The effects of selective logging in monodominant tropical forests on biodiversity

Final report of ODA project number R6057

A.J. Plumptre
V. Reynolds
C. Bakuneeta

June 1994 - June 1997

Supported by: Overseas Development Administration
The Wildlife Conservation Society
National Geographic Society

Budongo Forest Project, Institute of Biological Anthropology,
University of Oxford, 58 Banbury Road, Oxford OX2 6QS, UK.

EXECUTIVE SUMMARY

This report gives the main results of a three year research programme funded by the Overseas Development Administration (ODA), Wildlife Conservation Society and National Geographic Society. The study investigated the impact of selective logging in monodominant forests on wildlife, particularly concentrating on primates and birds and builds upon research carried out under another ODA grant between 1991-1994. Chapter 1 introduces the study area, the Budongo Forest Reserve in western Uganda. Chapter 2 summarises the 6 objectives of the ODA project proposal and the findings. Chapters 3 to 6 then give the details of the research and chapter 7 provides recommendations that arise from the research for the management of Budongo Forest. Chapter 8 lists the publications that have come out of the project and meetings attended.

In brief the research showed that primates and other frugivorous animals benefit from selective logging in monodominant forest because the removal of the monodominant tree leads to increased production of trees bearing the fleshy fruits that they prefer to feed on. Certain insectivorous birds, particularly sallying, ground feeding and leaf gleaning insectivores drop in number following logging because of changes in forest structure and composition. A test of these findings was made in the Ituri forest with another monodominant species of tree and found to hold for this forest also. Monodominant forest is valuable for the conservation of certain species and forest managers should recognise this. Low diversity of tree species does not necessarily meant that these areas are less valuable for conservation.

ACKNOWLEDGEMENTS

The research reported here was primarily funded by the Overseas Development Administration (ODA) Forestry Research Programme. Support for students from Makerere University to carry out research for one of the scientific objectives was provided by the Wildlife Conservation Society (WCS) and the National Geographic Society (NGS) provided support for the study of chimpanzees. This report covers the period of June 1994 to April 1997 and builds upon previous work carried out by the Budongo Forest Project. Prior to 1997 the Jane Goodall Institute and United States Agency for International Development (USAID) provided funding for Ugandan staff and infrastructure.

We are grateful for permission to work in Budongo Forest which was granted by the Uganda Forest Department and the National Council for Science and Technology. We are also grateful for the support of the staff of the Forest Department for this project, particularly E.D. Olet, F. Kigenyi, J. Kamugisha, L. Kiwanuka, Dr P. Howard, Dr R. Murtland and A. Finch at Headquarters and S. Kahuka, C.D. Langoya and G. Acaye in Masindi District. We are also grateful to the Institut Zairois pour la Conservation de la Nature, the Conservateur and the staff of CEFRECOF, particularly Drs J. and T. Hart and R. Mwinyihali, for permission and help with the collaborative study of birds in the Ituri Forest.

We would also like to thank the following Ugandans for the assistance in the collection of field data, often in arduous conditions: Tuka Zaphyr, Nabert Mutungire, Geresomu Muhumuza, Dissan Kugonza, Tinka John, Jachan Biroch Godfrey, Kyamanywa Julius, Hatari Stephen, Tholith Alfred, Nyakuni Akanya Martin and Kakura James. In addition we wish to thank the tourist guides at Busingoro and Kaniyo Pabidi for collecting chimpanzee faeces for us. We would also like to thank all the other staff working for the Budongo Forest Project for all the hard work they have put in maintaining the trail system in the forest and maintaining the Field Station.

In Oxford, Professors G.A. Harrison and R. Ward have been very generous with the use of facilities at the Institute of Biological Anthropology and we also wish to thank very much Val De Newton for the help she has given with the running of the Project in Britain. Several scientists have provided help, collaboration and advice during the project and we would like particularly to thank Professor D. Pomeroy, Dr D. Sheil, Professor R. Wrangham, Dr C. Chapman, Dr G. Basuta, Dr J. Kasenene, Dr P. Kasoma, Dr S. Buckland, R. Matthews, Dr C. Dranzoa, Dr T Katende and the staff of Makerere Herbarium and R. Kityo at Makerere museum.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

The Budongo Forest Project was established in September 1990 with the aims of undertaking research on the ecology of chimpanzees in this forest with a view to providing specific conservation and management recommendations to the Uganda Forest Department. In June 1991 the scope of the research was expanded to investigate the impact of long-term sustainable timber harvesting on the forest ecology, particularly primates. The Budongo Forest has been managed for timber by the Uganda Forest Department on a sustainable yield basis since the 1920s with good documentation of management practices (Plumptre, 1996), making it one of the oldest managed tropical forests in the world. The United Nations conference on environment and development in 1992 outlined in its Agenda 21 the need to carry out research in the 'field of sustainable forest management, conservation and development' and in its biodiversity treaty, the 'importance for research into the conservation and sustainable use of biological diversity' (Article 7). It is now well recognised that the use of natural resources such as tropical timber will have to take place in some forests if they are to survive the human pressure for land that exists around them. If these resources can be harvested sustainably, the management of tropical forests could provide ways of conserving at least some of the component species of primary tropical forest. If research can identify which species (plant and animal) are at risk from forest disturbance and determine their habitat requirements then the negative effects of sustainable timber harvesting on such species can be reduced.

Given the history and good documentation of management in the Budongo Forest Reserve, research between 1991 and 1994 focused on the impact of selective logging on primates and the role they play in the natural regeneration of the forest through seed dispersal (Plumptre *et al.*, 1994). During this time it was found that the management of Budongo Forest had changed the distribution of forest types considerably, mainly due to the removal of a dominant species of tree, *Cynometra alexandri* C.H. Wright, by arboricide treatment (Plumptre, 1996). Four species of mahogany (*Khaya anthotheca* (Welw.) C.DC. and three species of *Entandrophragma*) formed 70% the timber removed and this remained fairly constant between 1930 and 1990 despite attempts by the Uganda Forest Department to encourage the use of other species from the mid 1960s. It was found that three of the primates, blue monkey *Cercopithecus mitis stuhlmanii* Matschie, redtail monkey *Cercopithecus ascanius schmidti* Matschie, and black and white colobus *Colobus guereza occidentalis* Rochebrune, were at higher densities in logged forest. The chimpanzee *Pan troglodytes schweinfurthii* Blumenbach and the baboon *Papio anubis* Fischer showed no significant differences in density between logged and unlogged forest (Plumptre & Reynolds, 1994). Primates were shown to be dispersers of seed from commercially important trees (Bakuneeta *et al.*, 1995) and that fruiting in tree species varied greatly with size of the tree with important consequences for the natural regeneration of the forest (Plumptre, 1995).

From June 1994 research has focused on three main objectives:

1. Why the three primates have benefited from forest management?
2. How are other species affected by forest management?
3. How applicable are the findings from Budongo to other forests in Africa?

Further funding was obtained through ODA's Forestry Research Programme, the Wildlife Conservation Society and National Geographic Society to pursue these objectives and this report summarises the findings.

1.2 The Budongo Forest Reserve

The management of Budongo Forest and the floral composition of the forest has been detailed elsewhere (Eggeling, 1947; Synnott, 1985; Plumptre, 1996; Sheil, 1996) and consequently only a short summary will be provided here. The forest occurs in western Uganda (latitude: 1°37'-2°00'N; Longitude: 31°22'-31°46'E) and covers 793 km^2 of tropical moist deciduous forest and grassland, 428 km^2 of which is forested (Fig. 1.1).

The composition of tree species in Budongo varies across the forest from west to east (Plumptre, 1996) but can broadly be classified into four forest types (Eggeling, 1947):

1. *Cynometra* forest: dominated by *Cynometra alexandri* C.H. Wright.
2. Mixed forest: dominated by *Celtis mildbraedii* Engl., *Celtis zenkeri* Engl. and the mahoganies.
3. Colonising forest: dominated by *Maesopsis* Engl., *Cordia millenii* Bak., and

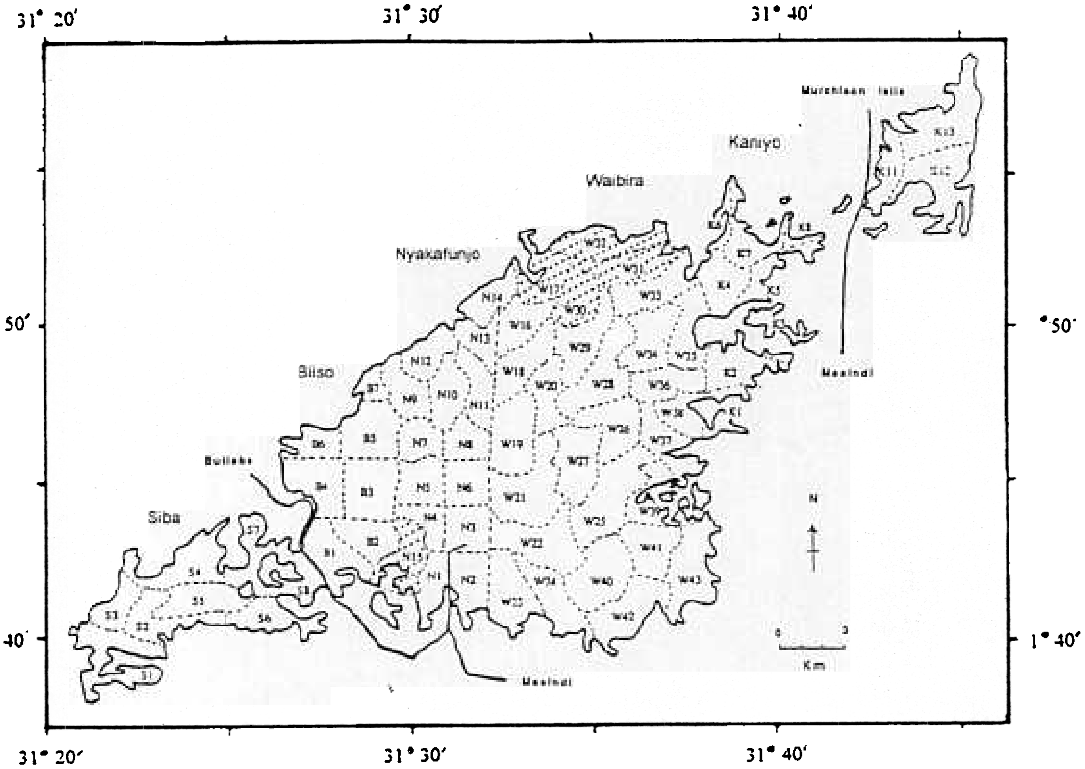

Figure 1.1 Map of the forested portion of the Budongo Forest Reserve showing the location of each of the forested compartments. The two nature reserves are stippled and the five main blocks from which the compartments take their letter codes are labelled.

Diospyros abyssinica (Hiern) F.White.

4. Swamp forest: a very varied forest type found along streams and where seasonal waterlogging occurs.

Eggeling (1947), proposed a model of forest succession that leads from colonising forest through mixed forest to a climax community dominated by *Cynometra* and illustrated this model with a plot based study. *Cynometra*-mixed and colonising-mixed ecotones between these main forest types were therefore identified also. This succession has been partially supported by analysis of his long term plots after 50+ years of growth (Sheil 1996) and from changes seen on aerial photographs (Plumptre, 1996).

Several theories have been proposed as to why this monodominance occurs in Uganda yet none of them have been tested. Eggeling (1947) proposed that the monodominance was due

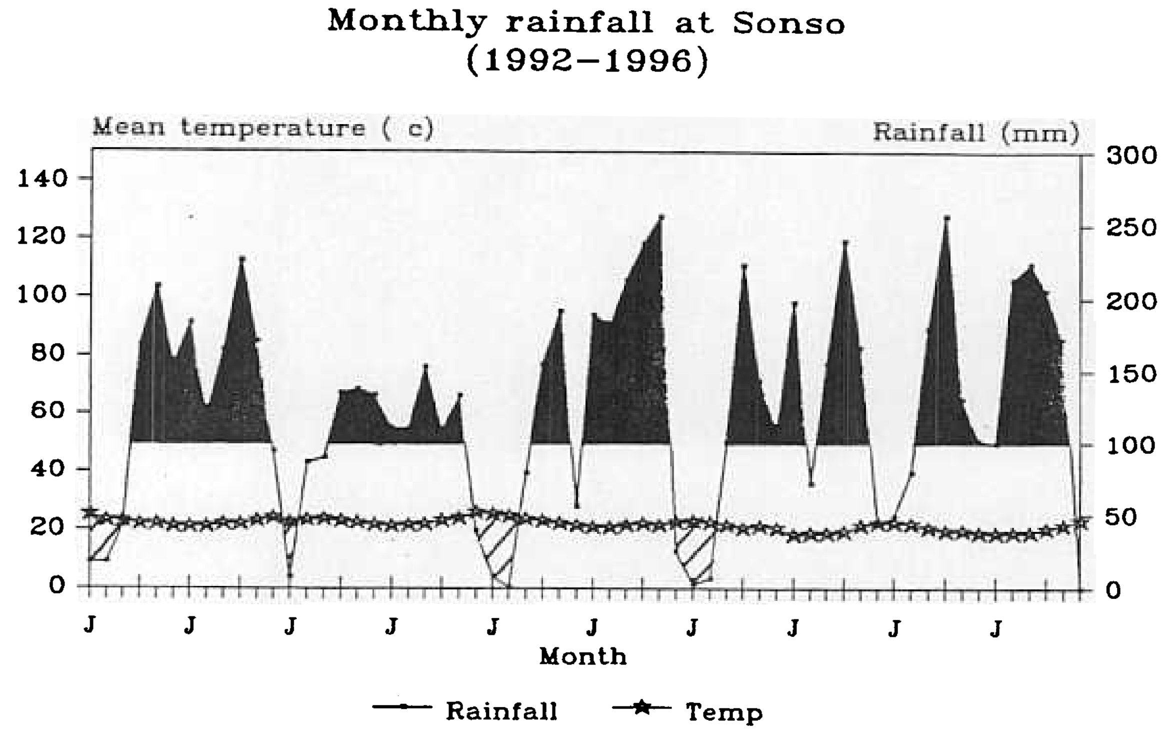

Figure 1.2 Monthly rainfall and mean temperature at the Budongo Forest Project Field Station from January 1992 to December 1996

to climatic factors and that *C. alexandri* is simply a superior competitor for light and nutrients within certain climatic regimes. Osmaston (1959), working in Bugoma forest, proposed that *Cynometra* trees became dominant on poor clay soils whilst mixed forest was capable of maintaining itself on richer soils and this was supported by Langdale-Brown *et al.* (1964). Laws *et al.* (1975) found that elephants debarked most trees in Budongo forest except *C. alexandri*, *Holoptelea grandis* (Hutch) Mildbr. and *Celtis mildbraedii* Engl. They concluded that *Cynometra* dominated forest is an elephant induced deflected climax. Sheil (1996, pers. comm.) supports this theory also.

Rainfall in Budongo is bimodal with a dry season between December and February and a period of lower rain between June and September. It is only during the December-February dry season that water is scarce. Figure 1.2 gives the rainfall recorded at the main study site since 1992.

The Budongo Forest Reserve has been the main timber production forest in Uganda since the 1930s, producing high grade mahogany for the domestic and international markets. For much of the period of management (1930 to the present) the offtake of timber was carefully monitored and recorded with research studies being used to change management practices in the light of their findings (Philip, 1964). It was found that a replanting programme where mahogany seedlings were planted in lines was labour intensive and not very successful and consequently management changed to encourage natural regeneration of the mahoganies. From the mid 1950s arboricide (2,4,5-T and 2,4-D in 1:2 proportions and mixed with diesel) was applied according to various protocols to trees that were not marketable ('weed species') in order to open up the canopy and remove the monodominance by *Cynometra* (Plumptre, 1996). This treatment ceased in the early seventies when it became difficult to import the chemicals and when more trees became marketable (Synnott, 1985) By this time much of the forest had been treated and converted to a mixed forest composition (Plumptre, 1996). During the civil wars in Uganda from 1979 to 1986 control of the forest by the Forest Department was not as good as it had been and illegal pitsawing by local communities around the forest began. It has since proved difficult to control these illegal activities and they have continued up to the present.

1.3 Study areas

The main study area where much of the work reported here was carried out is around the Budongo Forest Project Field Station, at the site of Budongo Sawmills ltd (compartment N3). In this area of the forest and the adjacent Nyakafunjo nature reserve (compartment N15) there exists an extensive network of trails at 100 metre intervals running north-south and east-west. Additional work on monkeys, birds and small mammals was carried out in compartments B1, B4, W21, N11, K4 and the isolated block of forest, Kaniyo Pabidi (K11-13). The main study of chimpanzees was of the Sonso community which ranges around the Budongo Forest Project Field Station but two additional communities which are being habituated for ecotourism were also studied; one at Kaniyo-Pabidi and one at Busingoro (compartments B1, B3, B4, S8). All these sites are shown on Figure 1.1. and Table 1.1 lists the history of logging in these compartments.

Table 1.1. The dates of logging and arboricide treatment of the eight compartments used as main study sites and the volume of timber removed. B1 was logged twice.

Compartment	Date logged	Volume of timber removed(m^3/ha)	Arboricide treatment
N15	Unlogged	none	none
KP11-13 (KP)	Unlogged	none	none
B4	1941-42	34.8	1957
N3	1947-52	80.0	1960-61
N11	1960	26.5	1959-60
W21	1963-64	36.1	1963-64
B1	1935	19.9	1958
and	1983-86	21.5	none
K4	1988-92	20.7	none

2. SCIENTIFIC OBJECTIVES AND SUMMARY OF FINDINGS

Six scientific objectives were stated in the initial ODA project proposal and these have been almost fully achieved although several could be followed up with further research. This chapter summarises the findings for each objective and later chapters of the report give more details of the methods and results.

2.1 Objective 1.*To determine the causal factors underlying the finding already made that three primate species show increased population densities in selectively logged areas of forest.*

It was hypothesised that two main factors could be responsible for determining primate density in Budongo: food supply or predation. Studies of primate diets were made in eight compartments of the forest with additional detailed studies of 17 habituated groups in two areas. In addition measures of food availability were made in the same eight compartments. Measures of predation threat were obtained from dawn to dusk follows of the 17 habituated primate groups.

The threat of predation, chiefly by crowned eagles, was shown to be low for individual monkeys. Although monkeys were at lower risk from predation in logged forest than in unlogged forest, predation was not responsible for the increased densities of primates in logged forest. It was shown that the density of trees bearing fleshy fruits (those chiefly eaten by primates) was higher in logged forest and in mixed forest and that density of blue and redtail monkeys was positively correlated with the percentage contribution of fleshy fruits to their diet. Colobus monkey density was positively correlated with the density of *Celtis durandii* which provided both leaves and fruits to their diet, formed the largest percentage intake of diet in seven of the eight compartments and both the leaves and fruit were preferred food items in every compartment studied. Monkey ranges were smaller in logged forest despite similar sized groups because more food was available in a smaller area. Consequently food supply determines primate densities in Budongo and it is the increase in trees bearing fleshy fruits following the removal of monodominance that benefits these primates.

This objective was fully achieved.

2.2 **Objective 2.** *Extend the analysis of the effects of logging on primates to small mammals and birds in case primates are unrepresentative of wildlife generally.*

Two Ugandan students from Makerere University in Kampala carried out studies on the bird and small mammal communities during 1994-95 as part of their Masters degree. Five of the eight compartments used in the primate research were studied and species compositions, densities and diversity indices calculated for each site. In addition two other research projects investigated amphibian and arthropod numbers in logged and unlogged forest.

12 small mammal species were caught in live traps and the rodent community was dominated by two species; *Praomys praomys jacksonii* and *Praomys hylomyscus stella* (Musamali, 1996). Both of these rodents were trapped more frequently in unlogged forest along transects during 1994 but less frequently in unlogged forest on trapping grids in 1995. Rodent numbers probably fluctuate greatly and may depend on the supply of seeds on the forest floor. At the time of the low densities in unlogged forest the *Cynometra* had failed to fruit for the first time since phenology records began in 1992 which may have resulted in the lower numbers. This study is being built upon by a doctoral study by A. Stanford based at Bristol University which includes squirrels and rodents.

The study of birds used mistnetting and point counts to look at community differences between logged and unlogged areas. Horn's overlap index (calculated on presence-absence data) between compartments was lower for the comparison of two unlogged compartments than between several logged-unlogged combinations. Adjacent compartments had a greater overlap in community composition. Analysis of bird guilds showed that there were significantly more frugivorous birds in logged forest and fewer specialist insectivores, particularly sallying species, ground feeding insectivores and understorey foliage gleaners. Attempts to partition out the effects of forest structure, forest type, logging and site on community composition showed that the effects of the site had by far the greatest impact on the analysis. This has implications for previous and future studies of the effects of logging on wildlife because it shows that the comparison of logged and unlogged sites is likely to be an invalid technique.

Amphibians did not vary greatly between two compartments studied, one logged and one unlogged. 23 species of frog were found in both sites with only two species not found at both sites.

A study of arthropods using pyrethrum fogging techniques showed that the relative proportions of different orders of arthropods did not differ greatly between the same trees in logged and unlogged forest. Phytophagous beetles may change in abundance following logging with increasing numbers of Alleculinae and Lagriinae at the expense of Chrysomelidae where logging has occurred.

This objective was fully completed although the findings showed that it would be better to carry out longitudinal studies and for birds this is currently being planned for these five compartments in Budongo. Further taxonomic groups could be investigated in future.

2.3 **Objective 3.** *Develop a model capable of predicting the responses of wildlife to changes in forest structure resulting from selective logging: the model to have general value, not just for Budongo Forest but for all monodominant African forests.*

Comparisons were made between Budongo and the Ituri forest where *Gilbertiodendron dewevrei* monodominance occurs (see objective 4). These showed that a general model that the density of frugivores increases following removal of monodominance was true for both forests with the loss of specialist insectivorous species. Densities of bird guilds were correlated with forest structure but the predictive value of each measure of forest structure was poor. Sallying and ground-feeding insectivorous birds responded to several measures of forest structure and are likely to be more affected by changes. The composition of trees or food supply was a good predictor for primates.

The effects of selective logging will very much depend on the intensity of logging, the extent to which climbers smother regenerating logged areas, the species of trees present, the effects of large herbivores such as elephants and the effects of seed predators on regeneration. Consequently it is not possible to model changes and produce predictions in great detail without studying the effects of all these other factors. However a flow diagram is produced which shows what are likely to be the important factors and how each will affect the forest in future.

This objective was partially achieved and further studies at Budongo are investigating aspects of the model (such as the effect of gap size on climber tangles) so that the model can be improved upon.

2.4 **Objective 4.** *Collaborate with studies ongoing at Epulu, Zaire with a view to determining whether findings from Budongo Forest are relevant to other, similar forests and testing of the model derived at Budongo; and collaborate with the forestry project headed by D. Sheil In Budongo, which studies long-term growth and regeneration in selected research plots.*
During 1996 A. Plumptre and one Field Assistant, N. Mutungire, spent two months at Epulu in the Ituri Forest. During this time a mistnetting study was made of the bird community in two primary forest sites and one secondary forest site where shifting cultivation had occurred. One primary forest site was monodominant *Gilbertiodendron* forest and the other was mixed forest. Discussions were had with Drs John and Terese Hart and Omari Lambu about studies of primates that had been made in the Ituri forest and how they might respond to removal of monodominance. The discussions, review of the literature and the mistnetting study supported the model that frugivores benefit from forest disturbance and that certain specialist insectivores are likely to be at risk from changes in forest composition or structure.

Collaboration with the project by Doug Sheil has been ongoing since 1992. A study of growth and mortality between 1992 and 1996 was made in 820 plots distributed in 8 compartments and covering an area of about 12.6 ha. This formed a complementary study to Sheils' (1996) which was of 5 plots in the west of the forest but over a much longer time interval. Comparisons of growth of trees over the 3.5 years between 1992-1996 produce similar results to his much longer study but indicate that growth and mortality may be different between areas, with fewer natural tree deaths and slower growth in *Cynometra* dominated forest.

This objective was fully achieved. Further analyses are being made of the growth data and it is recommended that the plots are measured regularly every 4 years in future.

2.5 **Objective 5.** *Continue ongoing study of seed dispersal by primates and widen to include non-primate species such as hornbills.*

Faecal samples were collected from 17 groups of habituated monkeys and three chimpanzee communities to measure the quantities of seed dispersed in an average dung sample. Chimpanzees disperse many more seeds per dung sample than the monkeys and many more species. Monkeys could be seed predators as well as seed dispersers. As monkey home ranges only spanned 400-500 metres in logged forest and 500-900 metres in unlogged forest the potential for seed dispersal by these species was far less than by chimpanzees which could move several kilometres.

The diets of three species of hornbill, black-billed turacos and great blue turacos were studied using scans of birds seen feeding whilst walking transects. These large frugivorous birds fed upon many of the fruits eaten by primates and probably disperse the seeds over longer distances. Faecal samples from mistnetted birds were inspected but few seeds were found. Germination trials were made of seeds that had passed through the gut of chimpanzees with those that had fallen off trees. These are still ongoing but show for several species that passing through the gut of a chimpanzee can increase the chance of germination.

This objective was fully achieved. Further work could investigate dispersal distances by chimpanzees, hornbills and turacos as could studies of the survival of deposited seeds and germinated seedlings.

