photos of the same leaves will be taken again in the same order so that leaf area lost to herbivory over that time period can be calculated for all leaves.

As leaves mature their structure and chemistry change and as a result different aged leaves attract different herbivores. Therefore it may be useful to take subsets of different aged leaves, to make comparisons more accurate. If possible (availability) it may be best to use just expanding leaves because they are less likely to have much herbivory to start with and generally more likely to be attractive to a wider range of herbivores.

Where possible photos of at least five leaves from each of five plants will be taken per plot. There will be three 5 x 5 m plots per tree: one plot under the crown of the tree (0-5m), one at 10-15m away from the tree and one 20-25m away. Herbivory will be measured in the three plots under each of twenty different parent trees for the three species.

When photographing, the leaves will be held up in front of a pale coloured, non shiny board with a grid on it as a scale. Up the lower midsection of the board will be a groove to accommodate petioles in order to get leaf surfaces as flat against the boards' surface as possible.

Large leaves will be marked with a water based permanent pen for identification after two months. Smaller leaves will be marked with twist ties just below the leaves, marks on the twist ties will enable later identification. Where there are whorls of leaves around the stem the base of the petiole will be marked as well.

Leaf area lost to herbivory will be calculated for each leaf at time 0 and after 2 months using image-J software. Because of different leaf sizes and leaf area increases over the two months leaf areas lost will be converted to percentage eaten per total amount of leaf. Then percent herbivory at time 0 can be subtracted from percent herbivory at 2 months.

Where the eaten area is so large that the total leaf area cannot be determined, the following approach will be taken to estimate that leaf area: Through observation while photographing and after looking at the photos of leaves of a particular species at time 0 that have remained largely uneaten after two months, the broadly different shapes that develop and the range of sizes at particular leaf ages will be taken note of. I will have to assume the heavily eaten leaf has been growing at a similar rate to other uneaten leaves. Then through using photos of the heavily eaten leaves at time zero I can fit heavily eaten leaves into their appropriate leaf age/shape/size categories and estimate their whole leaf areas.

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