2.6 **Objective 6.** *Survey chimpanzee populations in new parts of the forest and create a chimpanzee database: continue phytochemical analyses of chimpanzee foods in collaboration with Reading University (Professor Harborne).*

A database on the chimpanzee studies has been established at Oxford University by Professor V. Reynolds. This includes data on the 1992 census and a follow-up census in 1996. These longitudinal studies in the eight study compartments, showed that light pitsawing in the forest affected primate densities little but that estimates of chimpanzee numbers declined where many humans occurred. Data collected at Busingoro in the west, and Kaniyo Pabidi in the east of the forest on diets are being incorporated with the more detailed studies of the habituated community at Sonso. Studies of the nesting behaviour of chimpanzees have been used to improve chimpanzee censusing techniques. C. Bakuneeta organised a chimpanzee population and habitat viability analysis workshop in conjunction with the IUCN C[illegible]ation Breeding Specialist Group held in January 1997 to draw up a conservation management plan for chimpanzees in Uganda.

Phytochemical analyses have been made of several fruits from different tree species, comparing those eaten by chimpanzees and those rejected by chimpanzees. Tannin and sugar (glucose, fructose and sucrose) levels have been measured for each fruit. These show that chimpanzees can eat fruits with high tannin levels and show no selection for sugars or tannin levels. The monkeys preferred food items with low tannin levels and blue and colobus monkeys selected consumed foods with high glucose levels.

This objective was partially completed. Ongoing phytochemical analyses are being expanded to include leaves and other nutrients.

3. DETERMINANTS OF PRIMATE DENSITY: Why do the three monkeys benefit from the forest management in Budongo?.

3.1 Introduction

This chapter investigates the findings of the previous ODA project (R4738) which discovered that three species of monkey were at higher densities in logged forest and chimpanzees showed no difference in density (Plumptre *et al.*, 1994). What determines primate density in Budongo forest and why do the monkeys benefit from the forest disturbance caused by logging and arboricide treatment? This section gives results for objectives 1 and 6.

There have been several studies across taxonomic groups investigating the factors that determine primate biomass. Waterman *et al.* (1988) found that the ratio of protein (crude Nitrogen) to fibre content in leaves was a good predictor of colobine biomass in forests of Africa and Malaysia. Similarly Oates *et al.* (1990) found the same ratio (protein/fibre) to predict total anthropoid biomass in African forests whilst protein/(fibre + tannin) was a better predictor of colobine biomass. Ganzhorn (1992) also found the protein/fibre ratio to be a good predictor of folivorous lemur biomass in Madagascar. Colobines, however often form the bulk of the primate biomass where total biomass has been studied (Struhsaker, 1975 - 81% of total mass; Eisenberg *et al.*, 1972 - 88%; Oates *et al.*, 1990 - 56%; Bourliere, 1985 - 70%; Eisenberg & Thorington, 1973 - 87%) so that it is not particularly surprising that what predicts colobine biomass well also predicts total primate biomass well. Many primates are more frugivorous than colobines and therefore it is unlikely that the ratio of protein to fibre content in leaves is a good predictor of their densities. Few studies have looked at species individually to see what might determine their densities. Butynski (1990) investigated the factors that might determine the density of blue monkeys *Cercopithecus mitis* in Kibale forest, Uganda and found that food supply did not explain the low density found at Ngogo in the centre of the forest when compared with Kanyawara in the north of the forest. He resorted to suggesting that human hunting in the past or disease had reduced the population in the centre. In general three factors can affect population density: 1. food supply; 2. predation risk and 3. disease. Any one of these or all of them combined could be important in determining primate densities in Budongo forest. This study investigated which of these factors might be most important.

3.2 Methods used to study primates

Studies were made which aimed to investigate the primate feeding ecology and food availability at various scales in Budongo. The methods that were used are briefly summarised here.

3.2.1 *Tree enumeration and phenology*

During 1992, five 2 km transects were established in a stratified random manner (Plumptre & Reynolds, 1994) in each of eight compartments or areas of the forest (B4, B1, N15, N3, N11, W21, K4 and K11-13). Every 50 metres along these transects all tree species over 10 cm DBH were identified in 7 metre radius circular plots (Plumptre 1996) and their diameter at 1.3 metres (DBH) measured following Alder & Synnott (1992). Each plot was assigned one of five forest types: *Cynometra*, *Cynometra*-mixed, mixed, colonising and swamp. Every second plot at 100 metre intervals was marked, trees numbered and the measurement points of each tree painted.

These painted trees were used to obtain measures of phenology. Between January 1993 and January 1994 all plots in the eight study sites were visited twice each month and every tree scored for phenology (see below). Following January 1994, phenology records only continued in compartments N15 and N3 because of the costs involved and difficulty in accessing all the sites. The production of buds, young leaves, mature leaves, flowers, unripe fruit and ripe fruit for each tree were scored from 0-4 (0=none; 1=1-25% of crown...4=76-100% of crown). During the analysis the two scores for each month were combined for fruit in case observers missed any and the product of the DBH and whether the tree was fruiting (1) or not (0) calculated as a score of availability. Chapman *et al.* (1992) showed that DBH was a good predictor of fruit abundance in particular tree species. Dasilva (1989) used the product of fruit score (on a 0-5 scale) and DBH as a measure of fruit availability, however we felt that given the finding of Chapman *et al.* (1992) that DBH alone was a good predictor, multiplying by a score was likely to overweight large trees with big crops of fruit. Consequently we recoded all scores to 1 or 0. This has the advantage that there are fewer problems with inter-observer error as only an identification of whether the tree was fruiting is required.

3.2.2 *Primate censuses*

During March 1992- February 1993 and March-June 1996 the five transects established in each of the eight study sites were walked at a constant speed of about 1 km hr^{-1} and all primate groups and number of individuals recorded when seen. Measurements of perpendicular distance (Whitesides *et al.* 1988) from the transect to an individual in the centre of the group were taken and used to compute densities according to Buckland *et al.* (1993). Chimpanzee nests, hornbills and turacos were also censused. The heights of an individual in the centre of the group was measured using a rangefinder. The results of the 1992 census have been published in Plumptre & Reynolds (1994, 1996) and more details are given there. Between 1992 and 1996 several of the compartments were pitsawn (some illegally) and one harvested mechanically. Monitoring of the same area before and after harvesting is a better

Table 3.1 The past history of each of the compartments censused and measures of the harvesting damage made between 1992 and 1996.

Compartment	Previously logged	1992-96 Density of trees harvested (no. ha^{-1})	1992-96 % mortality of all trees cut[a]	1992-96 % no. plots affected[b]
Controls				
N15	Unlogged			
K11-13	Unlogged			
N3	1947-52			
Pitsawn				
B1	1935/1983-86	1.0	0.5	1.0
B4	1941-42	0.7	1.8	11.8
N11	1960	0.9	3.3	13.0
W21	1963-64	1.0	3.0	10.0
Mechanically				
K4	1988-92	2.5	4.7	22.0

[a] Some small trees are cut for props used in pitsawing and these are included here
[b] Percentage of 7 metre radius vegetation plots affected by felling damage.

method of studying the effects of logging than comparing logged and unlogged sites (Johns, 1988; 1992). Table 3.1 shows how each compartment was affected by harvesting.

3.2.3 *Feeding scans from transects*

From March 1993-February 1994 the same transects used for censusing were walked from 7.30 am to 11.00 am. Whenever a primate, hornbill or turaco was seen the observers watched it (if they had not been spotted by the animal) and recorded the first food item it was seen to feed upon. For groups of primates this involved scans of the group recording food items of all individuals that could be seen until one of them spotted the observer. Although it is acknowledged that this method may be biased towards easily observable food items we felt that this would not differ greatly between study sites so that relative intake of food items could be compared.

3.2.4 *Dawn to dusk follows*

In compartments N3 (logged) and N15 (unlogged) a total of 17 groups of monkeys were habituated sufficiently to follow them without affecting their behaviour greatly. In both compartments three groups of blue and colobus monkeys, and three redtail groups in N3 and two redtail groups in N15 were habituated. Some of the blue monkey groups were those followed by Fairgrieve (1995). In N3 the habituation of a chimpanzee group had begun in 1990 and by December 1994 it was sufficiently far advanced that individual chimpanzees could be identified and followed. Only data from a complete dawn to dusk follow were used in analyses for the chimpanzee data as individuals were sometimes lost. Primate groups or individual chimpanzees were located at about 16.00 and followed for a period of 48 hours from dawn to dusk. Each group of monkeys was followed for 2 days each month from October 1994 to January 1996. Individual chimpanzees were followed on two days each week by four observers between December 1994 and December 1996.

During each follow the following was recorded at 30 minute intervals for all individuals seen:

1. Activity: Feeding, resting, moving, grooming, play, aggression, vigilance.
2. Height above the ground for three monkeys (2 adults and 1 juvenile) or for the focal chimpanzee.

feedi thе lant spec part fed upon

Grot nread di tanc bet furthe di ial: nkey gro

group recorded f chimpan: subgroup

3.2. *Phytochemi al nalyse:*

Who frui and part of ger frui collected for specie by chi panzees other pri and for those uneaten rejected by mpanzees The were analysed for densed gl se and fructose by the phytochemical laboratory of Profe sor Harborn Readi Ui ty Thi dy goin as concentrated frui expandin ude troge fibre is of lea the common tree spec udongo

R lts

Fruit ability

as fo th the spec composi of the greate: between the and ea: of udongo (Plumptre 99) th comparin K ith and B ampered by th ffec Conseq as decided species into group ased th frui aracters Three group sel ted: trees bearin small fleshy frui (less than 2. m lon tree bearir larg fleshy fruits (greater than 2.5 m ong) and pod bearin trees

T ble the of th DBH al each compartme and fores type for category Th data for forest types confounded the effec of compartments because more *C nometra* fore plots were fo the nlogged treated compartments These al al do gi measure of the vari in potential frui vailability th year ariati between month be ial in determi in the density pri te are bec se the month th ail: ility ll be the importan Figures .5 gi the re of the h ol gy analy for the fru categori in each compartmen f pe an pe frui

Table 3.2 The sum of tree DBH measures for three categories of fruit type in each compartment and forest types summed over all compartments. The total DBH measure per hectare is given.

		Small fleshy (cm)	Large fleshy (cm)	Pods (cm)
N15	Unlogged	6,060	4,330	3,810
K11-13	Unlogged	3,770	5,440	3,570
B4	1941/42	4,960	4,390	3,190
N3	1947/52	6,440	5,120	3.740
N11	1960	5,370	4,880	4,230
W21	1963/64	4,960	3,680	3,070
B1	1981/86	4,560	3,580	2,600
K4	1988/96	4,740	4,100	4,170
Cynometra		4,030	5,300	5,480
Cynometra-mixed		5,340	4,550	3,860
Mixed		5,650	4,430	3,190
Colonising		3,320	4,300	3,350
Swamp		2,610	2,790	2,000

These figures show that trees producing small fleshy fruits are by far the most abundant but that production can fluctuate greatly between months and years. K11-13 can have bumper crops of large fleshy fruits (mainly *Uvariopsis congensis*) during certain months but at other times have a very low availability of these fruits. This fluctuation between boom and bust periods could be important for primates, with species preferring areas where food supply is relatively constant. In addition the patchiness of food availability will be important. If there are areas with lots of fruit and areas with little then primates will need larger home ranges to find sufficient food over the year and density will consequently be lower. Figure 3.6 plots the coefficient of variation (standard deviation/mean) between phenology scores in plots for N15 and N3 over the four years from January 1993 to December 1996. This shows that for most of the time for small fleshy fruits and large fleshy fruits the variation between plots is greater in N15, the unlogged compartment. Therefore the food supply is more patchily distributed here.

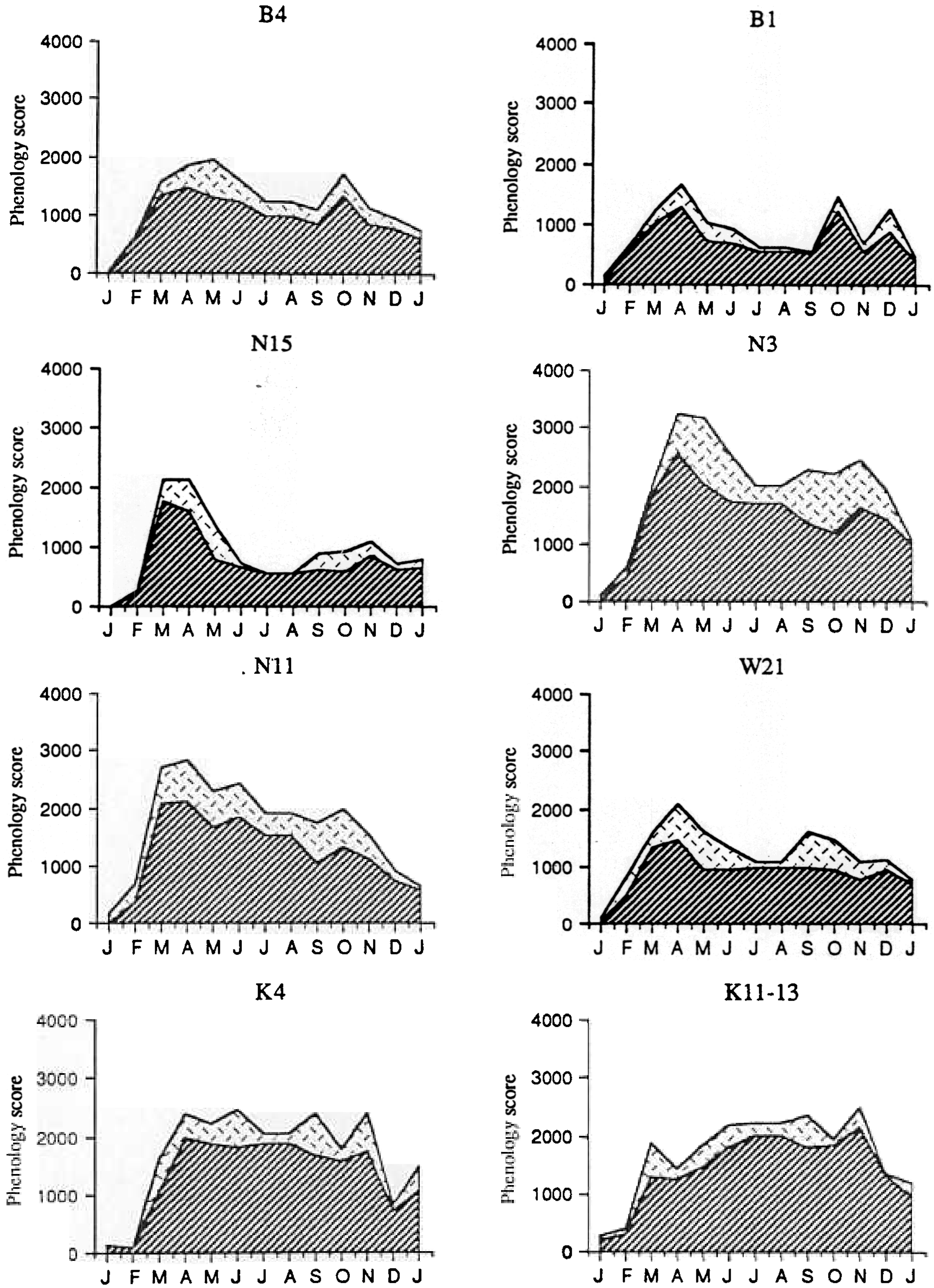

Figure 3.1 The phenology scores for small fleshy fruit bearing trees in the eight compartments from January 1993 to January 1994. Ripe fruits (light hatch) and unripe fruits (dark stripes) are shown.

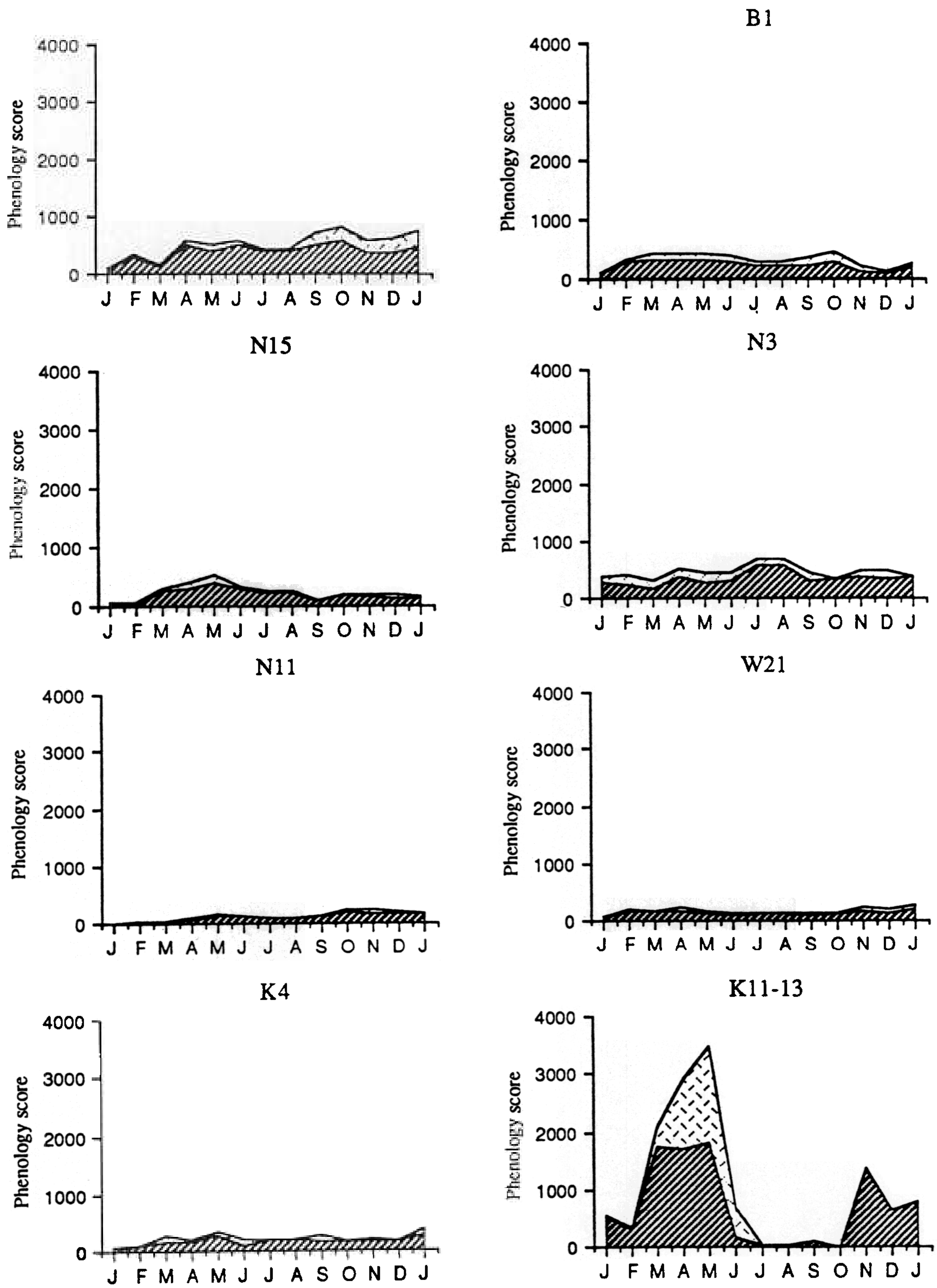

Figure 3.2 The phenology scores for large fleshy fruit bearing trees in the eight compartments from January 1993 to January 1994. Ripe fruits (light hatch) and unripe fruits (dark stripes) are shown.

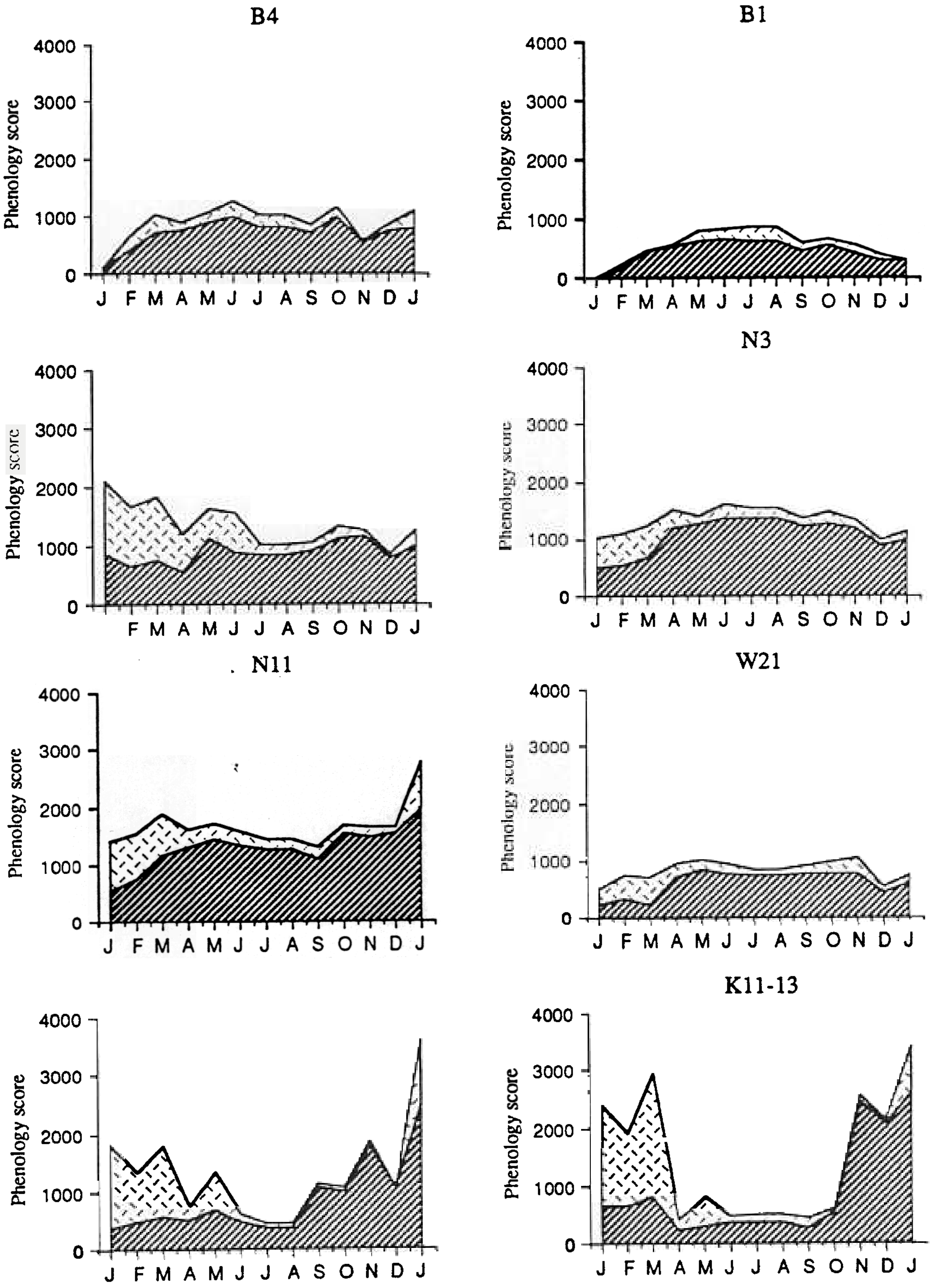

Figure 3.3 The phenology scores for pod bearing trees in the eight compartments from January 1993 to January 1994. Ripe fruits (light hatch) and unripe fruits (dark stripes) are shown.

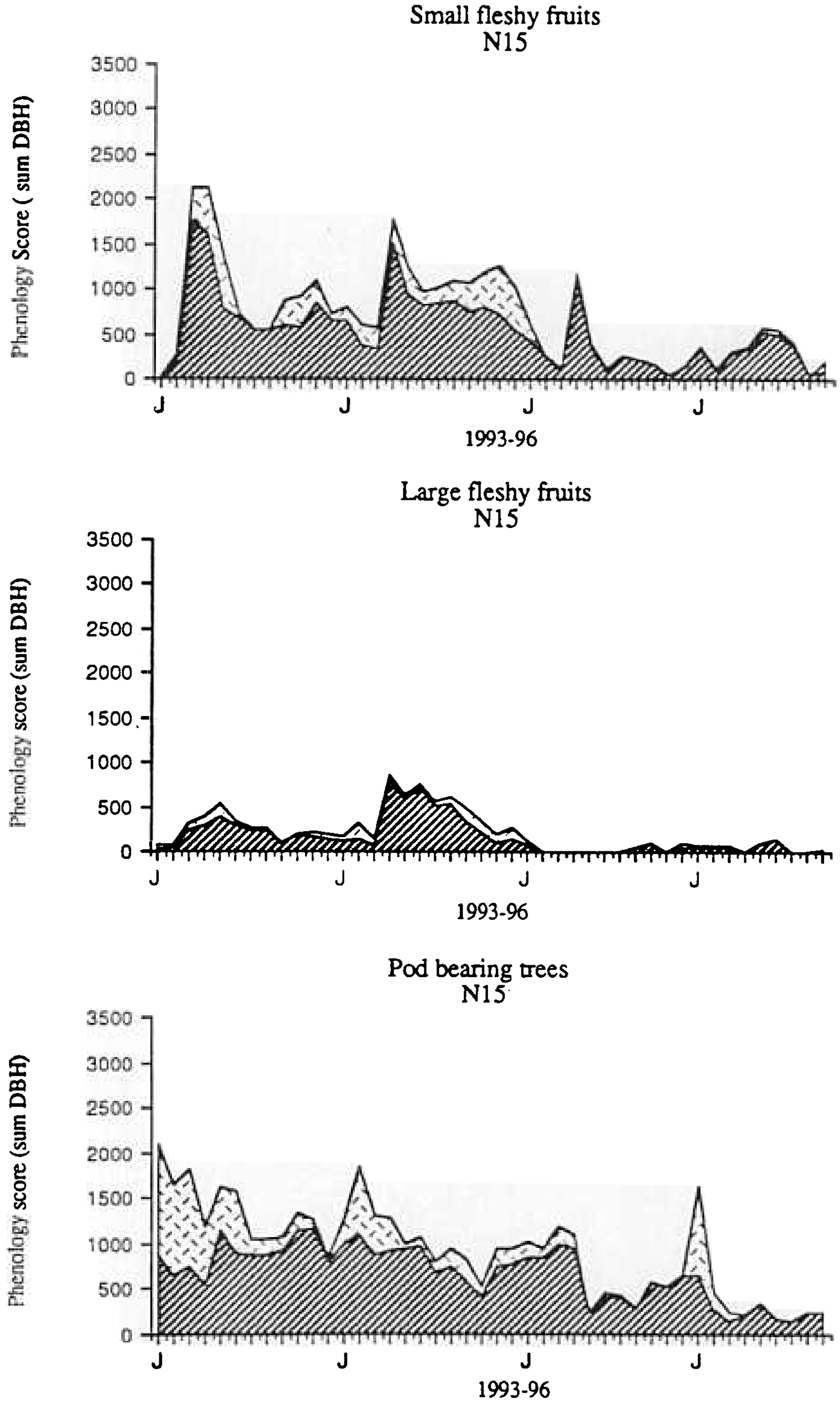

Figure 3.4 The phenology scores for the three fruit types in compartment N15 from January 1993 to October 1996. Ripe fruits (light hatch) and unripe fruits (dark stripes) are shown.

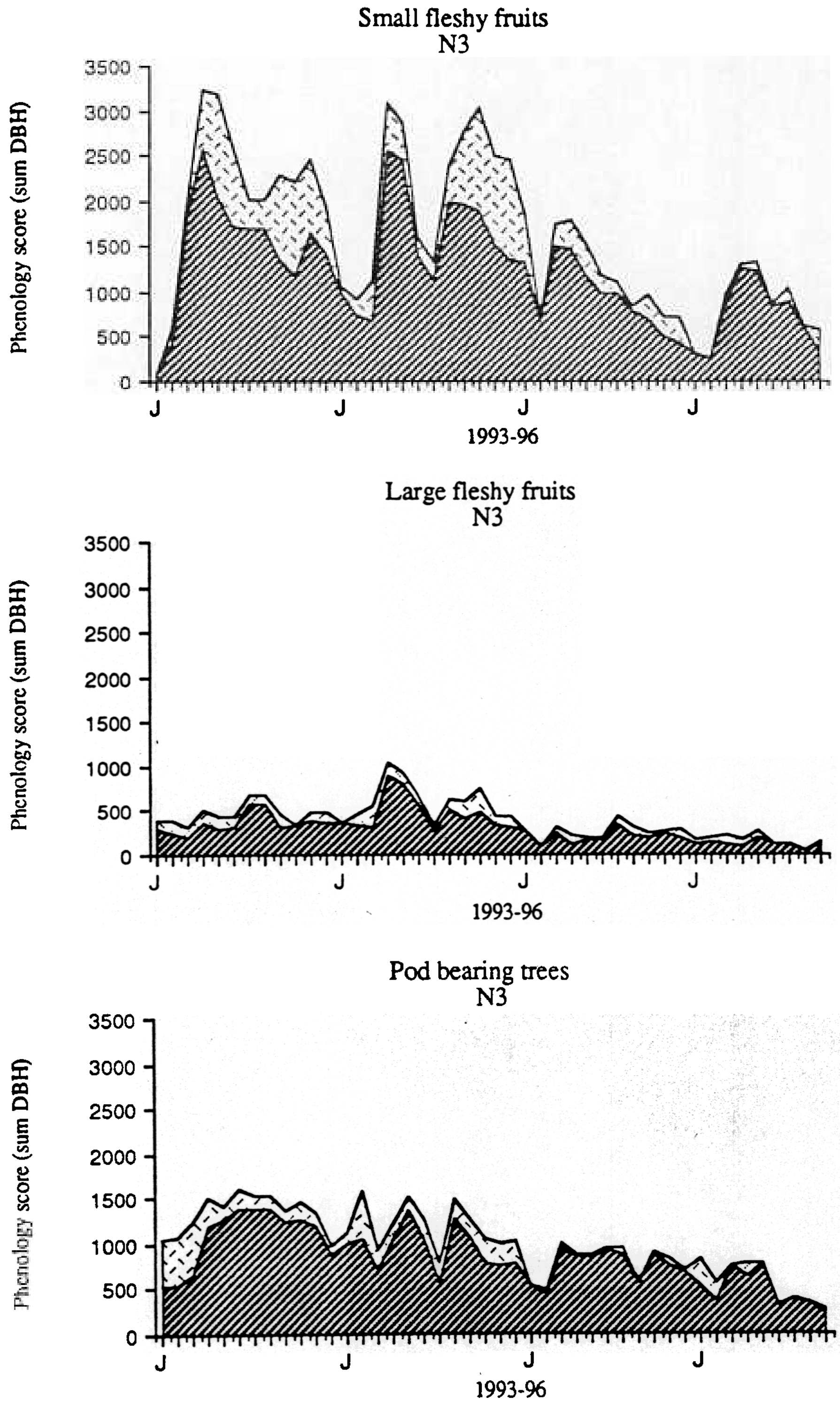

Figure 3.5 The phenology scores for the three fruit types in compartment N3 from January 1993 to October 1996. Ripe fruits (light hatch) and unripe fruits (dark stripes) are shown.

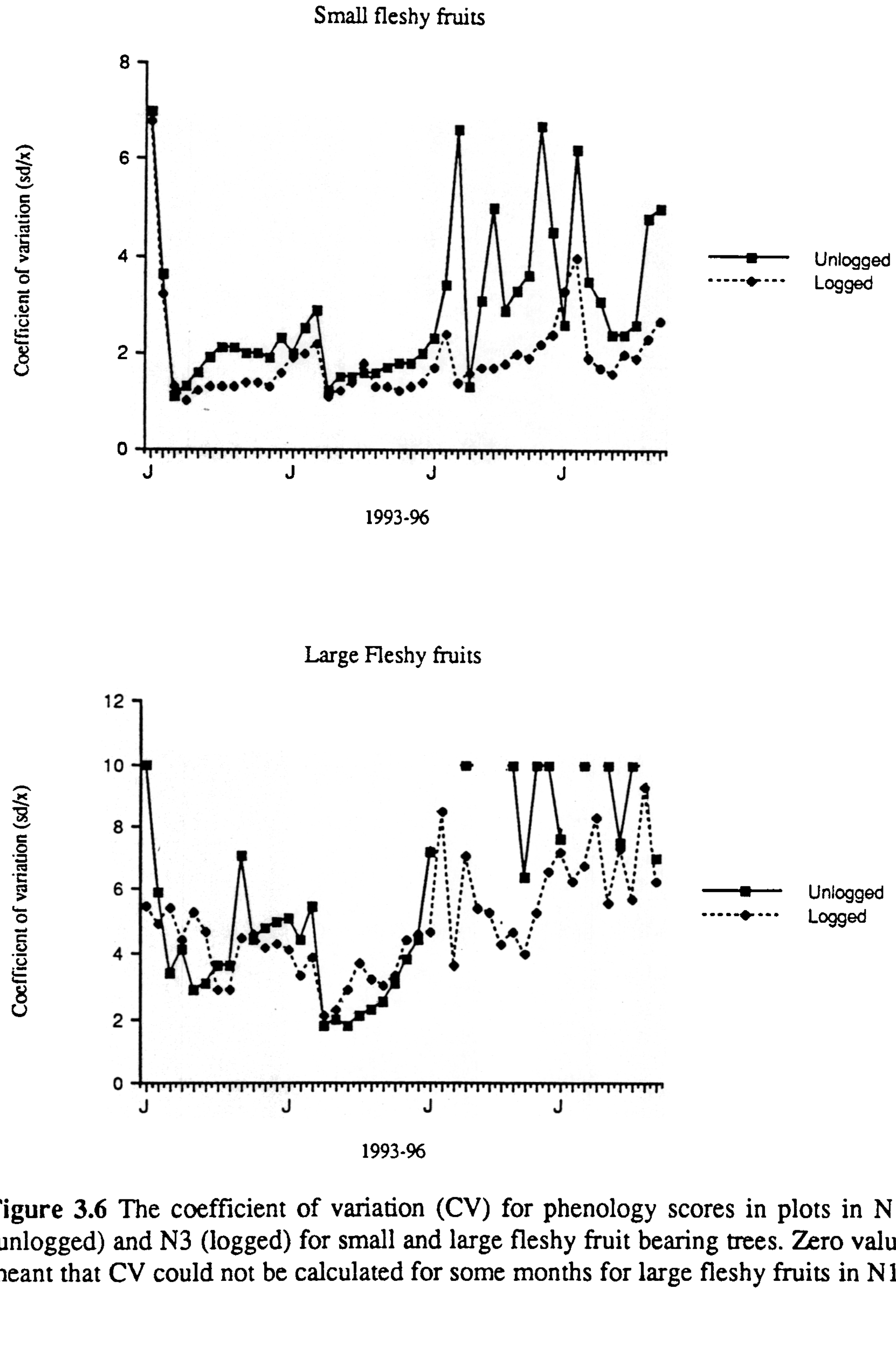

Figure 3.6 The coefficient of variation (CV) for phenology scores in plots in N15 (unlogged) and N3 (logged) for small and large fleshy fruit bearing trees. Zero values meant that CV could not be calculated for some months for large fleshy fruits in N15.

However, there was no correlation between primate density in each compartment and the mean coefficient of variation for the 13 months phenology scores.

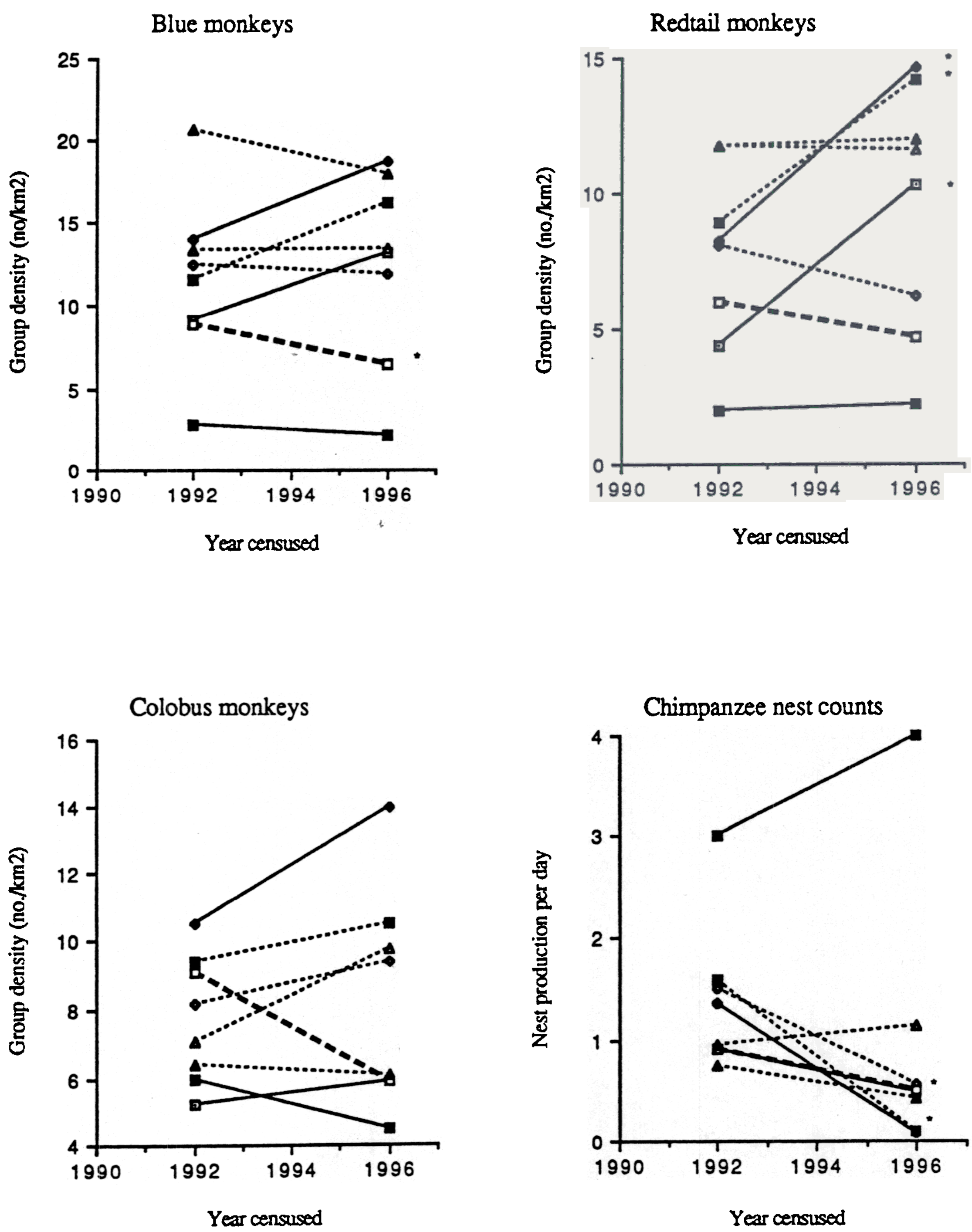

Figure 3.7 The changes in group density between 1992 and 1996. Those changes that are significant (Z-test) are marked with an asterisk.

Table 3.3 The changes in density of groups (or subgroups) and density of individuals between 1992 and 1996.

Compartment	Group density				Individual density			
	Blue	Redtail	Colobus	Chimp	Blue	Redtail	Colobus	Chimp
Controls								
N15	ns	+	ns	ns	+	+	+	ns
K11-13	ns	ns	ns	ns	ns	ns	ns	ns
N3	ns	+	ns	-	+	+	+	
Pitsawn								
B1	ns	ns	ns	ns	+	+	ns	ns
B4	ns	ns	ns	ns	ns	+	ns	ns
N11	ns	ns	ns	-	ns	ns	ns	
W21	ns	+	ns		+	+	+	
Mechanically								
K4		ns		ns	ns	ns	ns	ns

+, significant increase; -, significant decrease; ns, no significant change

3.3.2 *Census results*

The results of the 1992 and 1996 census are presented in figure 3.7 and table 3.3 gives the results of Z-tests between densities of primate groups and densities of animals between these two census periods.

There have been few decreases in density except for chimpanzees. The areas where the chimpanzee showed a significant decline were areas where many humans were working during the time of the 1996 census. In N11 and W21, pitsawyers were operating with many porters carrying out the planks of timber. In N3 research students and Field Assistants were following the habituated community of chimpanzees. It is known that this community has not declined in density because individual chimpanzees are recognised. An analysis of nesting sites showed that they were significantly avoiding nesting sites near census trails (Plumptre

& Reynolds, in press). The presence of many humans therefore can cause chimpanzees to alter their behaviour and use areas where the human disturbance is less. Logging practices in Budongo should take this into account and possibly have set days for portering out timber which would reduce the human disturbance.

3.3.3 *Diets*

Feeding scans in the 8 compartments.

Figures 3.8 to 3.10 plot the density of the three monkey species against the percentage of pods, fleshy, ripe and unripe fruit in the diets in each compartment. For redtail and blue monkeys there are significant correlations between the percentage of fleshy fruit (+ve) and unripe fruit (-ve) in the diet and density. For redtail monkeys the correlation between density and ripe fruit (+ve) is also significant as is the correlation between pods and density (-ve) for blue monkeys. There were no significant correlations for these measurements and colobus monkey density. It was not possible to obtain a measure of chimpanzee diets in the eight compartments because sightings were few.

Correlations were also made between primate density and the density of trees producing the three fruit types that actually fruited in 1993. Chimpanzee nest density was positively correlated with those trees producing large fleshy fruits whilst redtail density was negatively correlated with pod producing trees. Finally primate densities were correlated with the basal areas of five common or commonly eaten tree species; *Cynometra alexandri*, *Maesopsis eminii*, *Celtis durandii*, *Albizia* spp. and Fig spp. Colobus monkeys were positively correlated with *C. durandii*; blue and redtail monkeys were negatively correlated with *C.alexandri*. All correlations were judged significant at $P<0.01$ because of the number of correlations being calculated.

Table 3.4 gives the preferred food items for each species in each compartment. Preference was calculated using Manly's alpha as this is considered one of the least biased measures (Krebs, 1989).

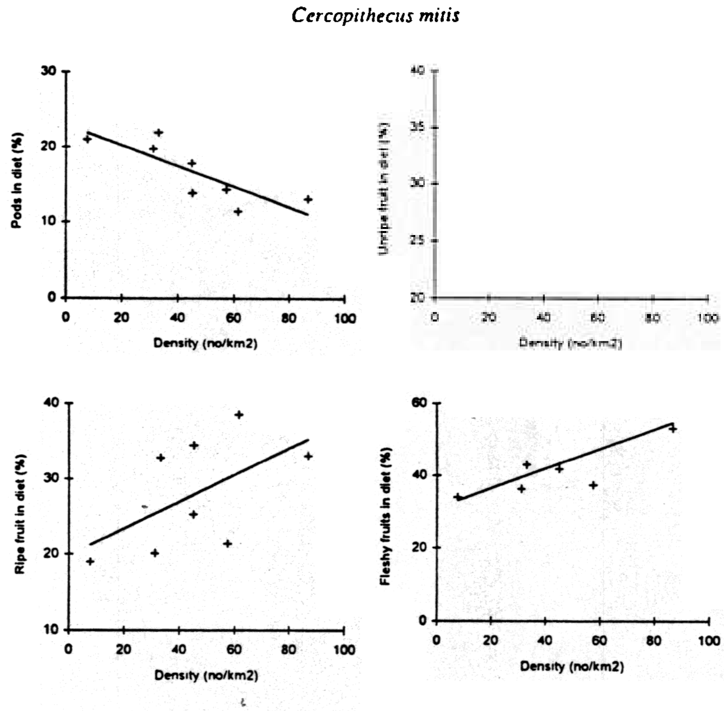

Figure 3.8 Plots of the density of blue monkeys and the percentage of four dietary items in the diet.

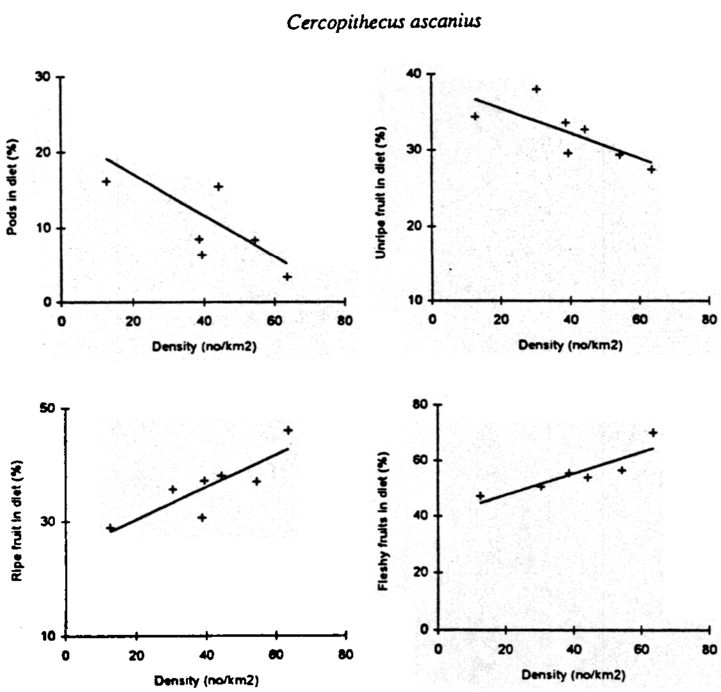

Figure 3.9 Plots of the density of redtail monkeys and the percentage of four dietary items in the diet.

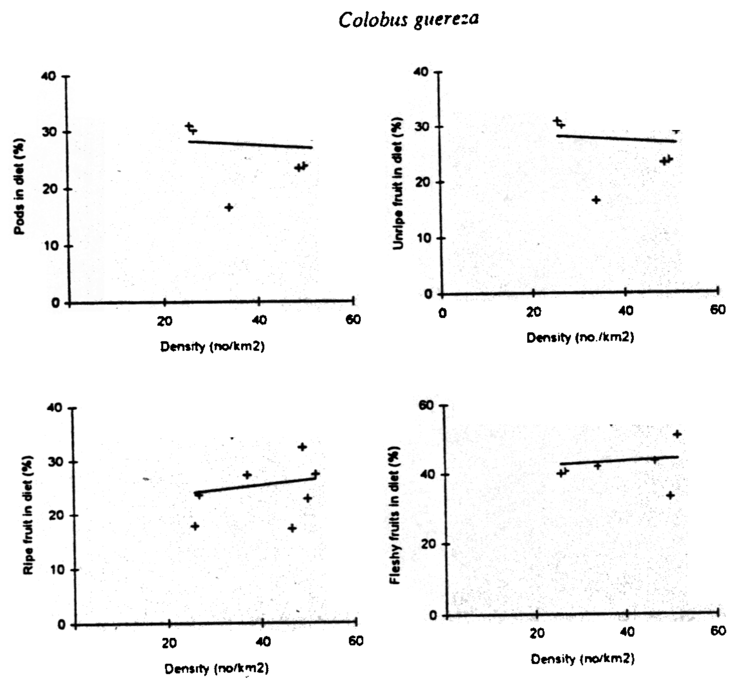

Figure 3.10 Plots of the density of colobus monkeys and the percentage of four dietary items in the diet.

Table 3.4 Dietary preferences for each monkey species in each compartment. Only those tree species which were relatively common and a preference was shown are listed. Preferences were calculated using Manly's alpha and the sum DBH values was used as a measure of availability. +=preference

Tree No. scans:	Part	N15 450	K11-13 50	B4 332	N3 823	N11 362	W21 576	B1 393	K4 192
Blue monkey									
Aningeria alt.	Fruit	+							
Alstonia boon.	Leaf							+	
Albizia spp.	Leaf		+	+	+		+	+	+
Bosqueia phob.	Fruit				+			+	
Broussonetia p.	Fruit				+				

Chrysophylum	Fruit					+	+		+
albidum	Leaf							+	+
Celtis durandii	Fruit	+	+	+	+	+	+	+	+
Celtis zenkeri	Fruit								+
Cleistopholis	Fruit						+		
Cordia millenii	Fruit							+	
C. alexandri	Leaf				+			+	
Erythropleum	Fruit								
suaveolens	Leaf	+			+			+	
Ficus exasper.	Fruit				+			+	
Ficus sur	Fruit					+			
Funtumia elast.	Fruit		+				+	+	+
Maesopsis emin.	Fruit							+	+
Morus lactea	Fruit								
	Leaf								
Tapura fisch.	Fruit							+	+

Tree	Part	N15	K11-13	B4	N3	N11	W21	B1	K4
No. of scans:		173	33	233	436	258	410	249	125

Redtail monkey

Aningeria alt.	Fruit								
Alstonia boon.	Leaf								
Albizia spp.	Leaf			+	+		+	+	
Bosqueia phob.	Fruit				+		+		
Broussonetia p.	Fruit				+				
	Leaf				+				
Chrysophylum	Fruit		+	+		+	+	+	
albidum	Leaf	+		+	+	+	+		
Celtis durandii	Fruit	+	+		+	+	+	+	
Celtis zenkeri	Fruit	+							
Cleistopholis	Fruit	+				+	+		
Cordia millenii	Fruit								
C. alexandri	Leaf	+			+				
Erythrophleum	Fruit								+
suaveolens	Leaf								+
Ficus exasper.	Fruit				+			+	
Ficus sur	Fruit				+	+			
Funtumia elast.	Fruit	+							
Maesopsis emin.	Fruit	+				+			+

Tree	Part	N15	K11-13	B4	N3	N11	W21	B1	K4
No. of scans:		222	95	149	389	131	277	88	147
Colobus monkey									
Aningeria alt.	Fruit			+					
Alstonia boon.	Leaf	+	+	+	+	+	+	+	+
Albizia spp.	Leaf				+			+	
Bosqueia phob.	Fruit			+					
Broussonetia p.	Fruit								
	Leaf								
Chrysophylum	Fruit		+		+		+	+	
albidum	Leaf							+	
Celtis durandii	Fruit	+	+	+	+	+	+	+	+
	Leaf	+	+	+	+	+	+	+	+
Celtis zenkeri	Fruit								
	Leaf					+			
Cleistopholis	Fruit					+	+		
C. alexandri	Fruit				+	+		+	
	Leaf			+	+	+	+	+	+
Erythrophleum	Fruit		+					+	
suaveolens	Leaf								+
Ficus exasper.	Fruit				+				
Ficus sur	Fruit				+			+	
Funtumia elast.	Fruit								
Holoptelea gr.	Leaf	+		+		+	+		
Maesopsis emin.	Fruit			+	+	+	+	+	
	Leaf	+		+	+				

This table shows the importance of *Celtis durandii* in the diets of all these three primates with a preference shown for its fruit (and leaves in the case of the colobus) in almost all compartments. This is despite the fact that it is an abundant tree species in some areas and availability values are high.

Horn's overlap index was calculated for the ingestion of plant parts (flowers, unripe fruit, ripe fruit, young leaves, mature leaves, buds,bark, insects) in different compartments. For blue monkeys overlap was 94% or greater for all comparisons, for redtail monkeys overlap was 89% or greater and for colobus monkeys overlap was 91% or greater. Horn's overlap was also calculated between species in each compartment separately using all tree species and parts eaten to calculate the percentage overlap. Comparisons were made with 'neutral models' (Joern & Lawlor, 1980) which replace the observed proportions of the diet by random proportions and then uses Monte Carlo analyses to calculate if the observed overlap is within the top or bottom 95% of values. Table 3.5 summarises the overlap values calculated between compartments.

Table 3.5 The percentage overlap in diets between primate species in each compartment. Where overlap was significantly greater than expected using neutral models this is marked. (**=P<0.01; *=P<0.05) Bl=blue monkey; Rt=redtail monkey; Bwc=colobus monkey.

	N15	K11-13	B4	N3	N11	W21	B1	K4
Comparisons								
Bl vs Rt	78 **	60	81 **	84 **	81 **	82 **	65 **	76 **
Bl vs Bwc	66 **	54 **	57 *	63 **	53 **	64 **	43 **	58 **
Rt vs Bwc	49	59 **	40	68 **	44	63 **	34	52 **

Overlap between most pairings was significantly greater than was expected using random models. The Monte Carlo analysis assumes that the monkeys could eat all dietary items equally and does not take into account availability or the importance of phytochemistry. The fact that each monkey species seems to prefer similar dietary items (Table 3.4) indicates that phytochemistry may be the important factor determining these dietary overlap values.

All day follows:

Figure 3.11 shows the percentage of scans of different plant parts in N15 (unlogged) and N3 (logged). These show that there is more ripe fruit being eaten in N3 supporting the findings that compared the diets in the eight compartments.

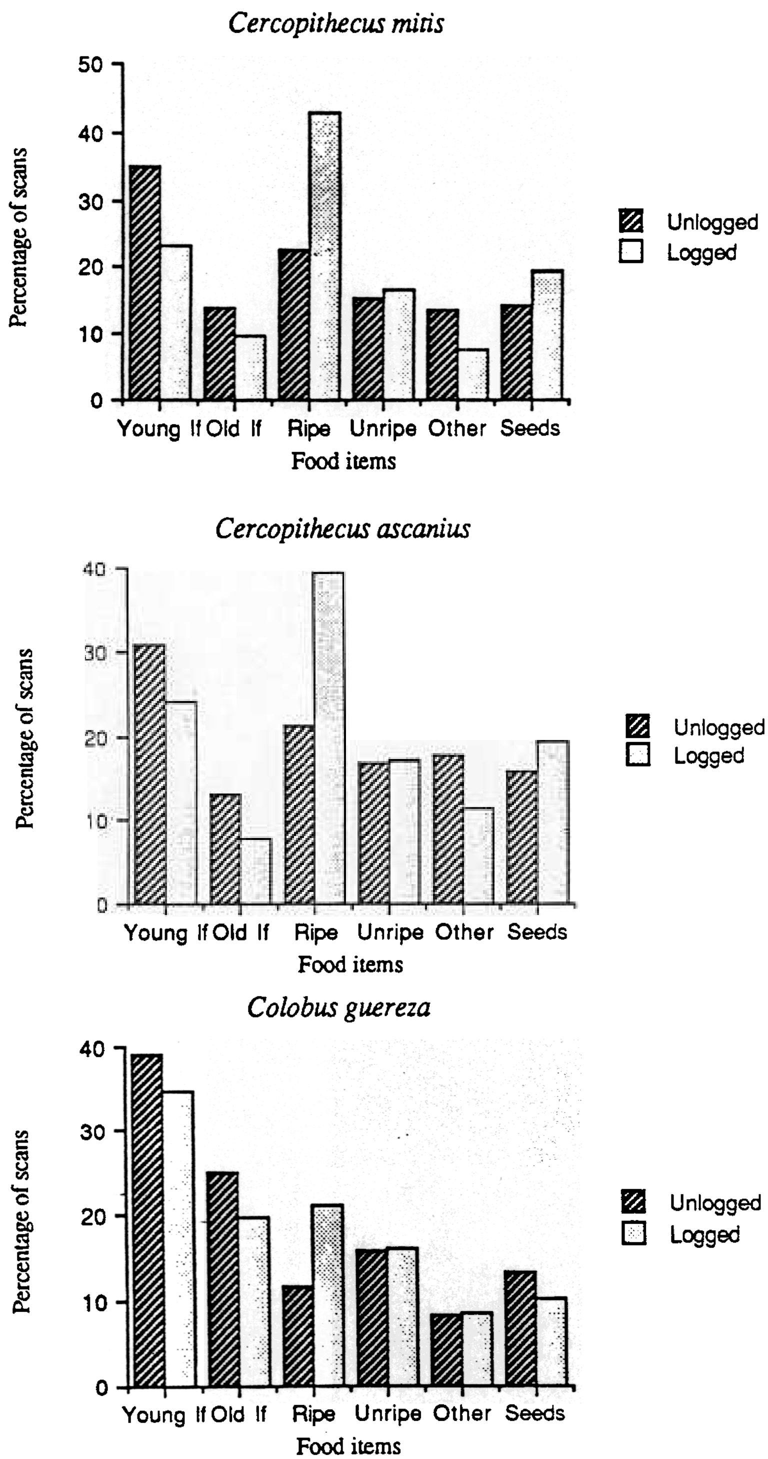

Figure 3.11 The percentage time spent feeding on different plant parts, comparing the groups in N15 (unlogged) and N3 (logged). The percentage of dietary items consisting of seeds are given but these form part of the ripe and unripe fruit values.

Table 3.6 gives the same measure of dietary preference for the feeding scans of the groups followed from dawn to dusk. The data for the groups in each compartment are combined because the measure of availability of trees used in the calculation was obtained for the whole compartment, not each group range.

Table 3.6 Manly's alpha preference values calculated for the same tree species as in Table 3.4 with a few others preferred by chimpanzees for the dawn to dusk follows data. +=preference.

		N3				N15		
Tree	Part	BL	RT	BWC	Chimp	BL	RT	BWC
No. of scans:		6637	5582	4182	4262	5120	2603	3689
Aningeria alt.	Fruit							
Albizia spp.	Leaf	+	+	+		+	+	+
Bosqueia phob.	Fruit	+	+	+				+
Broussonetia p.	Fruit	+	+	+	+			
	Leaf	+	+	+	+			
Chrysophylum	Fruit							
albidum	Leaf	+					+	
Celtis durandii	Fruit	+	+	+	+	+	+	+
	Leaf		+	+		+	+	+
Celtis zenkeri	Fruit	+	+			+	+	+
	Leaf	+	+			+	+	+
Cleistopholis	Fruit					+	+	
C. alexandri	Fruit				+		+	
	Leaf	+	+	+		+	+	+
Erythrophleum	Fruit	+		+		+		+
suaveolens	Leaf	+	+	+		+	+	+
Ficus exasper.	Fruit	+	+	+	+			
Ficus sur	Fruit	+	+	+	+			
Ficus mucuso	Fruit				+			
Funtumia elast.	Fruit						+	
Holoptelea gr.	Leaf	+	+	+		+	+	+
Maesopsis emin.	Fruit	+	+	+	+	+	+	+
	Leaf	+	+	+		+	+	+
Myrianthus hol.	Fruit				+			

The preferences found from the dawn to dusk follows are pretty similar to those found from the scan data along the transects, although there is a tendency for more preferences to exist with the follows data. This is probably due to the larger sample sizes of the scans which consequently leads to more dietary items being discovered which can affect the calculation of preference. The fact that the same species seem to be preferred at least in some of the compartments from the transect survey data lends support to this method being used for general surveys of large areas.

Horn's overlap values calculated using the proportion of plant parts in the diet (Bud, bark, young leaves etc.) showed that overlap between groups of the same species in each compartment were greater than 94%. Overlap between monkey species, comparing groups using similar ranges (see below), were greater than 90%. Nearly all comparisons were greater than expected using Monte Carlo analyses. However comparisons of monkeys in N3 with chimpanzees were lower, ranging from 68% between one colobus group and chimpanzees to 85% between one blue group and the chimpanzees. Overlap between one redtail group (group 1) and one colobus group (group 1) and chimpanzees was significantly lower than expected using Monte Carlo analyses. No monkey-chimpanzee comparison was greater than expected.

3.3.4 *Group sizes and reproductive success*

It is possible that logging can affect reproduction in monkeys by increasing stress levels and thereby reducing fecundity (Johns, 1989). During the census in the eight compartments groups were counted and the number of adults, juveniles and infants recorded. A Kruskal Wallis analysis of variance was calculated for the ratio of infants to adults in each group. No significant differences existed between compartments for any of the monkey species. Consequently there were no significant differences between compartments in the number of infants being produced. The same analysis was carried out on the ratio of juveniles to adults per group and this was significant for blue monkeys ($X^2 = 20.42$, $P<0.01$) but not for redtail and colobus monkeys. For the blue monkeys, in the logged compartments juvenile to adult ratio varied between 0.30 and 0.32, whilst in N15 it was 0.23 and in K11-13 it was 0.13. Consequently survival of blue monkeys is not as good in unlogged compartments when compared with logged compartments.

A oneway analysis of variance was calculated for mean group sizes in each compartment for each species separately. There was no significant difference in group sizes for redtails and colobus monkeys but there were significant differences for blue monkeys ($F=3.41$; $df=7$; $P<0.01$). Tukey's test was used to identify where significant differences lay and showed that group sizes in N3 were significantly larger than N15 and K11-13, and that group sizes in W21 were significantly larger than K11-13.

3.3.5 *Ranging behaviour of monkeys*

During the dawn to dusk follows the position of the main body of the group was plotted on maps of the trail system in N3 and N15 every 30 minutes (occasionally the groups split up to form sub groups in which case the position of the largest sub group was plotted). Acetate sheets with a grid of 25 x 25 metre squares were placed over these maps to transfer the plots to a coordinate system. Analysis of range size was calculated using two methods: the convex polygon and the kernel method using RANGES V (Kenward & Hodder, 1996; Priede & Swift, 1992; Harris *et al.*, 1990; Worton, 1989). In the case of the Kernel method isopleths ranging from 20% to 100% in intervals of 5% were calculated.

Figures 3.12 to 3.14 show the ranges of the three species of monkey in the logged and unlogged compartments for the kernel analysis. Table 3.7 gives data for the sizes of the home ranges for each group. Both the figures and table show that range size is significantly larger in the unlogged compartment (N15). This is despite the fact that group sizes are slightly larger in N3.

Z-tests of daily travel distance show that groups in the unlogged compartment travel significantly further each day than those in the logged compartment apart from the second group of blue monkeys in N3 which show no difference in travel distance when compared with each group in N15.

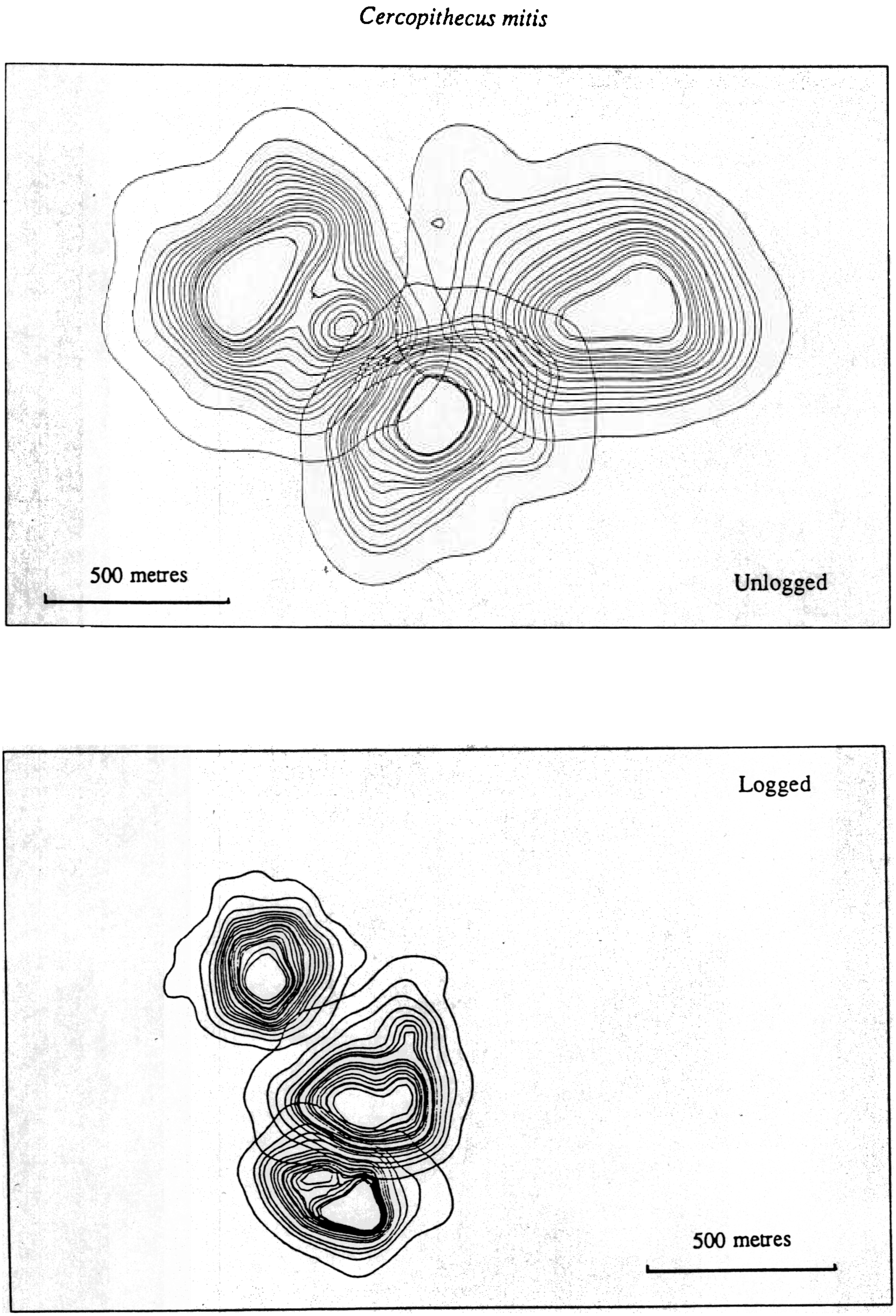

Figure 3.12 Kernel analyses of blue monkey ranges in unlogged (N15) and logged (N3) compartments plotted to the same scale.

Cercopithecus ascanius

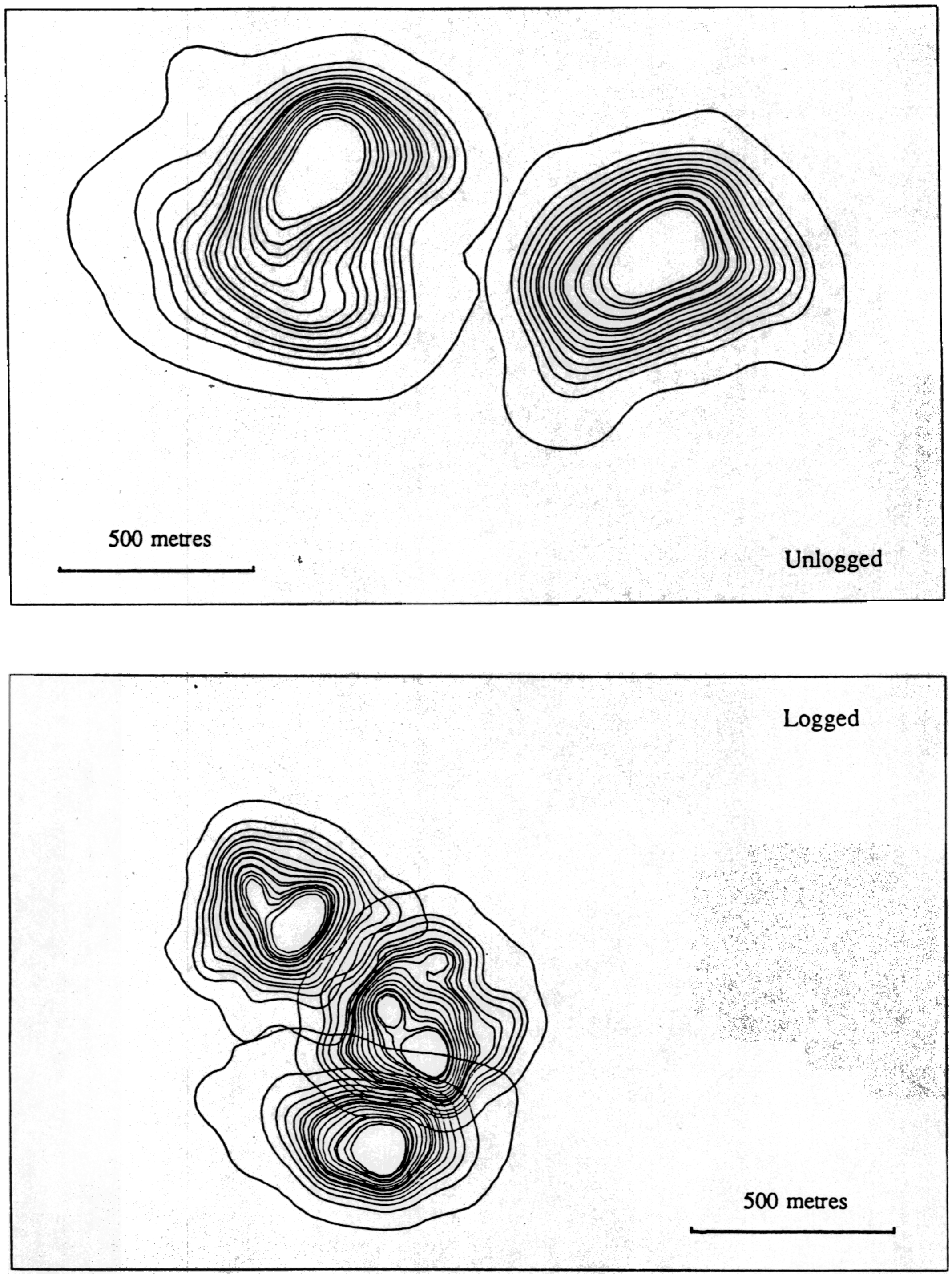

Figure 3.13 Kernel analyses of redtail monkey ranges in unlogged (N15) and logged (N3) compartments plotted to the same scale.

Colobus guereza

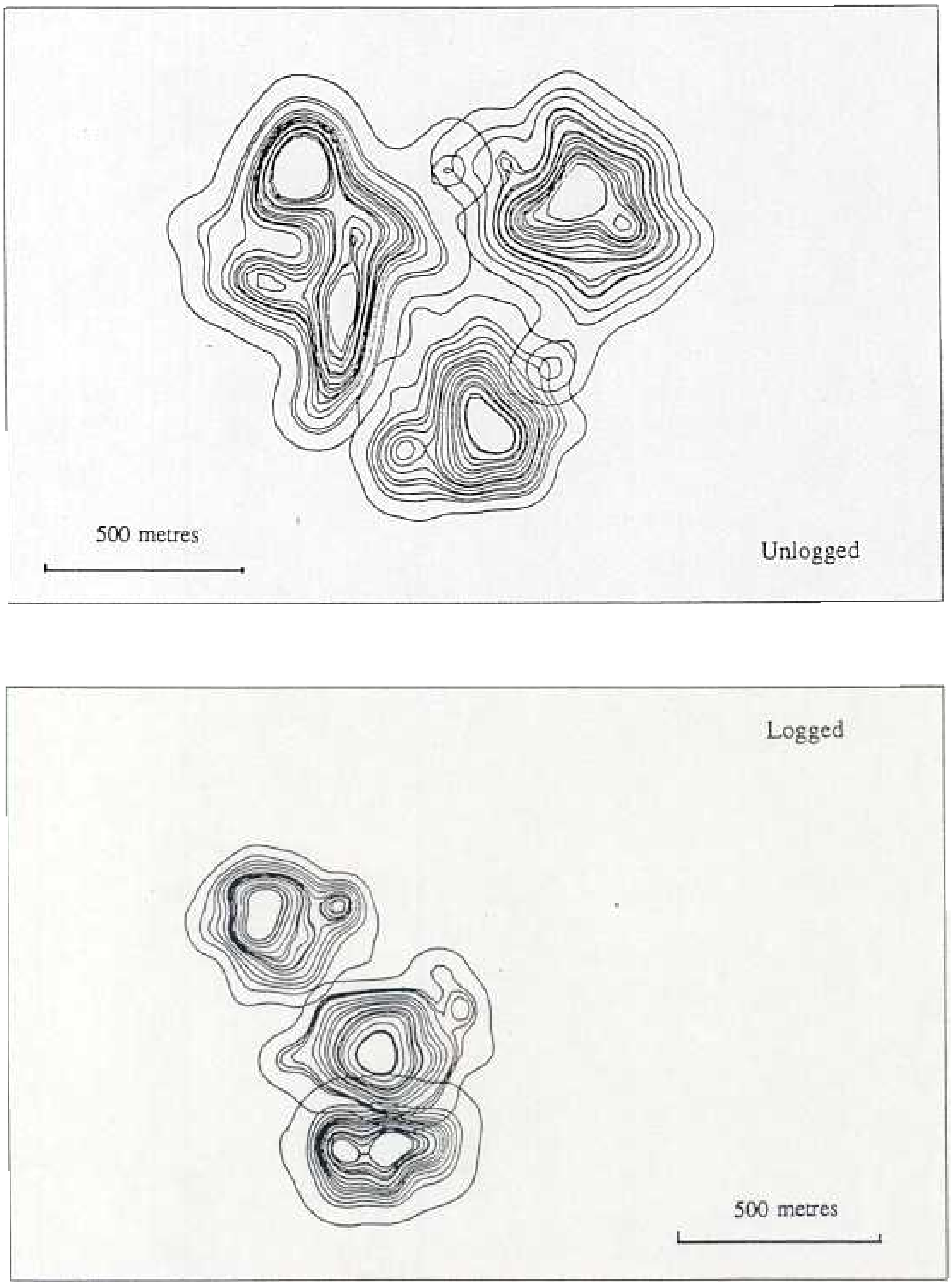

Figure 3.14 Kernel analyses of colobus monkey ranges in unlogged (N15) and logged (N3) compartments plotted to the same scale.

Table 3.7 Data on average group size between months (excluding suckling infants) range size, range span and daily travel distance for each group of monkeys followed. Range size is given for the Convex polygon method and 25% intervals for the Kernel method.

	Group size	Convex polygon (ha)	Range span (m)	Kernel 25%	50% (ha)	75%	100%	Distance travelled (m)
Blue monkey								
N3 group 1	20	13.3	485	1.2	2.6	4.5	14.3	2,100
N3 group 2	16	19.0	583	2.0	4.2	7.1	21.3	2,300
N3 group 3	15	14.5	460	1.1	2.7	4.9	14.1	2,070
N15 group 1	15	41.7	797	4.6	10.5	19.6	52.0	2,210
N15 group 2	15	44.2	901	4.1	10.2	19.2	55.0	2,260
N15 group 3	14	34.1	818	2.5	6.2	12.9	39.1	2,270
Redtail monkey								
N3 group 1	17	18.8	650	1.4	3.5	5.7	24.5	2,160
N3 group 2	18	20.9	530	1.6	4.7	8.7	23.6	2,420
N3 group 3	14	22.4	577	1.5	3.8	6.9	22.1	2,170
N15 group 1	13	49.1	897	3.9	10.6	19.9	62.2	2,430
N15 group 2	13	39.6	816	4.0	9.1	16.0	44.9	2,560
Colobus monkey								
N3 group 1	17	10.1	427	0.8	2.0	3.8	12.7	1,160
N3 group 2	12	13.1	477	0.7	2.6	5.0	14.8	950
N3 group 3	11	11.0	412	0.8	2.4	4.4	11.7	960
N15 group 1	11	33.6	751	2.8	7.1	13.3	36.9	1,480
N15 group 2	11	27.4	676	2.3	5.4	9.8	28.1	1,430
N15 group 3	10	19.0	515	1.1	3.0	7.1	20.3	1,320

3.3.6 *Phytochemical analysis of fruits*

208 samples of 45 plant parts were analysed for tannins, glucose, fructose and sucrose content. Combining all fruits, T tests between the content of these chemicals in ripe and unripe fruit were significant for sucrose and fructose with higher concentrations in ripe fruit.

Tests were also made between the tannin and sugar contents of seeds and pulp from the fruits of two fig species, *Ficus vallis-chaudae* and *F. sansibarica*. Total sugar content was significantly higher ($t=7.76$, $P<0.001$) and tannin content significantly lower ($t=4.47$, $P<0.001$) in the pulp. This would explain why chimpanzees often 'wadge' these figs, chewing the fruits and spitting out the seeds, and is similar to findings from Kibale (Wrangham *et al.*, 1993b).

Mean values for the tannin, glucose, fructose, and sucrose content were calculated for each plant species and part. Two analyses were made on this preliminary data set as follows:

1. A logistic regression of preferred food items vs non-preferred food items for each primate species (using Manly's alpha preference as above). None of the four phytochemical measures significantly explained chimpanzee preference but tannin was significantly avoided by the three monkey species.
2. The effects of these four phytochemical measures on the percentage contribution to the diet of primates followed in N3 (because the fruits were collected in N3) were analysed with multiple regression analysis. Blue monkeys ate food items with significantly higher glucose contents ($F=2.75$, $df=4,37$, $P<0.05$) although the regression equation was a poor predictor ($R^2_{adj}=0.15$). Similarly colobus ate items with high glucose content and low fructose and tannin content ($F=3.59$, $df=4,37$, $P<0.05$, $R^2_{adj}=0.20$). These phytochemical measures did not significantly predict redtail monkey or chimpanzee diet. The poor prediction might be due to the intake of leaves by all of these primates. Leaves have higher protein contents than fruits but also have low sugar content and high tannin content. Consequently if protein is being selected as well as sugars there will be trade-offs between all these nutrients. However when regressions were made on data for fruits only then only colobus diets were significantly predicted ($F=3.56$, $df=4,20$, $P<0.05$, $R^2_{adj}=0.30$) with a selection for fruits with high glucose values and low tannin and fructose values.

3.3.7 *Predation risk*

The three monkey species are at risk from only two main predators that live in the forest of Budongo. These are the chimpanzee and the crowned eagle *Stephanoaetus coronatus* L. Man is also a potential predator although in Uganda primates are usually not hunted because they are not eaten (only some Zairois immigrants occasionally hunt primates in Budongo).

Chimpanzees:

The Sonso chimpanzee community has been observed now since January 1991, although as time has passed habituation has improved greatly. During this time only three monkey kills by chimpanzees are known of and two chimpanzee infanticides. Analysis of dung samples (see chapter 5) show that few samples contain meat or bones for the Sonso community although in Busingiro the chimpanzee community appears to hunt more frequently. However the risk to an individual monkey from chimpanzee predation appears to be slight.

Crowned eagle:

Crowned eagles have been reported to prey almost exclusively on primates where they have been studied in forest (Skorupa, 1989; Struhsaker & Leakey, 1990). During the dawn to dusk follows the number of times the monkey group fled from an eagle was recorded as was the number of attempted attacks by eagles. Only one successful attack was seen where two eagles caught a juvenile colobus monkey from group 1 in N15. One eagle drove the monkeys towards the other during this attack supporting other sightings that eagles hunt in pairs (Maisels *et al.*, 1993; Brown, 1971). Figure 3.15 shows the mean number of days each year that a monkey group responded to an eagle flying past or attacking for unlogged (N15) and logged (N3) forest. These values were calculated by summing the total number of days that monkey groups had been followed (N3:224; N15:195) and using the number of responses seen during this time (N3:5; N15:13).

Eagles were significantly more likely to be reacted to in the unlogged N15 compartment than in N3 (X^2=7.3 (with Yates' correction), df=1, P<0.01). Eagles may attack more frequently in N15 because primate densities are lower there so that there is less chance of being spotted. It is also possible that these eagles nest in mature undisturbed forest and tend to hunt nearer the nest, however no nest was ever found in N15 despite being visited frequently.

One kill was made in a total of 419 days from a total of 242 animals followed. This is equivalent to a risk of 0.000098 kills per animal per day or a 0.01% risk for an individual. This can be compared with the risk of dying for an ungulate in the Serengeti (0.02%), a buffalo in a herd in Manyara National Park (0.012%) or the risk of death or hospitalisation

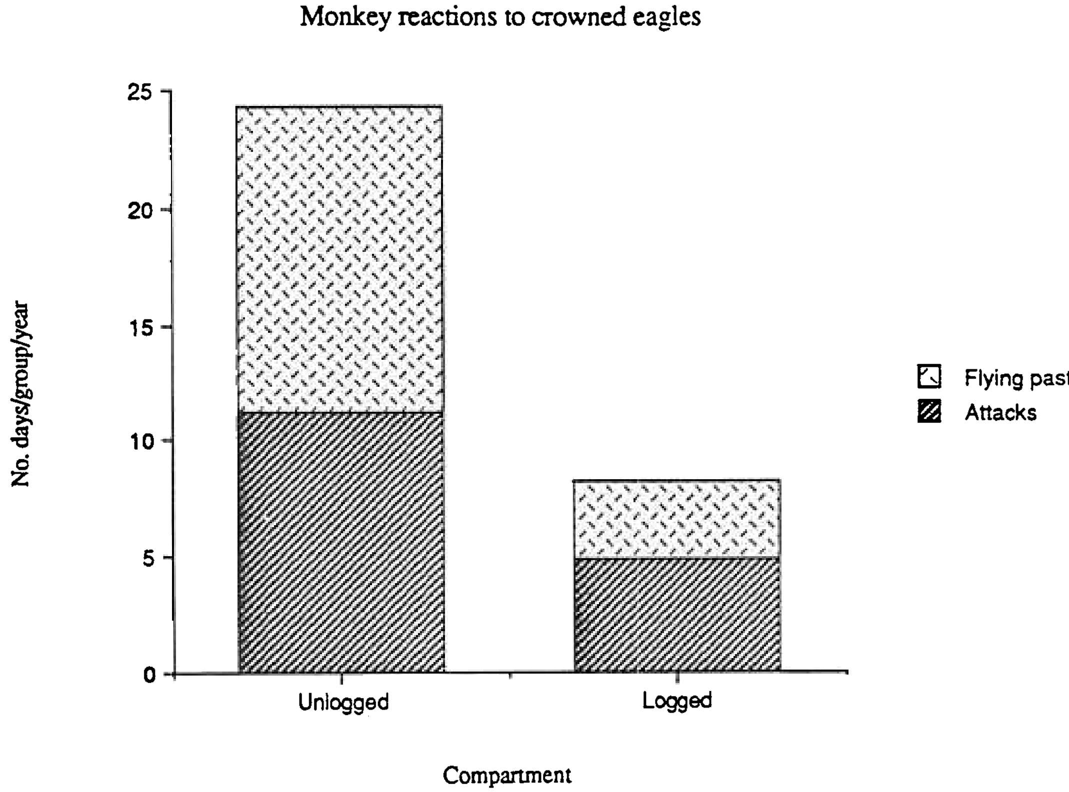

Figure 3.15 The average number of days each year that a monkey group would have to respond to passing eagles or attacking eagles in unlogged and logged forest.

faced by a driver or passenger in a car (0.006% per car-hour) in the Netherlands (Prins, 1996). Prins (1996) argues that buffalo ignore risks this low, as do humans although they try to be vigilant and avoid accidents or death. All three monkeys feed at the top of the trees and spend a lot of time in the tree canopies where they are more likely to be caught by eagles (% time above 20 m in the canopy: blues=42%; redtails=34%; colobus =48%) and therefore seem to ignore this threat to a great extent.

Brown (1971) estimated that crowned eagles required about 480 g meat per day or 175.2 kg per eagle per year and that a home range is about 10 km^2. If the average blue monkey is 6 kg, redtail monkey is 3.6 kg and colobus is 9 kg (Struhsaker, 1981) then using the density estimates from the 1992 census there is 465 kg km^{-2} of monkeys in N15 and 947 kg km^{-2} in N3. If the eagles only eat monkeys (monkeys formed about 87% of kills in Kibale (Skorupa, 1989)) and the home range of a pair in the forest is 10 km^2 then in Budongo they would be removing 7.5% of the primate biomass per year in N15 (assuming their range was only in this compartment) or 3.7% in N3. This latter value is similar to offtake in Kibale which was calculated as 2.4% (Struhsaker & Leakey, 1990). If these values are converted to the daily risk to individual primates in each compartment in Budongo then the risk in N15 is 0.014% and in N3 is 0.015% which is very similar to the 0.01% found above.

3.4 Discussion

In Budongo Forest food availability is important in determining the abundance of the monkey species whilst predation is having limited impact on the populations. During the five years of studying monkeys in Budongo we have not seen any outbreak of disease but this is not to say that disease is not important. An epidemic may take many years to recover from as can be seen by the impact of rinderpest in the Serengeti (Sinclair & Arcese, 1995) or anthrax in Manyara (Prins, 1996). The fact that there were strong correlations between species density and measures of food supply or intake, however means that the monkeys were probably not recovering from disease at any of the study sites; if they had been no correlations would have been expected. During the six years of study four monkeys, 3 of which were blue monkeys were recovered alive with broken bones on the ground, having fallen from trees. These are likely to have resulted from intraspecific fights and given that predators may find and consume these animals fairly soon after they have fallen it could contribute significantly to mortality.

Both blue monkeys and redtail monkeys had positive correlations between density and the percentage of fleshy fruit in the diet. However a comparison of density (Figure 3.7) and the availability of fleshy fruit types (Figures 3.1 and 3.2) as measured by the phenology data shows a poor correlation. For instance these monkeys are consuming most fleshy fruit in B1 where both their densities are highest but least in K11-13 where both their densities are lowest. However the phenology figures show that K11-13 has higher availability of large fleshy fruits during much of the year and a good supply of small fleshy fruits also. Whilst some of this is likely to be explained by tree species composition and phytochemistry we also feel that this highlights a big problem in the measurement of food availability as it is currently being measured. A tree is scored as fruiting if it has unripe and or ripe fruits.

However if monkeys have come along and eaten all the fruits during the days before the phenology was recorded then it will be scored as not fruiting. Where primate density is high consumption of fruits will be heavy so that fruits will be removed from trees more quickly than where primate density is low. Consequently this measure of availability is likely to under-represent food availability in areas of high primate density. This will be particularly true where scores of the percentage fruit in the canopy are estimated and we would recommend measuring the DBH of the tree and only recording if the tree is in fruit or not (this is also less time consuming and likely to be less affected by use of different observers). Measures of potential availability such as tree density or sum DBH values can be used as an alternative method and do show increased fleshy fruit potential in treated and logged forest for some species (eg. Figs: Earl, 1992) but this method does not allow you to investigate seasonal and annual changes.

Colobus monkey density was significantly correlated with the density and basal area of *Celtis durandii*, a species of tree whose leaves and fruits are preferred food items in every compartment studied for this primate. This tree species also forms the greatest percentage contribution to the diet of this monkey (32.7% of colobus diets in N3; 17.3% in N15). *C. durandii* is not so good for timber as the other *Celtis* species (R. Plumptre pers. comm.) and is unlikely to be harvested heavily even if the Uganda Forest Department promotes the use of more tree species for timber production. Consequently colobus are not likely to be at great risk from timber harvesting unless this tree species is targeted for removal in order to increase the stocking density of more desirable species. This species was treated with arboricide during the 1950s and 60s but has recolonised or regenerated in treated areas successfully. In the mid 1950s an experimental plot (RP100) was established in compartment N2 to investigate the effects of different treatment programmes on regeneration. Five replicates of four treatments and a control were established in a latin square design, each square of 100x100 metres (only the central 60x60 m were measured to avoid edge effects). Rukundo (1997) showed that where the treatments had occurred *Celtis durandii* is more abundant (5-14% of trees) than in the untreated control plots (3% of trees). Consequently this tree seems to be a good colonising species that can establish itself even where it has been selectively poisoned. This may explain why *C. guereza* often seems to survive in scrubby or isolated patches of forest where *Celtis* *durandii* is likely to occur.

Chimpanzee nest density correlated with the density of trees bearing large fleshy fruits. Large fleshy fruits formed 22.85% of the diet of the Sonso community, a much larger contribution than for the monkey species and consequently this correlation makes sense. Of particular importance were *Chrysophyllum* species, *Uvariopsis congensis*, *Ficus mucuso*, *F. sansibarica* and *F.saussureana*. The latter three fig species and the *Uvariopsis* are not considered to be valuable timber species but the *Chrysophyllum* trees are. It is recommended that some large *Chrysophyllum* trees are left in each logging concession to support the chimpanzee populations and also to provide seed for a future crop. A greater threat to chimpanzees in Budongo is the presence of large numbers of people in pitsawing concessions. During 1996 numbers exceeding 100 men were common in and around the two pitsawing concessions in compartments N5 and W21. Most of these people were portering out planks of timber to the loading bays. We have shown that human disturbance causes chimpanzees to leave an area (even minor disturbances from researchers caused them to change their behaviour) and if the disturbance is over a large area this is likely to lead to conflicts between neighbouring chimpanzee communities which can lead to the elimination of a chimpanzee community (Goodall, 1986). We would recommend that portering of timber be limited to two days per week and that pitsawing be confined to coupes concentrated in small areas to limit the human disturbance.

4. EFFECTS OF LOGGING ON OTHER TAXONOMIC GROUPS IN BUDONGO

This section reports results from several researchers who were invited to work in Budongo to investigate the effects of logging on different taxonomic groups of animals. Two were Ugandan MSc students who were supported by the Wildlife Conservation Society and were supervised in the field by A. Plumptre. As some of the results have been written up elsewhere or are in the process of being written up only summaries will be given here. This section provides the results for objective 2 of the ODA proposal.

4.1 Small mammals - rats and shrews

4.1.1 *Methods*

This research was carried out by Paul Musamali Buyerah as part of his MSc studies at Makerere University and has already been published (Musamali, 1996). Five of the study sites (B1, N15, N3, W21 and K11-13) used for the primate studies (chapter 3) were selected for the study of small mammals (rats and shrews). Live trapping studies with 40 Sherman traps were made between April - August 1993 and October 1994 - March 1995. Two traps were placed between ground level and 2 metres above the ground at each 100 metre marked point along the five 2 km transects used for primate censusing (see chapter 3). Traps were baited with peanut butter and inspected early in the morning before transferring them to the next transect. Animals caught were ear-clipped and identified to species following Delaney (1975). Shrews were identified by R. Kityo at the Makerere University museum. Trapping was carried out at each point four times, spread over the study period to even out seasonal variation in numbers.

Pitfall traps in the form of jugs (30 cm deep) were sunk into the ground at marked sites along transects with tops level with the surface. Wire mesh sheeting was placed above the sunk jars to encourage small mammals to move towards the pits. Shrews and pygmy mice *Mus minutoides* were caught in these traps. Live trapping with Sherman and larger Havahart/Tomahawk traps was also carried out *ad lib.* in other areas of the forest.

Trapping in four quadrats (49x49 m) with 7 m intervals between traps was carried out between October 1994 - March 1995. The Schnabel method (1938) for the analysis of capture-mark-recapture data was used to calculate densities for these quadrats.

4.1.2 *Results*

Transect studies

Twelve small mammal species were recorded during the ten month study (Appendix 1.). Species diversity was low compared with other tropical forests and given the large trapping effort and number of sites studied. Two species formed the bulk of captures: *Praomys jacksoni* (60.3%) and *Hylomyscus stella* (28.0%). One species, *Malacomys longipes*, was only trapped in swamp forest along streams where there was constant water available. All other species were caught in logged and unlogged areas. Higher total numbers of rodents were caught in unlogged forest. Oneway analysis of variance was used to test for differences between compartments for the two most frequently caught species and Tukeys test used to identify where differences lay. There were significant differences for both species: *P. jacksoni*: F=16.40, P<0.001 (N15 > B1, W21 and K11-13> N3, B1, W21); *H. stella*: F=6.7, P<0.001 (B1>N15, W21, N3 and K11-13> N15, W21, N3). Captures were more frequent during May - August 1993 than during the October 1994 - March 1995 period.

T-tests were made between the mean number of captures of these two rodents in logged and unlogged forest. Both had significantly higher capture rates in unlogged forest (*P. jacksoni*: T=6.82, df=116, P<0.001; *H. stella*: T=2.44, df=116, P<0.05). For *P.jacksoni* for which a large sample size (>50) existed these differences were maintained during both wet and dry seasons.

Both these rodents showed strong correlations between capture frequency and the density of *Cynometra alexandri* on the trap site (7 m radius circular plot).

Quadrat trapping

The results of the capture-mark-recapture analysis in the 49x49 m quadrats are given in Table 4.1.

Table 4.1 The density estimates of *P. jacksoni* (Pj) and *H. stella* (Hs) from capture-mark-recapture analysis in four quadrats. The 95% confidence limits are given in brackets and the forest type of each quadrat is shown.

Quadrat	Species	Schnabel estimate	Forest type
1	Pj	13.2 (8.1-25.7)	*Cynometra*
	Hs	19.0 (8.9-43.6)	- mixed
2	Pj	18.1 (10.7-32.5)	*Cynometra*
	Hs	8.7 (5.0-18.0)	- mixed
3	Pj	-	Swamp
	Hs	14.9 (10.1-27.9)	
4	Pj	25.0 (18.0-36.9)	Mixed
	Hs	22.0 (4.1-31.4)	

These results indicate that higher densities of these two rodents occur in mixed and thereby managed forest than in *Cynometra*-mixed or unlogged forest.

4.1.3 *Discussion*

The results of the quadrat trapping conflict with the transect trapping. Transect trapping caught higher numbers of the two commonest rodents in unlogged and *Cynometra* dominated forest whilst the quadrat trapping caught higher densities in the mixed forest quadrat. However because of the low number of traps available these trapping sessions were not concurrent. Most of the transect trapping occurred between April - August 1993 whilst the quadrat trapping was between October 1994 and March 1995. The transect trapping during this latter period (one trapping session at each point in N15 and N3) caught much lower numbers of rodents (Musamali, pers. comm.) than previously. Normally *C. alexandri* produces fruit between November and February but the crop failed for the 1994-95 fruiting period. The seeds of this tree are eaten by rodents and consequently rodent numbers may have crashed at this time in *Cynometra* forest, hence leading to lower densities in the quadrats. Studies in Kibale forest showed that although rodent diversity may be higher in logged forest, densities of *P. jacksoni* and *H. stella* (the two most abundant species in this forest also) were higher in unlogged forest (Isabirye-Basuta & Kasenene, 1987; Lwanga, 1994).

Longer-term trapping data are currently being analysed by A. Stanford at Bristol University. These investigated seasonal fluctuations in density and also expanded the analysis of small mammals to include squirrels.

4.2 Birds

4.2.1 *Methods*

Between April - August 1993 and October 1994 - March 1995 birds were studied in Budongo by Isaiah Owiunji for his Masters thesis (Owiunji, 1996). Point count and mist-netting studies were made in five of the compartments used for the primate studies (B1, N15, N3, W21, K11-13). Mist nets were placed at the 100 m points along the five 2 km transects in each compartment and the point counts also used these sites. This allowed bird sightings/captures to be related to measures of forest structure and forest type taken at each point as part of the vegetation survey (section 3.2.1).

Point counts

Point counts were made between 8.00 am and 11.00 and were made by one observer, I. Owiunji, for consistency. This followed a training period in bird identification with Dr C. Dranzoa in Kibale Forest. The observer would arrive at a point and wait 2-3 minutes for birds to settle down before counting. Counts lasted 5 minutes and for any sighting of a bird the distance from the observer to the bird was measured with a rangefinder. In each of the five compartments, each point was visited 4 times at least and 5 times in N3 and N15. Where comparisons were made of sightings between compartments only the first four counts in N3 and N15 were used in the analysis. Analysis of the observer-distance data was made using DISTANCE (Buckland *et al.*, 1993) and several curves fitted. The Fourier curve (uniform with cosine adjustments) provided the best fit for most species.

Mist-netting

Standard BTO (British Trust for Ornithology) mistnets (14 m long x 2.5 m high) were placed perpendicular to and along the transects. Nets were opened at dawn (6.45-7.00 am) and closed at 13.00. This closure near mid day allowed equal sample periods for each site because it rarely rained during this period so that nets were not closed because of rain. Each day nets were moved to a new location after 13.00 to avoid problems that can occur when birds learn where the nets are. Nets were checked every 30-45 minutes. Mist netting was carried out by A. Plumptre and I. Owiunji with several Field Assistants. Birds were identified by reference to Mackworth-Praed & Grant (1960), Keith *et al.* (1992) and in the case of one species a specimen was collected and identified at the Africa Museum at Tervuren.

For both mistnetting and point count studies analyses were made of guild structure in different compartments and also the proportion of forest specialist, forest generalist and forest visitor species (Bennun *et al.*, in press).

4.2.2 *Results*

Point counts

Appendix 2 gives the numbers of birds seen from the point counts and the category of forest specialisation seen in each compartment. Figure 4.1 shows the species accumulation curves from the point count data for the first 400 point counts. These have not completely levelled off yet. Two interesting discoveries were made during this research: Nahan's Francolin *Francolinus nahani*, an IUCN red data book species, was discovered to occur with a reasonable population size in Budongo and the first ever recording of its call was made. This recording is being used to determine where it occurs elsewhere in Uganda (recently it was rediscovered after 50 years in Mabira Forest, C. Dranzoa, pers. comm.). Puvel's illadopsis *Trichastoma puveli* was also discovered in Kaniyo Pabidi. The nearest previous record was in central Zaire near Kisangani and it is possible that this bird in Budongo is a sub-species. Both birds are currently attracting specialist bird safaris to the two ecotourism sites in Budongo.

Table 4.2 gives Horn's overlap values for community composition based on the presence or absence of a species between the compartments. Overlap values varied between 72% and 82% and showed no correlation with the time since logging, the two unlogged compartments having a low overlap value. Comparison of the overlap values between forest types (Table 4.3) gives slightly lower overlap values (67-78%), the bird community in mixed and swamp

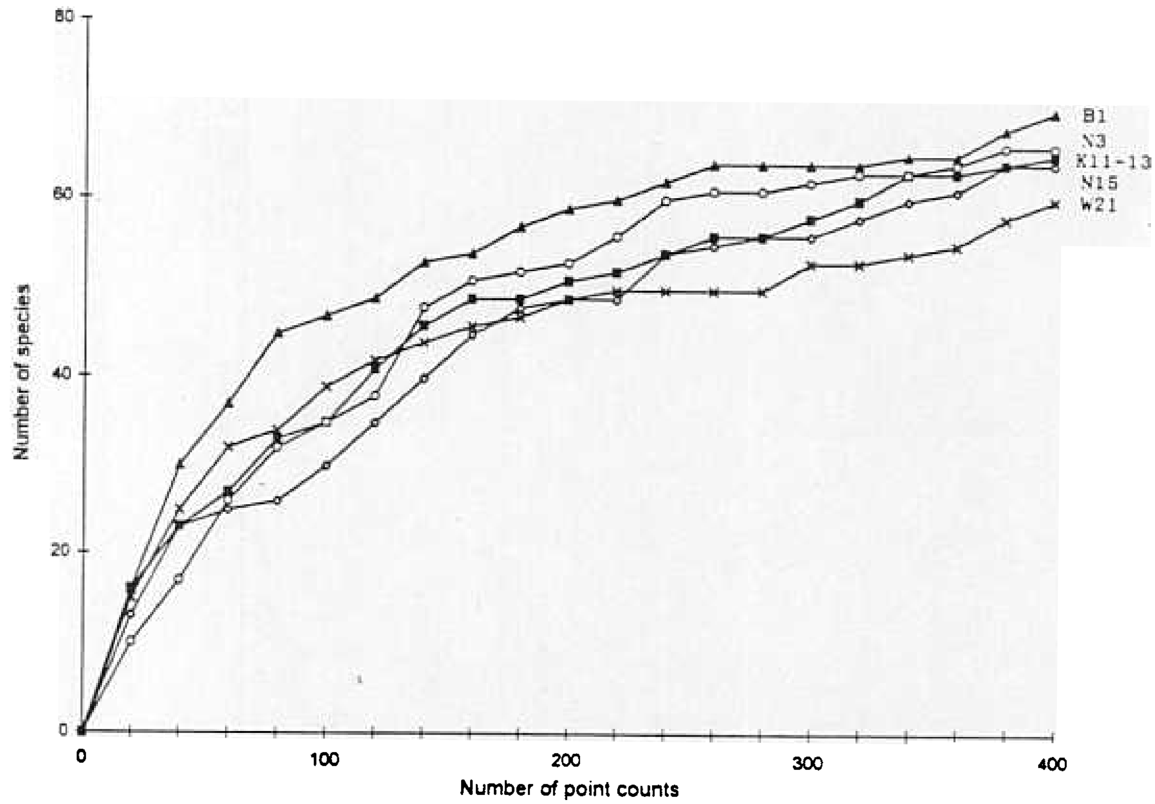

Figure 4.1 Species accumulation curves for increasing numbers of point counts for each of the five compartments.

Table 4.2. Horn's index of similarity (%) between the species found in each of the five compartments. Overlap was calculated using the presence or absence of each species after 400 point counts (the lowest number in any compartment).

	K11-13 Unlog.	N3 1950	W21 1965	B1 1984
N15 (Unlogged)	75	78	78	82
KP (Unlogged)		75	72	72
N3 (Logged 1950)			80	77
W21 (Logged 1965)				78

forest least similar to that in *Cynometra* forest. Observations in colonising forest were too few to include.

Table 4.3. Horn's index of similarity (%) between species found in the three commonest forest types. Overlap was calculated on presence and absence data after 135 point counts (the lowest number in any forest type).

	Cynometra -Mixed	Mixed	Swamp
Cynometra	71	67	68
Cynometra-Mixed		78	73
Mixed			71

Table 4.4 gives the densities for the 22 most commonly recorded species in logged and unlogged compartments and their forest specialisation. Most did not show significant density differences between logged and unlogged forest. Where differences occurred, not all species affected negatively by logging were FF (Forest specialist) species and not all those benefiting were F (forest generalist) or f (forest visitor) as expected.

Densities were correlated with the percentage of each forest type in each compartment. With only five compartments studied an exact match in ranks for a spearman rank correlation is required for significance. For three species from Table 4.4, yellow whiskered greenbul *Andropadus latirostris*, red bellied paradise flycatcher *Terpsiphone rufiventer* and rufous thrush *Neocossyphus fraseri* there was a significant positive correlation between density and the percentage of *Cynometra* and *Cynometra*-mixed forest (the most mature forest types). This supports the hypothesis that higher densities in unlogged compartments can be explained by changes in forest composition for these three species.

Table 4.4. Comparison of bird densities (no. km^{-2}) in logged and unlogged forest for 22 species with over 25 sightings. *, p<0.05; ***, p<0.001; ns, not significant

Species	Unlogged	Logged	Z-tests	Habitat category
Red-bellied paradise flycatcher	123.1	23.7	***	FF
Rufous thrush	57.7	20.9	***	FF
Yellow-whiskered greenbul	73.7	28.7	***	F
Green hylia	110.6	82.2	*	F
Red-chested cuckoo	18.1	4.0	*	F
Red-tailed greenbul	60.7	57.1	ns	FF
Western Black-headed Oriole	39.0	18.7	ns	F
White-throated greenbul	114.8	83.2	ns	FF
Tambourine dove	47.6	39.1	ns	F
Bristlebill	16.6	12.0	ns	FF
Crested malimbe	31.8	29.8	ns	F
Blue-breasted kingfisher	9.6	4.3	ns	FF
Nicator	27.6	28.9	ns	F
Fire-crested alethe	16.8	20.8	ns	FF
White-thighed hornbill	45.6	53.6	ns	FF
Yellow-crested woodpecker	13.1	30.7	ns	FF
Spotted greenbul	59.1	76.6	ns	FF
Olive-green camaroptera	31.3	51.5	ns	FF
Olive sunbird	151.9	168.3	ns	FF
Brown-crowned eremomela	21.7	58.4	*	F
Chestnut wattle-eye	37.3	118.2	***	FF
Little greenbul	94.5	205.4	***	F

Table 4.5 gives the differences between guilds of birds in logged and unlogged compartments for both density and biomass.

Table 4.5. The responses of different guilds of birds following forest disturbance. Tests were made between the biomasses and densities of each guild in logged (L) and unlogged (U). The guilds were taken from Dranzoa (1995). (+=significantly more abundant following logging; nc=no change; -=significantly less abundant following logging ; P<0.05).

	Density	Biomass
Frugivore	ns	+
Frugivore/insectivore	ns	ns
Sallying insectivores	-	
Terrestrial insectivores	ns	ns
Foliage gleaners	-	ns
Bark gleaning insectivores	ns	ns
Nectarivore/insectivore	ns	ns
Omnivore	ns	ns
Predator/insectivore	ns	ns
Gramnivore-insectivore	ns	ns

Correlations were made between the number of birds in each guild (square root transformed to normalise the data) and measures of forest structure and the density of *C.alexandri*, *Celtis zenkeri*, *Celtis mildbraedii*, mahogany and figs at each point. The structural variables measured were: density of foliage at five metre intervals from ground level to 30 metres (scored on a 1-5 scale); percentage canopy cover (measured with a spherical densiometer - a concave mirror with gridlines etched on it), liana density (all lianas over 2cm diameter where they leave the ground), and the number of 3 inch squares covered by foliage on a 90x6 inch board placed at 2.5 metres from the observer. Table 4.6 gives the results of these correlations.

Mistnetting

2,085 birds of 60 species were captured in the nets at a rate of 0.022 birds per metre net hour. Figure 4.2 plots the number of new species caught as the number of individuals caught increases. The two unlogged compartments (N15 and K11-13) had lower species richness.

Table 4.6. Correlations between measures of forest structure at each point and numbers of birds in each guild. Only significant (P<0.01) correlations are listed. Fdens=foliage density - height interval given after this; Sq. cov.=number of squares covered on board; Tree names=density of that species; % cover=canopy cover measured with densiometer.

	Positive correlations	Negative correlations
Frugivore	Fdens 0-5m	-
Frugivore/insectivore	Sq. cov.	% cover; *C. zenkeri*
Sallying insectivores	*Cynometra*	Liana, Fdens 0-5m, Mahogany
Terrestrial insectivores	% cover, *C. mildbraedii* Fdens 11-15m, mahogany	Sq. cov., Fdens 0-5m
Foliage gleaners	*Cynometra*	Mahogany
Bark gleaning insectivores	-	-
Nectarivore/insectivore	-	% cover
Omnivore	Fdens 0-5m	*Cynometra*
Predator/insectivore	-	-
Gramnivore-insectivore	Fdens 0-5m	

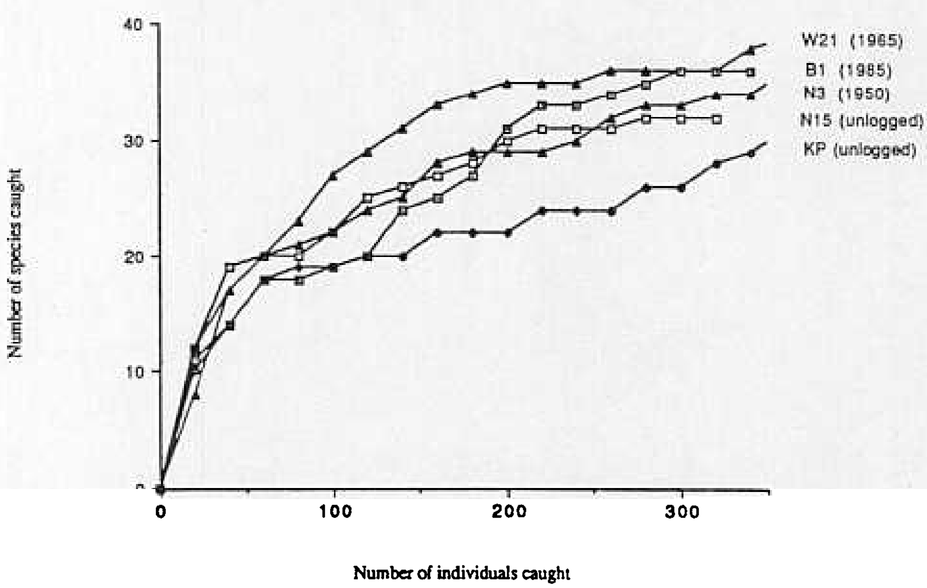

Figure 4.2. Species accumulation curve for mistnetting captures in each compartment.

Horn's overlap values were similar to Table 4.2 in that unlogged compartments had lower overlap values than many logged-unlogged comparisons. Similarly an analysis of guilds showed that there were significantly more insectivores (gleaners, terrestrial feeders and sallying species combined) in unlogged forest (T=3.03, P<0.01) and a lower number of frugivore-insectivores (T=3.03, P<0.01).

Canonical Correspondence Analysis

Canonical Correspondence Analysis (CCA) (Ter Braak, 1986) was used to look at the relative effects of forest type, logging, site and forest structure on the bird community composition. CCA allows you to examine the explanatory effects of one set of variables whilst partitioning out the effects of other variables and allows you to test whether they significantly explain some of the variation in community composition by Monte Carlo analyses (Ter Braak 1987-92). The counts for each species at each point count site (first four visits combined) were analysed using CANOCO (Ter Braak, 1988) and the following variables analysed as environmental variables: Forest type: entered as dummy variables (*Cynometra*, *Cynometra*-mixed, mixed, colonising and swamp); structural variables: % canopy cover (measured with densiometer - see above), number of squares covered by foliage on checkerboard, tree density, liana density; compartment: entered as a dummy variables and whether a point was in a logged compartment or not.

Table 4.7 gives the results of the effects of one set of variables after partitioning out the effects of another. The table follows a set of successive tests looking at the effects of a group of variables having partitioned out another group. This table shows that the compartment explains more of the variation in the community composition than any other set of variables and once the effects of this are removed none of the other variables explain any more of the variation significantly.

4.2.3 *Discussion*

These results show that in general frugivorous birds occur at higher densities in disturbed forest whilst certain insectivores, particularly sallying species such as flycatchers are at lower densities. This would tally with the findings that frugivorous primates also do well in disturbed forest which is explained by increased frugivory and density of fruit producing trees

Table 4.7. The results of the CCA, listing the effects of variables on the analysis after removing the effects of covariables.

Test	Variables	Covariables	Probability[a]
	Forest type	Structural	*
2.	Structural	Forest type	ns
3.	Logged	Forest type	**
4.	Forest type	Logged	ns
5.	Compartment	Forest type	**
6.	Forest type	Compartment	ns
7.	Compartment	Forest type & logged	**
8.	Forest type & logged	Compartment	ns

[a] Probability values from Monte Carlo analyses (100 runs for each test).
*, p<0.05; **, p<0.01; ns, not significant

(chapter 3). However, caution must be taken when interpreting these results. The results produced here were made by comparing logged and unlogged sites as has been done for most studies of the effects of logging. The CCA showed that the effect of the site (compartment) explained more variation than whether the site had been logged, structural differences or forest type. This throws doubt on the validity of comparing logged and unlogged sites which necessarily assume that the communities were identical before logging took place. This is unlikely and given the findings that site has an effect post logging it is likely there were differences before logging took place. The use of replicates of unlogged and logged sites (rare in other studies) may compensate for some of the effects of sites. It is recommended that longitudinal studies (before, during and after logging) are carried out in future so that the effect of site is controlled for.

Another potential problem with this analysis concerns breeding in birds. Birds can exist in a habitat but fail to breed there and are only forced to live there because all the available breeding areas are occupied. Kalina (1988) found that black and white casqued hornbills (*Ceratogymna subcylindricus*) preferred to breed in unlogged forest although logged forests attracted many hornbills because of mass fruiting trees. Higher densities of a species may occur in "sink populations" rather than "source populations" (*sensu* Pulliam, 1988) if the birds do not have to defend territories in a sink population and consequently comparisons of measures of relative or actual density should be interpreted with caution.

4.2.4 *Recommendations for future research*

Studies of the effects of logging on birds in future should aim to include the following recommendations:

1. monitor several sites over time from before the logging event and ideally for several decades after the event.
2. Replicate unlogged sites as well as logged sites should be monitored, and monitored regularly (every 3-5 years) so that patterns in bird density can be detected through the noise of different censuses.
3. Where logging takes place the same intensity of harvesting and forest damage levels should be similar for each replicate site.
4. In each site effort must be made to detect breeding by birds at that site as well as crude densities.
5. Logging will never cause identical changes at different sites even if the forest is similar and consequently measures of changes in tree species composition and structure should be made at each site as logging proceeds so that in future we can investigate what causes the changes in the densities of the birds.

4.3 Amphibians

4.3.1 *Methods*

An undergraduate expedition from Oxford University Zoology Department came to Budongo in June-August 1996 to survey amphibian populations in Budongo. Methods included *ad lib.* sampling of different areas, attempting to build up a species list for the forest and also the intensive searching of 8x8 m quadrats between the ground and to a height of 1.5 m. Quadrat searches were undertaken in N15 (unlogged) and B1 (logged) as these were adjacent compartments and probably more similar floristically (because of the east-west gradient in tree species composition (Plumptre, 1996)) before B1 was logged. Forty quadrats were searched at each site. All frogs found were collected and preserved for identification at Makerere University and the Natural History Museum in London. The results are still being analysed and a full report due once identifications have taken place. A few results are presented here.

4.3.2 *Results*

22 species (those that have been identified) were found in both N15 and B1 in the quadrats. However, alpha diversity seems to be higher in B1 with all 22 found after sampling 11 quadrats compared with 22 quadrats in N15. Apart from two species, most frog species occurred at both sites. *Ptychadena* sp. was only found in N15 and *Leptopelis christyi* only found in B1. Two species, *Arthroleptis adolfriederici* and *A. poecilonotus* dominated the numbers of individuals caught at both sites (over 90% at both sites). Table 4.8 summarises the counts from the plots.

Table 4.8 The number of frogs found, density, Shannon-Wiener diversity and eveness for unlogged (N15) and logged (B1) forest.

	Unlogged	Logged
Total no. frogs caught in 2560 m^2	173	151
Density (no./64 m^2 plot)	4.3 ± 0.5	3.8 ± 0.6
Diversity H'	0.40	0.43
Evenness	0.47	0.51

4.3.3 *Discussion*

Amphibians are thought to be particularly sensitive to changes in microhabitat (Clarke, 1989;

Johns, 1985). However the findings from this short study indicate that in Budongo most species have survived the two logging events that have occurred in B1. It is hoped that a follow-up study could investigate seasonal variations in species in case some more susceptible species are only found during certain seasons.

4.4 Arthropods

4.4.1 *Methods*

As part of his PhD investigations into the diversity of arthropods in the tropical forests of Africa, Thomas Wagner spent from June to August 1994 collecting arthropods from trees in Budongo Forest. As many arthropod species are thought to be very specific to certain tree species he collected from the same tree species in logged and unlogged forest. Collections were made by insecticide fogging of the canopy of each tree, fogging for about 5 minutes with a Swingfog SN-50 and a solution of 1% pyrethrum. The dropping arthropods were collected in sheets covering an area of 16 m^2 under each tree. Eight trees of *C. alexandri*, *Trichilia rubescens*, and *Rinorea ardisiaeflora* were sampled in N15 (unlogged) and eight of each in N3 (logged). In addition eight *Rinorea ardisiaeflora* and eight *Teclea nobilis* were sampled in swamp forest. Arthropods were sorted into orders and in the case of beetles they were morphotyped under each family.

4.4.2 *Results*

The following results were taken from a preliminary report by Thomas Wagner sent to the Budongo Forest Project, some of which was presented at the International Congress of Ecology in 1996. On all 64 trees sampled about 130,000 arthropods were found of which 30,000 were beetles. The species accumulation curves for beetles are still rising steeply after 8 trees have been sampled at each site and the curve still rises steeply if all 64 trees are combined. Figure 4.3 shows mean abundance of each arthropod order for each tree species in each compartment. This shows that the relative contributions of different orders is similar between logged and unlogged forest. Analysis of biomass showed that ants and Lepidoptera dominated the biomass of arthropods on all the trees.

Phytophagous beetles are thought to be very specialised on certain tree species (T.Wagner,

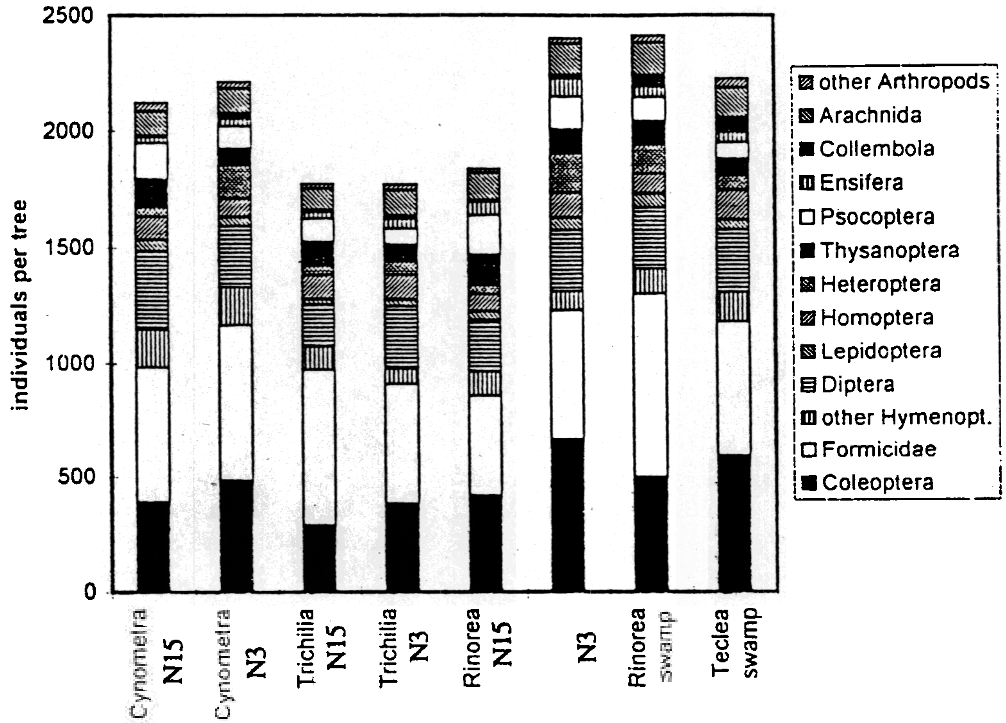

Figure 4.3 The abundance of arthropods on the investigated trees in primary forest (N15), logged forest (N3) and swamp forest (T. Wagner).

pers. comm.) and many are monophagous. When the number of Chrysomelid beetles were compared with the number in the families Lagriinae and Alleculinae, it was found that for all trees in unlogged forest the ratio of Chrysomelids to the Alleculinae/Lagriinae was high whilst in logged forest the ratio of Chrysomelids declined. It is thought from this result that the Chrysomelids are less specialised in Budongo forest than they are in Europe because many species were found on all tree species.

4.4.3 *Discussion*

Although these results are preliminary and further collections have recently been made in the dry season they do indicate that proportions of orders of arthropods do not change between logged and unlogged forest greatly. It is thought that phytophagous beetles are less dependent on one species of tree than they often are in Europe because of the much larger abundance of tree species in the tropics. However, this then begs the question; 'why there are so many beetle species in the tropics'. Future research will hopefully answer this question.

5. SEED DISPERSAL, GERMINATION, GROWTH AND MORTALITY OF TREES

5.1 Introduction

The role animals play in the natural regeneration of tropical forest is still poorly known despite much research in this area (Pannell, 1989; Howe, 1984). Apart from a few cases such as denuded islands (Whittaker & Jones, 1994) the importance of dispersers for regeneration is not known. It is still impossible to predict how a forest will change following changes in numbers of seed dispersers yet in the management of a forest for timber such as Budongo this is one of the crucial questions that needs to be answered (Pannell, 1989; Gorchov *et al.*, 1993). Do primates act as seed dispersers all the time or are they mainly seed predators in Budongo as has been found elsewhere (Gautier-Hion *et al.*, 1993)? How important are different species and how might changes in the habitat affect seed dispersal?

This chapter investigates the role of primates and birds as seed dispersers, how seed dispersal affects germination success and then goes on to investigate growth and mortality of trees and compares the findings with those of Douglas Sheil for the permanent plots in Budongo. This chapter provides results for parts of scientific objectives 4, 5 and 6.

5.2 Seed dispersal and germination success

5.2.1 *Methods*

Primate and bird diets

Primate and bird diets were studied with two methods: visual observation and faecal analysis. Both the feeding scans along transects in the eight compartments and the dawn to dusk follows were used to investigate what tree fruits are consumed and which parts of the fruit. In addition to the primates the following large frugivorous birds were studied: black and white casqued hornbill *Bycanistes subcylindricus*, white-thighed hornbill *Bycanistes cylindricus*, white-tailed hornbill *Bycanistes fistulator*, black-billed turaco *Tauraco schuetti*, and great blue turaco *Corythaeola cristata*.

Faecal samples were collected from the monkeys and chimpanzees followed from dawn to dusk, washed and sieved and all seeds counted. Those seeds that were very abundant such as figs were counted by counting seeds in a sector of the sieve and multiplying the number obtained by the number of possible sectors required to cover the sieve. In addition the presence of flesh/bones and worms were noted and areas of bark and leaves were measured by counting the number of approximately 1 cm^2 sized pieces in the faeces. Chimpanzee faecal samples were also collected from two ecotourism sites, one in the west of the forest at Busingoro (compartments B1-B3 and S8) and one in the east at Kaniyo Pabidi (compartments K11-13). Samples were collected each month between October 1995 and October 1996 for chimpanzees and between January 1995 and December 1995 for monkeys. Faecal samples from birds caught in mist nets (section 4.2) were also analysed for seeds.

Seed germination

For several species of tree, seeds that had passed through the gut of a chimpanzee were collected and planted in pots. Seeds of the same tree that had also fallen to the ground in ripe fruits were also planted in pots. In the case of these seeds they were planted with their fruit casing as this is how they would have to germinate naturally (for those species with several seeds in one fruit one seed was removed with some of the fruit flesh around it and planted). For each species of tree 50 fruits from dung and 50 fallen from the tree were planted at around the same time (within 3 days of each other). Pots were kept damp in a store room and the germination success measured by counting the number of seedlings that appeared up to 6 months post planting.

5.2.2 *Results*

Seed dispersal by primates and birds

Table 5.1 lists the fruits seen to be eaten by primates, hornbills and turacos from the transects in the eight compartments and from the dawn to dusk follows. Turacos probably eat a greater variety of fruits but observations were not many for these species (n=30). This table show that a large number of tree species have fruits eaten by primates and birds and many are eaten at ripe and unripe stages by primates.

Table 5.1 All fruits that were observed to be eaten by primates and large frugivorous birds. The ripeness of the fruit and part of the fruit if not all of it is eaten is recorded as follows: R=ripe; U=unripe; U/R= both ripe and unripe; S=seeds only.

	Blue monkey	Redtail monkey	Colobus monkey	Chimpanzee	Hornbills	Turacos
Transect scans:	3,458	1,988	1,389	127	736	30
Follows scans:	11,757	8,485	8,501	4,262		
Alaphia landolphioides	R	-	-	U/R		
Alstonia boonei	U/R	U/R	-	-		
Aningeria altissima	U/R	U/R	U/R	U/R	-	-
Antiaris toxicaria	U/R	U/R	-	-	U/R	U
Bosqueia phoberos	U/R	U/R	U/R	-	U/R	U
Broussonetia papyrifera	U/R	U/R	R	-	U/R	
Caloncoba schweinfurthii	R	U/R	R	R	-	-
Celtis durandii	U/R	U/R	U/R	U/R	R	U/R
Celtis mildbraedii	U/R	U/R	U/R	U/R	U/R	U/R
Celtis wightii	R	-	-	-	-	-
Celtis zenkeri	U/R	U/R	U	U/R	U/R	R
Chrysophyllum albidum	U/R	U/R	U/R	R		
C.perpulchrum	R	R	-	-	-	-
C.murense	U/R	U/R	R	R	-	-
Cleistophollis patens	U/R	U/R	U/R	U/R	R	U
Cola gigantea	R	-	U	-		
Cordia millenii	U/R	U	-	U/R	-	
Crossonephelis africana	U/R	-	-	-	-	
Croton macrostachys	U/R	U/R	U/R	R	R	
Cynometra alexandrii	S	S	S	S		
Desplatsia dewevrei	-	-	-	U/R		
Entandrophragma utile	U	-				
Erythrophleum suaveolens	U/R	U/R	U/R	-		
Ficus barteri	-	-	-	U/R		
Ficus exasperata	U/R	U/R	U/R	U/R	U/R	U/R
F. mucuso	U/R	-	-	U/R	R	
F. natalensis	U/R	R	-	U/R	U/R	
F. polita	U/R	U/R	U	U	R	
F. sansibarica	U/R	U/R	U	U/R	R	
F. saussureana	U/R	-	-	U/R	R	
F. sur	U/R	U/R	U/R	U/R	U/R	
F. thonningii	-	-	-	U/R		
F. varifolia	-	-	-	U		
Funtumia africana	S	-	S			
F. elastica	S	S	S	-	-	
Guarea cedrata	R	U/R	-	-	U/R	
Klainedoxa gabunensis	U/R	-	-	U/R	-	
Lannea welwitschii	-	-	-	R	R	
Lasiodiscus mildbraedii	U/R	U/R	U	R	-	-
Maesopsis eminii	U/R	U/R	U/R	U/R	U/R	R
Manilkara dawei	U	U	-	-	-	

	Blue monkey	Redtail monkey	Colobus monkey	Chimpanzee	Hornbills	Turacos
Margaritaria discoidea	U/R	U/R	U/R			R
Mildbraediodendron excellsum	U/R	U/R	U/R	U/R		
Milicia excelsa	-	-	-	U/R		
Mimusops bagshawei	U	-	-	R		
Morus lactea	U/R	U/R	U	U/R		
Myrianthus holstii	R	U/R	-	R	-	-
Olea welwitschii	U/R	U/R	-	-	R	U
Psidium guajava	U	U	-	-	-	-
Pseudospondias microcarpa	U/R	U/R	-	R	U/R	-
Raphia farinosa	-	-	-	R		
Ricinodendron heudelotii	U/R	U/R	U	-		
Schrebera arborea	-	-	U	-		
Strychnos mitis	R	R	R	R		
Tapura fischeri	U/R	U/R	R	-		
Tabernaemontana pachysiphon	U	U	-	-		
Trichilia dregeana	U/R	-	-	-		
Tetrapleura tetraptera	U/R	U	U/R	-		
Tetrorchidium didymostemon	-	U	-	-		
Uvariopsis congensis	-	-	-	R		

Ideally a tree wants its fruits eaten when they are ripe and are ready for dispersal. Figures 3.8-3.11 show the proportions of ripe and unripe fruit in the monkeys diets and show that more ripe fruit tends to be consumed by blue and redtail monkeys in logged forest. Hence less seed predation and more dispersal is occurring in logged forest by these species. Figure 5.1 shows the diet of the habituated chimpanzee community between December 1994 and December 1996. This shows that ripe fruit forms over 50% of the diet for much of the time except during the December-February dry season. During December-February 1994/5 *C. alexandri* failed to fruit and more unripe fruit was consumed than in the same period during 1995/96 when *Cynometra* seeds formed a large part of the diet.

Chimpanzees in this community rarely eat terrestrial herbaceous vegetation (THV) which is considered to be a fall-back food in times of low fruit availability (Wrangham *et al.*, 1996). A measure of THV availability was obtained by counting stems of Marantaceae and Zingiberaceae in fifteen 20 m strip transects of 1m width. each transect was located in a stratified random manner within the trail system of the main study area. In addition three 20

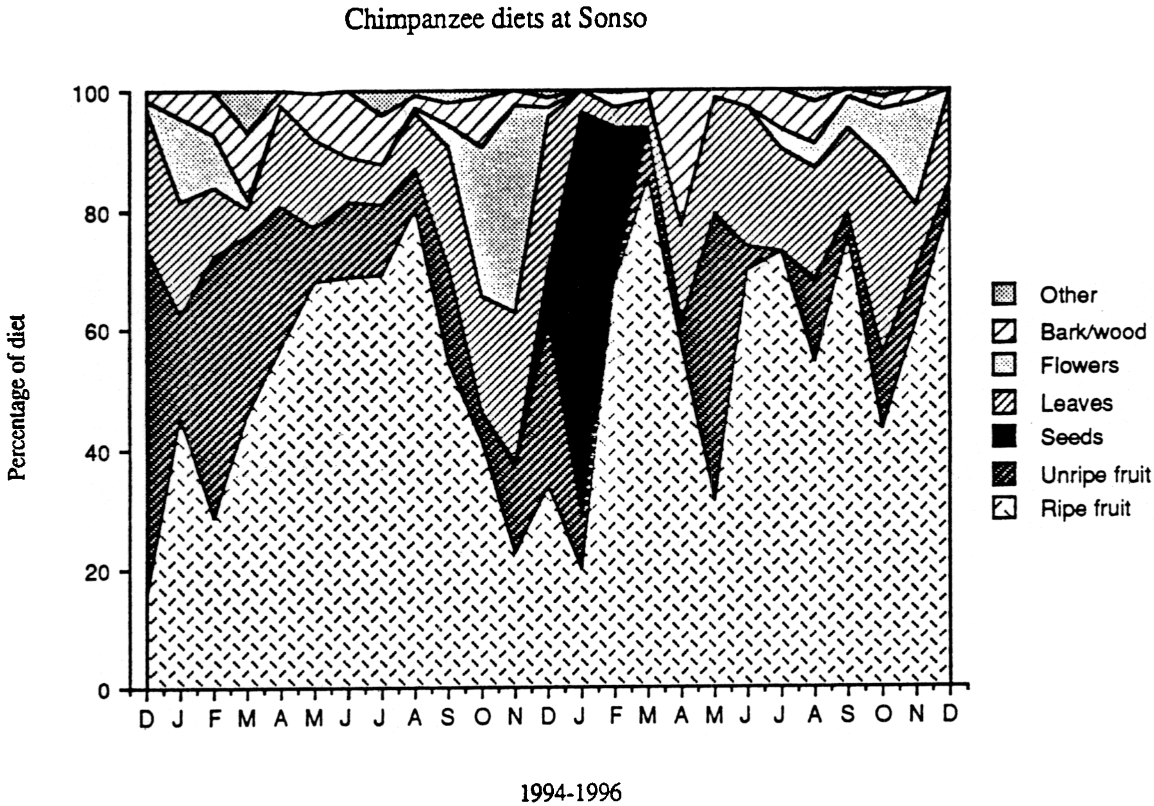

Figure 5.1 The monthly percentage of plant parts consumed by the habituated chimpanzee community at Sonso between December 1994 and December 1996. Data are from 30 minute scans of dawn to dusk follows.

metre transects were measured in swampy areas where THV was abundant. Table 5.2 compares the stem densities in Budongo with those found at other chimpanzee and bonobo sites (Wrangham *et al.*, 1993a; Malenky & Wrangham, 1994). Whilst availability is lower than at other sites it is not so low that they are prevented from consuming THV. Therefore it is concluded that the chimpanzees in Budongo are living in a particularly rich habitat in terms of fruit availability.

Table 5.2 Measures of THV stem density in Budongo Forest and comparisons with other forests. Availability=measure of stem density in study area; swamp=measure of stem density in swampy areas.

	Marantaceae	Zingiberaceae	Total
Budongo, Uganda			
availability	0.22	0.08	0.37
swamp	6.30	3.65	10.05
Kibale, Uganda			
availability	0.04	0.37	0.67
swamp	0.00	18.88	18.94
Lomako, Zaire			
availability			1.06

The results of the faecal analysis showed that more seeds and more species passed through the guts of chimpanzees than the monkeys. Table 5.3 compares the average number of seeds per sample for monkeys in N15 (unlogged) and N3 (logged) and table 5.4 compares the average number of seeds in chimpanzee faeces in the three sites where faeces were collected. Mann-Whitney U tests of the mean number of seeds per dung sample between logged and unlogged forest are significant for all monkeys (Blue: $U=378.5$, $P<0.001$; Redtail: $U=191.0$, $P<0.001$; Colobus: $U=597.0$, $P<0.01$).

Kruskall-Wallace analyses of variance of the number of seeds, leaf area and bark area per chimpanzee faecal sample between the three sites in Budongo are all significant (seeds: $X^2=206.3$, $P<0.001$; leaf area: $X^2= 129.3$, $P<0.001$; bark area: $X^2=171.2$, $P<0.001$). If trees that produce lots of tiny seeds such as figs and *Broussonetia* are removed from the total then there are no significant differences between mean seed number per sample in different sites ($X^2=2.85$, P=ns). It can be seen from the total numbers of seeds per dung sample that chimpanzees disperse considerably more seeds than monkeys.

Table 5.3 The average number of seeds per sample of faeces for three monkey species in unlogged (N15) and logged (N3) forest.

	Blue		Redtail		Colobus	
	N15	N3	N15	N3	N15	N3
Samples	32	47	19	42	29	62
Alaphia l.	0.3	0.1			-	
Bequartiodendron o.	0.1	-		-	0.1	-
Broussonetia p.	-	29.6		17.9	-	6.9
Celtis durandii	-	-	-	0.1	0.1	1.1
Climbers (unknown)	0.1	0.7	0.2	0.2	-	0.1
Figs	-	49.7	5.2	32.1	5.2	3.0
Margaritaria d.	0.7	3.4	0.7	4.3	0.7	4.6
Tapura fischeri	-	0.2	-	0.3	-	0.2
Unknown trees	5.4	-	0.1	0.1	0.5	10.1
Total	6.6	83.7	6.2	55.0	6.6	26.0

Table 5.4 The average number of seeds per faecal sample for chimpanzees in three sites in Budongo Forest: Sonso (N2-4), Busingoro (B1-3, S8) and Kaniyo Pabidi (K11-13). The mean area of leaf and bark material and the percentage of samples with worms and flesh/bones are also given.

	Busingiro	Sonso	Kaniyo Pabidi
Samples:	374	248	371
Aningeria altissima	0.01	-	
Afromomum spp.	2.36	0.11	
Alaphia landolphoides	0.15	5.15	
Antiaris toxicaria	0.27	1.94	-
Balsamocitrus dawei	-	-	0.03
Broussonetia papyerifera		585.18	-
Caloncoba scweinfurthii	-	0.01	0.11
Celtis durandii	0.58	0.39	0.01
Celtis mildbraedii	-	0.21	2.30
Celtis wightii		-	0.01
Chrysophylum albidum	-	0.01	0.42
Chrysophyllum spp.	3.05	0.09	0.64

	Busingiro	Sonso	Kaniyo Pabidi
Chrysophyllum murense	-	-	0.24
Cleistophollis patens	0.01	0.67	
Coffea spp.	-	-	4.63
Cola gigantea	-	-	0.11
Cordia millenii	0.10	0.23	0.08
Croton macrostachys	0.47	-	-
Ekbergia senegalensis	-		0.94
Erythrophleum suaveolens	-	-	0.04
Figs	2323.70	8330.21	1091.73
Grewia sp.	-	-	5.97
Maesopsis eminii	1.34	1.23	0.18
Mimusops bagshawei	0.16	0.23	-
Milbraediodendron excels.	-	-	0.33
Monodora angolensis	-	0.56	
Morus lactea	61.67		
Myrianthus holstii	2.25	2.17	
Olea welwitschii	0.24		
Psidium guava	1.86	-	
Pseudospondias microcarpa	0.72	0.83	-
Rubus spp.	-	-	2.98
Sterculia dawei			0.22
Treculia africana	-		0.91
Tetrapleura tetraptera	0.01		-
Uvariopsis congensis	-		18.76
Vitex doniana	0.16	-	0.02
Unknown seeds	1.88	2.35	13.43
Total	2401.40	8942.63	1146.50
Leaf area (cm^2)	3.70	1.11	8.40
Bark area (cm^2)	1.56	1.10	1.50
% samples with worms	22.0	2.0	0.0
% samples with flesh	5.0	2.0	0.0

Seed germination trials

Table 5.5 gives the results of seed germination trials for selected tree species. This study is ongoing and more species are currently planted. So far it appears that more seeds that have passed through the gut of a chimpanzee germinate than those that have fallen from the tree for most species.

Table 5.5 The number of seeds that successfully germinated comparing those ingested by chimpanzees and those that fell from trees.

	Fallen from tree	Ingested
Broussonetia papyerifera	0	5
Myrianthus holstii	2	31
Uvariopsis congensis	50	49
Pseudospondias microcarpa	7	19
Ficus mucuso	0	0
Maesopsis eminii	0	1
Cordia millenii	5	23

5.2.3 *Discussion*

Monkeys in logged forest are more frugivorous and hence disperse more seeds in their faeces. However, monkeys in logged forest also have smaller ranges and cannot travel as far as those in unlogged forest. Table 3.7 showed that the range span is smaller in N3 than in N15 for all monkey species. Consequently there is a trade-off as far as a tree is concerned between increased seed ingestion and smaller potential dispersal distances. Monkeys will also disperse some seeds by storing them in cheek pouches and spitting them out later (Corlett & Lucas, 1990) but dispersal distances are likely to be less far with this method.

Chimpanzees have the potential to range much more widely with a probable range span of at least 4 km for the Sonso community. Birds, particularly large birds such as the hornbills and turacos, also range widely and can disperse seeds even further than chimpanzees. However, they do not disperse the quantity of seeds that chimpanzees do. Some seeds of figs and *Celtis durandii* were found in faecal samples from smaller birds caught in the mistnets (particularly greenbuls) but numbers of seeds were few. Consequently chimpanzees are likely to be much more important for seed dispersal than the monkeys or the birds. This was also the conclusion reached by Wrangham *et al.* (1994) for Kibale Forest. The number of seeds defaecated by chimpanzees in Kibale was 22 per defaecation (excluding very abundant small seeds 'hereas was 96.5 for B giro for Sonso and 7 for Kaniyo Pabidi whe figs and *B netia* uded. Similarl the number of seeds per sampl for monkeys bi ed 7 per sampl for Kibale whi :h is ower than the bers found for monkey in Budongo (excludin figs and *B oussonetia*) Consequently seed dispersal by primates is greater in Budongo than in Kibale.

M seeds germinate when they have passed through the gut of chimpanzee as found in Kibal (Wrangham *al.*, 994) Whether this increased germination is actually beneficial for the seedl gs r.eeds to be tested. pos ble th seeds germinate from du at th do not the ong-term survival of the seedling. Clumps of seedlings found du ay attract seedlin predators (Willson & Whelan, 990) suffer from heavy competi between seedlings for vailable utrients.

Growth morta ty of trees

5. *Introduc and Methods*

heil (99 analysed the long-term growth da from c2 hectare permanent plots established 93 W.J. Eggeling (Eggeling, 94 '). In brief his findings concurred with ggeli model of fore succession from colonisin forest mixed forest and then to *Cynometra* forest in the past for Budongo. Poachin of elephants occurred Murchi Falls during the 970s ir the Uganda Forest Departments policy of cullin elephants in Budongo Forest durin the 960s heil believes that the succession may be changing with the loss of elephants. La *et al.* (:97 were the first to ggest that the *Cynometra* domin ted forest may be elephan induced climax vegetation type. heil (1996) showed that the pl in udongo how high recruitmen wh is thought to be mature mixed forest. He attributes this to greater survival of young stems following the loss of elephants from Budongo The five plots hei analysed are all in the west of the forest and ured at intermitten intervals since 933. This study aimed to complemen his analysi of growth in the large plots by analysin the growth rates of trees in several differen areas of the forest and also to vestigate the causes of mortality of trees.

T tha marked for phenology (tion .2) in the radius ular plots 00 m intervals along the transects were also measured and marked for growth measurements during 1992. All plots were visited and trees remeasured in 1996. Measurements were made using diameter tapes above painted marks. In 1992 every tree was given one of Dawkin's crown and liana scores (Alder & Synnott, 1992) and analyses were made of the differences in growth for trees with different scores. As these trees were visited at monthly intervals during 1993 in all compartments, and from 1993 to the present for N15 and N3, it was possible to determine the causes of mortality for each tree that died. Causes of mortality were allocated as follows:

1. Felled by man
2. Killed by tree felled by man
3. Killed by falling tree or branch (natural cause of death)
4. Killed by competition/climbers/rot/wind - tree died of natural causes.

5.3.2 *Results*

Growth

All trees over 10 cm DBH were measured and marked in 820 plots covering an area of about 12.6 ha. There is still much to analyse on the growth data but some preliminary findings are presented here. An analysis of variance of increment per year of trees with different Dawkins crown position was highly significant ($F=113.44$, $P<0.001$) as was a comparison of growth of trees with different liana scores ($F=15.74$, $P<0.001$). Table 5.6 gives the mean increment per year for the different scores and where the differences lie.

Analysis of increment in different forest types also shows significant differences ($F=35.13$, $P<0.001$). *Cynometra* forest has the slowest average increment per tree with swamp forest having the highest: *Cynometra*: 0.25; *Cynometra*-mixed: 0.26; mixed: 0.33; colonising: 0.33; swamp: 0.70 (swamp is significantly different to the others; mixed is significantly larger than *Cynometra* and *Cynometra*-mixed). These values do include growth from all sizes of tree as do the ones in Table 5.6 and species will differ in the different forest types, so care must be taken before extrapolating these values too far. Sheil (1996) found that there was a lot of variation around mean growth rates of particular diameter classes for each species of tree and that the means did not vary greatly between diameter classes over 10 cm DBH. Therefore

Table 5.6 Growth increment (cm per year) for trees with different crown position and liana scores. Those values with different superscripts are significantly different.

Score	Crown position	Liana score
1	0.22[a]	0.32[a]
2	0.28[b]	0.34[a]
3	0.39[c]	0.24[b]
4	0.52[d]	0.19[b]
5	0.50[d]	

Crown position: 1=no direct light; 2=some side light; 3=vertical light; 4=vertical & side light; 5=emergent (all round light)
Liana score: 1=no lianas; 2=lianas on stem; 3=lianas in crown; 4=lianas covering crown.

trees in the older *Cynometra* dominated forest probably do grow more slowly than those in younger mixed and colonising forest. This is similar to the findings of Chapman and Chapman (1990) for growth in mature vs successional forest in Costa Rica. Why growth in swamp forest is so high relative to the others is unclear.

Mortality

Table 5.7 shows the percentage of trees that died and the cause of mortality for each compartment and forest type. Forest type is not independent of compartment because unlogged forest has more *Cynometra* dominated forest but it gives an approximate measure of mortality. These results show that the average tree in the *Cynometra* dominated forest tends to grow more slowly but also it is less likely to die from natural causes (competition/rot/climbers/wind). Van der Meer & Bongers (1996) studied mortality over the period of 1 year (instead of 3.5 years) in French Guiana and found percentage mortality to be 0.4% for natural deaths and 1.1% for tree or branch falls. If these values are multiplied by 3.5 then natural mortality is lower than in Budongo (1.4%) but mortality due to treefalls/branch falls is higher (3.9%). Further data analysis will investigate growth and mortality in Budongo Forest in further detail and will test for differences between the percentage mortality figures in Table 5.7.

Table 5.7 The percentage of trees that died in the seven metre radius permanent plots giving the approximate causes of death. See text for definitions of mortality

Compartment	Harvesting mortality Direct felling	 Killed by felled tree	Natural mortality Competition or rot	 Killed by falling tree
Controls				
N15			3.2	3.1
K11-13			3.4	0.7
N3			5.1	2.3
Pitsawn				
B1	0.5	0	3.4	4.4
B4	1.4	0.4	4.7	4.1
N11	1.3	2.0	4.5	1.0
W21	1.4	1.6	5.0	3.7
Mechanically				
K4	2.0	2.7	2.1	1.5
Cynometra	0.2	1.6	2.7	1.1
Cynometra-mixed	0.6	0.7	3.5	0.9
Mixed	1.0	0.9	4.1	1.2
Colonising	1.4	0	7.4	2.3
Swamp	0.9	0	6.9	0.9

In addition to mortality on the plots measures of harvesting intensity were made by counting the number of mature mahoganies felled visible from the censusing transects. Perpendicular distances from the transect to the felled stump were used to calculate densities using DISTANCE (Buckland *et al.*, 1993). The main purpose of this exercise was to estimate the impact of illegal harvesting of mahogany on the crop of mature mahoganies determined in an inventory made by the Forest department in 1990. The two main study areas N15 and N3 were excluded from the density estimate because these had been extensively patrolled to keep illegal pitsawyers out. W21 was also excluded because it had been designated as a legal pitsawing concession. The density of illegally felled mature mahogany was 31 ($\pm$ 10) trees per km^2. The 1990 inventory gave a value of 71 mature mahoganies per km^2 for the forest, however this value included the protected areas such as the N15 Nature Reserve. If protected areas are excluded the value drops to 61. Given that there have been two tourism projects in B1, B4 and K11-13 which have also patrolled for pitsawyers and the fact that regular visits to other sites by Budongo forest project staff will have deterred pitsawyers to some extent from these areas this value of 31 trees removed out of 61 is likely to be on the low side. These estimates are crude but show that illegal pitsawing since 1992 has had a considerable impact on the available timber stock in Budongo. Much of this illegal harvesting can be attributed to lack of control by the Forest Department. Since early 1996 the Forest Department have deployed a new District Forest Officer and Forest Officer who have been cracking down on illegal pitsawing. It is hoped that this continues. It is recommended that another inventory of Budongo is made in the near future and that the current levels of harvesting are reduced. It is unlikely that Budongo can support the 3 sawmills and two pitsawing concessions that currently exist, particularly if they were to work at full capacity and it would be better to close down some of the sawmills which are currently hardly operating before they invest in new machinery

6. A MODEL OF THE EFFECTS OF LOGGING ON WILDLIFE IN MONODOMINANT FORESTS

6.1 Introduction

One of the main objectives of this second phase of ODA support to the Budongo Forest Project was to develop a general model that is capable of predicting the responses of wildlife to selective logging in Budongo Forest and also to test this model in monodominant *Gilbertiodendron* forest in Zaire. One of the main criticisms that can be levelled at the findings from this study in Budongo Forest is that it is not representative of other forests. Budongo lies at the north eastern extreme of a line of forests which occur down western Uganda and probably is a remnant of the eastern limit of the last forest expansion when the climate was wetter and warmer (Kingdon, 1990). Consequently it may have a tendency to contain those species that were able to colonise new areas rapidly. In addition, Budongo can be thought of as an island of forest amongst grassland and cultivation and edge effects on species composition could be important in determining what exists there today. Therefore mature forest in Budongo may have those species that are ideally adapted to disturbance.

This chapter describes a simple model of the effects of selective logging in monodominant forest on primates and birds and then tests the model in the Ituri Forest in eastern Zaire. Results of objectives 3 and part of 4 are presented here.

6.2 A model for Budongo

Figure 6.1 gives a schematic diagram of the model and looks at two possible scenarios: a. if logging removes the monodominant tree species and b. if the monodominant species is not removed. This model assumes that man does not settle in the logged area and does not hunt in it either.

6.2.1 *Monodominant species not removed*

Monodominant forests have been defined as those where over 50% (Connell & Lowman, 1989) or over 80% (Hart *et al.*, 1989) of the canopy trees are one species. If the monodominant species is not removed then gap sizes created by logging are necessarily going to be small and harvesting intensity will be light. Consequently the impact

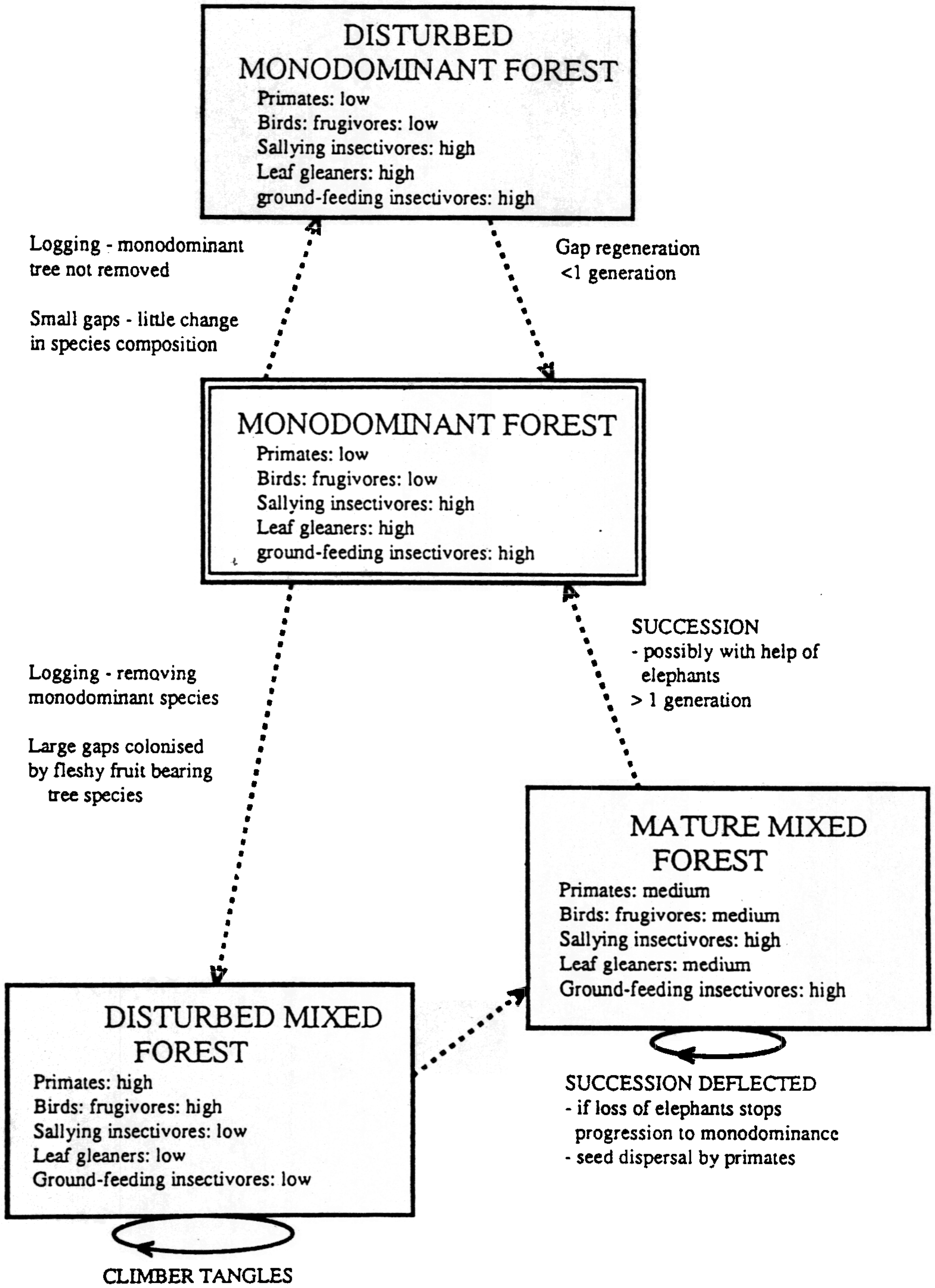

Figure 6.1 A flow diagram depicting the main aspects of the model which predicts how a monodominant forest would change following logging disturbance and how primate and bird populations would change. See text for explanation of model.

on the forest will not be very high and may not be very different to the natural pattern of tree falls. Hart (1995) showed that in monodominant *Gilbertiodendron dewevrei* forest seedlings of this species could survive for many years (49% survived 10 years) in the understorey waiting for a gap to grow into. Regeneration in gaps is likely to be composed of many seedlings and saplings of the monodominant species if this is the case and the forest composition is unlikely to change greatly. Return to mature monodominant forest structure will probably be less than the time for one generation of the monodominant species. Consequently it is predicted that primate and bird populations will not change very much.

6.2.2 *Monodominant species removed*

If the monodominant species is removed, either by arboricide treatment as occurred in Budongo during the 1950s and 60s or by harvesting it for timber as currently occurs in Budongo by one sawmill, then much larger gaps will be created and the composition of the forest will change. Larger gaps will encourage quicker growing light-dependent species which will compete more effectively with the seedlings of the monodominant species in the gap. Consequently a disturbed mixed forest will be created.

Given that monodominant forests in Africa and elsewhere are dominated by trees in the predominantly pod bearing Leguminosae (Connell & Lowman, 1989), removal of monodominance is likely to increase the availability of trees producing fleshy fruits. This will lead to increased populations of frugivores (both primates and birds) over time as these trees grow in the gaps and start to bear fruit.

The creation of large gaps will lead to dense foliage in the forest understorey which will have effects on the bird species that respond to forest structure. Table 4.6 showed that sallying insectivores and terrestrial insectivores were negatively correlated with dense vegetation in the understorey and consequently their populations will drop soon after logging. Foliage gleaning insectivores will also decrease following the loss of *Cynometra* forest (Table 4.6).

Climbers increase in number in disturbed forest and can take over large gaps in the forest. There are some large areas in Budongo which have not shown any recovery between 1992 and 1996 where climbers have smothered the vegetation. Other more recent logged sites are already regenerating and saplings are higher in these sites than in the climber [illegible] Climber cutting used to be carried out in the past in Budongo (Philip, 1964) to encourage natural regeneration. [illegible] in chapter 5 to sign[illegible]tly [illegible] the growth rates of trees in Budongo if they get into the canopy. Consequently climbers can slow down forest recovery considerably and will act as a negative feedback where they occur, maintaining the forest in a disturbed state.

The forest understorey will remain fairly dense for many years. Even after 45 years post logging in Budongo Forest [illegible] structure i[illegible] [illegible] to mature [illegible] Gradually however, the forest will become mature, forming a mature [illegible] and frugivorous bird numbers will remain relatively high in comparison [illegible] monodominant forest. Sallying and terrestrial insectivores will become more common [illegible] approaches a more closed canopy and open understorey. Leaf gleaning insectivores Budongo will remain low however, because of the preference for *Cynometra* forest.

[illegible] remain [illegible] several generations or even indefinitely [illegible] monodominance are. If [illegible]nonodominance is a deflected succession [illegible] elephants selectively feeding on young saplings of certain trees, the loss of the elephants [illegible]tenance of mature mixed forest. The Uganda F[illegible]t's 1990 in[illegible] *C[illegible]ometra* is still one of the most [illegible] trees in [illegible] treated compartments [illegible] even [illegible] elephants have been absent for most [illegible]tment. We [illegible] remain to be convinced that *Cynometra* monodominance [illegible] importance of primates and to some extent frugivorous birds in seed d[illegible] will slow down the progression to monodominant [illegible]g and p[illegible]g germination of seeds of trees bearing fleshy fruits. Thus large herbi[illegible]ores act as a negative f[illegible] monodominance.

[illegible] monodomin[illegible] superior competi[illegible] monodominan[illegible] [illegible]inant [illegible]. This will probably take several generations. As growth rates of trees in Budongo are between 0.2-0.7 cm DBH increment per year (Sheil, 1996; chapter 5) a tree of 70 cm DBH will have taken about 140 years to reach that girth. *Cynometra* trees can reach over 1 m in diameter and probably last between 150 and 200 years before they die of old age. Therefore recovery of monodominant forest will take this sort of timescale.

Tropical forests however, are not stable systems. Hart *et al.* (in press) showed that for the past 4,000 years the Ituri Forest has changed in species composition, often quite dramatically. *Gilbertiodendron dewevrei* which now is monodominant over much of the southern Ituri was not found in this area earlier than about 500 years ago. Trees that were very abundant in the past are now rare. Consequently, although this model predicts a return to monodominant forest following heavy logging disturbance, the forest may vary in composition and even the monodominant species may differ.

6.3 Testing some aspects of the model

A test of this model's applicability to other monodominant forests was made in monodominant *Gilbertiodendron* forest. During February and March 1996 Dr Plumptre went with a Field Assistant (N. Mutungire) to the Ituri Forest in eastern Zaire to carry out a study of the bird communities in monodominant, mature mixed and secondary forest. Primate studies had already been made in this area (Thomas, 1991; J.Hart, unpublished) from which comparisons of primate responses could be made.

6.3.1 *The Ituri Forest*

The Ituri Forest is the name given to about 70,000 km^2 of tropical lowland forest in North-eastern Zaire which occurs in the watershed of the Ituri river. In 1992 over 13,000 km^2 of this region was designated as a Forest Reserve, the Réserve de Faune à Okapis. The Okapi Reserve lies between 1°N - 2° 29'N and 28°E-29°4'E and occurs between 700-1,000 metres altitude. The trans-african highway traverses this reserve and about 150 km from the forest edge lies the town of Epulu. Much of the research that has taken place in the Ituri Forest has been based at Epulu (Hart *et al.* in press, Hart J. 1986; Hart T. 1985, Hart J. 1978) and has lead to the creation of the Okapi Reserve (Stephenson & Newby, 1997).

Three main forest types are found in the Ituri as follows:

Monodominant forest

Large areas of the Ituri forest are dominated by one species of tree, *Gilbertiodendron dewevrei*, which can comprise over 75% of the individuals (Hart T. 1985). Most of the monodominant forest is found in the south of the Okapi Reserve (Wilkie, 1989).

Mixed forest

In the northern part of the Okapi reserve no single species of tree dominates but instead a mixed forest composed of a much higher diversity of species (per unit area) occurs. Here species such as *Cynometra alexandri*, *Julbernardia seretii* and *Brachystegia laurentii* are the more common trees. Disturbance from wind can be high in the mixed forest and may contribute to its maintenance, stalling a progression to monodominance.

Both monodominant forest and mixed forest is classed as primary forest and forms about 90% of the Okapi reserve (Wilkie, 1987; 1989).

Secondary forest

Along the trans-african highway and other roads leading from this one there is a strip of about 3 km width of secondary vegetation. This is due to the practice of shifting cultivation which occurs around the settlements along the roads. This vegetation varies from fields that are

resettled all villages within the forest along roads to allow them better control of the population and to provide labour to help build the roads (Tondeur and Bergeroo-Campagne 1955). This led to a more longterm method of shifting cultivation.

Agriculture in the Ituri is known as swidden horticulture and involves the cultivation of about 1 hectare of land per family per year. The forest is cleared to plant peanuts, cassava, sweet potatos, oil palms and bananas and after the first crop rice is then grown. The field is abandoned after 15 months and visited periodically for the next 1-5 years to harvest any remaining bananas or oil palm nuts. The land is then left for 15-20 years as fallow (Wilkie 1987).

Secondary forest forms about 6% of the Okapi reserve and agricultural land or plantations form another 2% (Wilkie, 1989).

6.3.2 *Methods*

Study areas

Three study sites (Figure 6.2) were selected to allow the comparison of the understorey bird communities in the three major vegetation types described in section 3.3.2. These were:

A.*Lenda*

The Lenda study site is about 10 km south of the trans-african highway at 1°19' N, 28°38' E and at an elevation of 770 metres. This site is the main research site for CEFRECOF in monodominant *Gilbertiodendron* forest. A grid system of trails at every 125 or 250 metres exists covering an area of about 11 km^2. The vegetation is typical of monodominant forest with a lower density of trees to the mixed forest, a dense canopy and a sparse understorey of herbs. The canopy trees are dominated by *Gilbertiodendron dewevrei* (about 80% of basal area of trees > 30cm DBH) with *Cynometra alexandri*, *Alstonia boonei* and *Julbernardia seretii* being the other most common species (Makana and Hart in press). The understorey trees are dominated by *Scaphopetalum dewevrei* (79% of stems), with *Drypetes bipendensis* and *Pancovia harmsiana* as the next most common species.

B. *Apharama*

The Apharama study site is about 25 km north of the trans-african highway at 1°33' N, 28°32' E and at an elevation of 800 metres. This site has been the focus of the Okapi research and consists of a trail system in a grid every 125/250/500 metres covering an area of about 45-50 km^2. The forest here has been disturbed by strong winds, causing many treefalls. For the purposes of this study areas where relatively intact forest was present were chosen for study. Due to the disturbance from wind the understorey here is not so open and the canopy is more broken. *Cynometra alexandri* dominates the canopy trees (about 40% of the basal area of trees >30cm DBH) with *Fagara macrophylla*, *Julbernardia seretii*, *Cleistanthus michelsonii* and *Canarium schweinfurthii* forming the next most abundant species (Makana and Hart in press). *Scaphopetalum dewevrei* once again is the most abundant understorey tree (63% of stems) with *Pancovia harmsiana* and *Diospyros bipendensis* as the next most common species (Makana and Hart in press).

C. *Babukeli*

The Babukeli study site is a recently established research site where CEFRECOF aims to investigate the effects of animals on the fields of the people who live at the village of Babukeli. The site consisted of several randomly placed transects perpendicular to the road which traversed farms, abandoned cultivation and secondary forest. The location of Babukeli is six kilometres east of Epulu (1°23' N, 28°35' E) on the trans-african highway. The trees that are commonly found in the secondary forest are *Musanga cercropioides*, *Croton macrostachys*, and *Trema orientalis*, with oil palms that have remained from abandoned fields.

Methods

At each site similar methods were used to allow comparison of the different forest types. We decided to concentrate on mistnetting of understorey birds rather than include point counts of all birds because of time constraints.

At each study site 15 nets of 14 metres length were sited at 50 metre intervals along grid trails or transects. A similar netting protocol was used as that in Budongo: the nets were opened at dawn (about 6.00 am) and checked at 30-45 minute intervals up to 12.15 pm. At this time the nets were closed and moved to the next transect position. At Lenda and Apharama netting was carried out for 11 days and at Babukeli for 10 days. Transects or trails used for netting were 1.5 km long and at least 250 metres apart. Nets were placed along the first 750 metres on the first day and then the second 750 metres on the subsequent day.

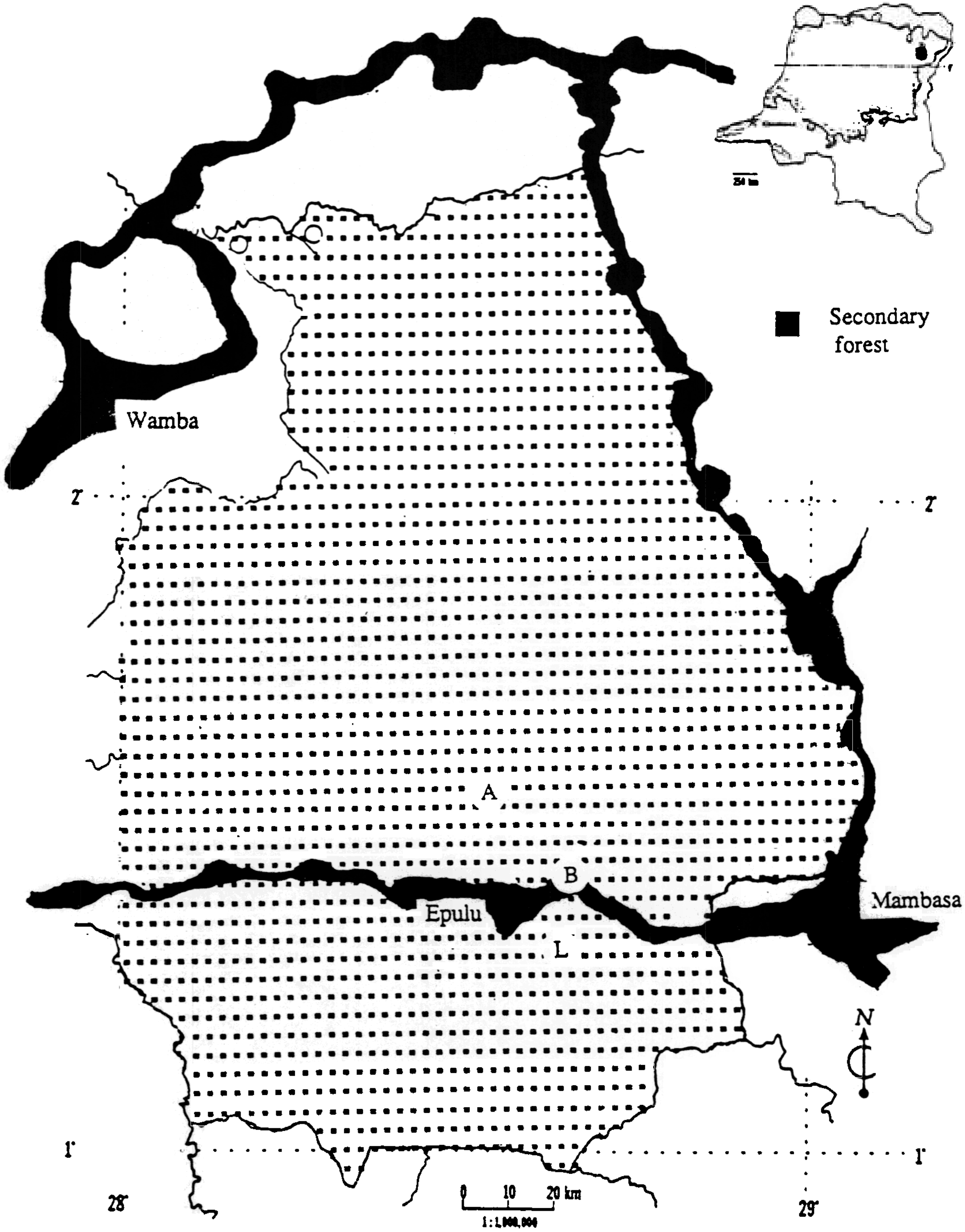

Figure 6.2 A map of the Okapi Reserve showing the locations of the three study sites (A=Apharama; B=Babukeli, L=Lenda). Secondary forest resulting from shifting cultivation is shown in black.

6.3.3 *Results*

Species caught

Appendix 3 gives the list of the species caught and the numbers of each species caught at each site. A total of 59 species were caught at all three sites and a total of 1,123 individuals.

The following seven species were new records for the Okapi Reserve : Chestnut-flanked Sparrowhawk (*Accipiter castanilius*), Black-eared Ground Thrush (*Zoothera camaronensis*), Crossley's Ground Thrush (*Zoothera crossleyi*), Forest Ground Thrush (*Zoothera oberlaenderi*), Chestnut-breasted Negrofinch (*Nigrita bicolor*), Northern-bearded Scrub Robin (*Cercotrichas leucosticta*) and Red-fronted Antpecker (*Parmoptila rubifrons*). However, none of these were particularly unusual records as they have been recorded in eastern Zaire before.

Community overlap

Table 6.1 gives the results of Horn's overlap index calculated on presence/absence of each species. The Secondary forest is most dissimilar to the monodominant forest which is probably a function of changes in forest structure.

Table 6.1 The overlap in species presence between the three bird communities calculated using Horn's overlap index.

	Monodominant	Mixed
Mixed	0.76	-
Secondary	0.49	0.53

Guilds

One way analysis of variance was used to test the differences between the mean daily capture percentages of each guild category between the three sites. Tukey's test was used to find where the differences lie. The secondary forest is significantly different to the two primary sites for four guild categories; Frugivore-insectivores ($F=14.94$, $P<0.001$; secondary > mixed, monodominant); Ground-feeding insectivores ($F=7.73$, $P<0.01$; mixed, monodominant >

secondary); Nectarivores (F=6.3, P<0.01; secondary > mixed, monodominant); Gramnivore-insectivores (F=7.09, P<0.01; monodominant > secondary, mixed). The high value for gramnivores in Lenda is attributable to Grant's bluebill (*Spermophaga poliogenys*) which may be more of a frugivore in this forest. Sallying insectivore catches did not differ significantly because of low sample sizes. If the total numbers caught are examined: monodominant:23, mixed: 18, secondary:8 it can be seen that there is a tendency for more sallying insectivores in mature forest.

6.3.4 *Discussion*

The results presented here show that shifting cultivation as it is currently practised in the Ituri Forest causes marked changes to the bird communities that live in this forest region. The overlap in species composition between the secondary forest and the two primary forest sites is much lower than the overlap between the two primary forest sites. This is despite the fact that the mixed forest site has a fair amount of disturbance from wind and contains a fairly broken canopy.

Species that seem to be particularly affected by disturbance include ground- feeding insectivores such as ground thrushes (*Zoothera*). Four ground thrushes were caught at Lenda and one at both the other sites, although the one at Babukeli was caught in a strip of mature riverine forest between secondary forest. During a major study of the birds in the forests of Uganda by the Uganda Forest Department with 1,210,978 metre-net-hours and 14,216 birds caught only three ground thrushes were captured, one black-eared ground thrush and two grey ground thrushes. In 158,508 mnh and after capturing 3,993 birds in Budongo Forest we have only caught one black-eared ground thrush which was in undisturbed forest. Consequently, the Ituri forest seems to be particularly rich for these species. At all the sites where they were captured the understorey was very open with a short herb layer of marantaceae and zingiberaceae up to a height of about 40 cm. These species are likely therefore to suffer from forest disturbance and this may be why they are so uncommon in the forests of Uganda. Brown chested alethes (*Alethe poliocephala*) also seem to require undisturbed forest and this is also true in Budongo Forest. Many frugivore-insectivores such as greenbuls on the other hand seem to do well in disturbed forest and some species in the Ituri only occurred in the disturbed secondary forest.

6.4 Comparisons with Budongo

The effects of disturbance in both forests produced similar results in terms of community changes. Certain sallying and ground-feeding insectivores were at lower numbers in disturbed forest whilst frugivores or frugivore-insectivores, mainly greenbuls, were at higher numbers. Most species of primates also increased in density in mixed and secondary forest in the Ituri (J. Hart, pers. comm.; Thomas, 1991). Only the owl-faced monkey *Cercopithecus hamlynii* may prefer monodominant forest, a possible consequence of leopard predation (J.Hart, pers. comm.). These primates forage on the ground a lot and are therefore at risk from leopards. Mature mixed forest was more similar in species composition to monodominant forest than secondary forest was in the Ituri.

Consequently the predictions of the model described above seem to hold for the Ituri Forest also. The few other studies of the effects of logging on birds in Africa also show similar responses to disturbance. Allport *et al.* (1989) showed that very disturbed forest (farm bush) in Sierra Leone had more frugivorous and gramnivorous birds and fewer leaf gleaning and ground-feeding insectivores. Logged forest was similar in bird community composition to primary forest but it is not clear how heavy the logging was. Dranzoa (1995) found that the biomasses of frugivore-insectivores and gramnivores were at higher density and sallying, bark gleaning and ground-feeding insectivores were at lower density in logged forest in Kibale Forest Reserve, Uganda. Arboreal foliage gleaners decreased in logged forest also, but understorey foliage gleaners increased. Neither of these studies was in monodominant forest, however, so it appears that disturbance of mature mixed forest can also cause similar changes in bird community composition. Primate responses in Kibale were variable, however, and the model does not appear to apply to these animals in mixed forest (Skorupa, 1988).

7. IMPLICATIONS FOR THE MANAGEMENT OF BUDONGO FOREST RESERVE

7.1 The importance nationally of Budongo Forest

Management of Uganda's forests for timber production and conservation goes back as far as the 1929 Forest Policy which recognised the importance of protecting forests for climatic reasons (Karani, 1994). The current policy aims to maintain and safe guard enough forest land so as to ensure that:

1.sufficient supplies of timber, fuel, pulp, paper and poles and other products are available in the long-term for the needs of the country, and where feasible export.

2. water supplies and soils are protected, plants and animals (including endangered ones) are conserved in natural ecosystems, and forests are also available for amenity and recreation (Howard, 1991).

Budongo Forest Reserve has always been one of the most important for timber production in Uganda and supplies quality mahogany timber favoured by timber merchants above that from elsewhere in the country. Budongo is also very important for conservation both nationally and globally. This study discovered that it has a reasonable population of Nahan's Francolin, an IUCN red data book species, and also the only east African population of Puvel's illadopsis. This study also discovered a new species of tree for the world in Budongo belonging to the Sapindaceae. Budongo probably has the largest chimpanzee population in Uganda (Edroma *et al.*, in prep.), and the Uganda Forest Department's inventory of Forest Reserves ranks it as one of the most important forests for biodiversity conservation in the country (P.Howard, pers. comm.). Consequently management of Budongo Forest must be well planned and properly implemented if both the timber production and conservation goals are to be achieved.

Recommendations for timber management and conservation that arise from our research in Budongo are presented here.

7.2 Recommendations for timber production and management

The findings of this report show that since 1992 Budongo Forest has lost at least half of the standing crop of mature mahoganies to illegal pitsawing activities in the production areas of the forest. Much of the illegal pitsawing went on because the Forest Department did not have complete control of the forest. With this illegal activity it was unlikely that any management recommendations would be implemented. Since early 1996, however, a new District Forest Officer, new Forest Officer have cracked down on illegal activities and with the support of Forest Department Headquarters established two legal pitsawing concessions to control this activity. Already much of the illegal pitsawing has been reduced. Consequently the possibility now exists to return Budongo to a system of long-term sustainable management. There are however, some difficult decisions that must be made.

- *Recommendation 1:* **There is a need to reduce the number of licensed people harvesting in Budongo.** The findings of this study and that of Sheil (1996) are that the growth rates of trees in Budongo are about 3-5 mm DBH increment per year. This is lower than the 8 mm assumed by Alder (1991) in his report on the Budongo Forest inventory. Although the difference between 5 and 8 mm does not sound much, over 50 years it can lead to a difference of 15 cm in tree diameters. Alder (1991) recommended that only one sawmill could be sustained by mahogany production at a volume of 1,000 m^3 per year and a maximum of 4,000 m^3 per annum could be achieved utilising *Cynometra*. Given that about half the mature mahoganies have been lost from the forest then this will be even less now. It is not possible for Budongo Forest to sustain three sawmills and two pitsawing concessions as currently exist now. If the Uganda Forest department is serious about managing this forest on a sustainable yield basis then they are going to have to take the hard decision to close down some of the legal felling that occurs.

- *Recommendation 2:* **Get the benefits from timber harvesting to the local community, by employing only local pitsawyers.** The Uganda Forest Department is to be commended for allowing Districts to keep the taxes collected from timber harvesting. The current pitsawing concessions in Budongo were established, partly to try and control the illegal pitsawing that was going on and also to provide some benefits to the local community. However, as it is currently practised, the people who cut the timber come from Kabale District in the south west of Uganda because they work harder. The only local benefit comes from portering out the planks of wood and the selling of food and alcohol to the pitsawyers. Local people have stated to researchers at Budongo that they are unhappy ıbout the 'imported' pitsawyers. It is likely that local pitsawyers will continue to illegally if they are not employed the legal corcessions the local communities will val the forest

R ommendation 3. **Stockmappin shoul mark trees that shoul be left to provi seed for natural regeneration.** Plumptre (.99) showed that mahogan trees do not produce fruit unti the are over 50 cm DBH and therefore if the Uganda Fores Department is rely natural regenerati it is vital that seed tree (of good genetic tock) left to provide seed. Species suc *Chrysophyllum Cordia, Maesopsis emini* and *Myrianthus holstı* importa species for chimpanzee as bein usefu secondary ımber species Seed hould be left for these species to aid regenerati and provide food for chımpanzees. Figs al important for prımates and birds bu very alu ble tımber th they unlikely be felled much. If they do become pop lar then seed trees should also be eft for these

Recommendatio 4 **Do not create large gaps wh felling trees by imiti the ımber ıf adjacen trees that be felled by using directional felling.** Large gap in Budongo h bee created in the pa and ha been smothered by climber gles and *Lantana* th generation is occurring. If more timber specie goin to be promoted U anda amongst timber sers (Kity & Plumptre, press then there is goin to be greater likelihood for large gaps to be created as more species are felled. A current tudy the Budongo Forest Project (F abweteera) investigatin the relation bet ga sıze and climber tangles and hopefully will produce recommendations th maxımum sıze of gaps that should be created. Until then probable rule of thum would be that than adjacen trees should be felled and that not more than 50% of the canopy should be destroyed.

R ndation **Consider some climber cutting aroun desirable trees.** Climbers severely reduced tree growth in thi study and can prevent generation altogether In addition when fellin trees the presence of limbers can ther adjacent tree to come do also creatin more damage Consequently the cuttin of climbers on mahoganıes might be desirable if it is possible to finance this. Climbers can provide food for primates and birds and should be left in protected areas and also on non-marketable tree species.

Recommendation 6: **Pitsawyers and sawmillers should have some training in reduced impact logging techniques.** Studies elsewhere have shown that certain felling techniques can significantly reduce the negative effects on the forest. These include directional felling, climber cutting before felling, planned cutting and processing, and planned road construction to minimise road length. It is recommended that pitsawyers and sawmillers have some training in these techniques and that the Forest Department monitors and enforces implementation of these techniques following the training sessions.

7.3 Recommendations for conservation

Budongo Forest has been found to contain more moth and tree species than any other forest in Uganda. It is also is in the top five forests for bird species and butterflies (P. Howard, pers. comm.). Three IUCN red data book species occur in the forest; the Chimpanzee and Nahan's Francolin, and the giant swallowtail butterfly *Papilio antimachus*. Efforts should be made to maintain viable populations of these two species. The Budongo Forest Project identified two sites as suitable for ecotourism in 1992 and these have since been established by the Uganda Forest Department with the help of VSO and the EC. These tourism areas with the nature reserves and the research area around the Budongo Forest Project site protect a reasonable area of Budongo. The ecotourism sites are also being used to educate local school children and village elders about the importance of conserving Budongo. The ecoutourism sites have recently contributed money to improve schools in the local communities around the forest.

- *Recommendation 1:* **Conserve wildlife in production as well as protected areas.** With the current zoning of Uganda's forest estate into nature reserves, buffer areas and production areas there is a danger that people will consider that conservation should be kept to the nature reserves and buffer areas. Many species require large areas to maintain a minimum viable population and this is certainly true for the chimpanzees in Budongo. There are several management practices that can be employed in production areas that can help conserve wildlife and in the small forests in Uganda these will be important if viable populations of species are to survive.

- Felling can be prohibited within 30 metres either side of streams - this will protect water sources and prevent soil erosion and also provide corridors for wildlife to move between protected areas.

limit the number of people in concessions so that disturbance to chimpanzees is minimised - this could be done by designating two days each week when portering and collecting of timber by lorries occurs. This would also help Forest Department staff patrol concessions and contain illegal activities.

- insist that pitsawyers dig proper latrines so that the risk of passing human diseases to primates is minimised.

- insist that pitsawyers do not set snares in the forest and link their licence to this so that they can lose it if snares are discovered in their coupe.

Recommendation 2: Cynometra **forest is important for the conservation of some species and care should be made to preserve it.** Both nature reserves and Kaniyo Pabidi (figure 1.1) protect areas of *Cynometra* forest. The open understorey in this forest type is important for ground-feeding and sallying insectivorous bird species such as the ground thrushes *Zoothera* spp. There is a danger that because this forest type has low diversity it will not be considered important. If this forest type is an elephant induced climax then positive management measures may be needed in the long-term future to maintain areas of this forest type.

- *Recommendation 3:* **Efforts must be made to protect the chimpanzees, Nahan's Francolin and *Papilio antimachus*.** These IUCN red data book species are classified as 'endangered' or data deficient and efforts must be made to ensure viable populations for these species. Chimpanzees are also important seed dispersers and probably encourage the natural regeneration and diversity of species found in Budongo. Both chimpanzees and Nahan's Francolin are found in logged and treated compartments and therefore can tolerate some forest disturbance but chimpanzees seem to be particularly vulnerable to the presence of humans in the forest (see above). Nahan's Francolin is vulnerable to trapping by hunters and pitsawyers setting traps for guineafowl and chimpanzees are vulnerable to traps set for antelope. The chimpanzee population and habitat viability assessment held in January 1997 (Edroma *et al.*, in prep.) showed that snaring could have a large impact on chimpanzee populations and was one of the main threats to their survival in Uganda. Currently about 20% of the Sonso community have snare injuries. Efforts must be made to limit the setting of snares in the forest through education and patrolling.

Recommendation 4: **Monitoring of populations of species should take place to see how they are changing and whether any are declining.** The repeated primate censuses carried out in this study should be continued and the bird point counts should be repeated in future at regular intervals so that populations can be monitored over time. Other species should be studied and monitored in future also. This can be carried out by the Budongo Forest Project and Makerere University.

7.4 Recommendations for research

This study has thrown up further questions as is the case with any research. The following are considered of importance for the management of Budongo:

- *Recommendation 1:* **Monitor the survival of seedlings germinating in dung of chimpanzees.** This study showed that germination was better if seeds had been ingested by chimpanzees. How does this affect survival of seedlings in the wild - does it really benefit them?
- *Recommendation 2:* **Study the recruitment of seedlings to the sapling and pole stage.** Much of the research on tree growth and mortality in Budongo has concentrated on mature trees or on seed dispersal and germination. Nothing is known about the process of seedling recruitment to the tree stage - what causes mortality and how can seedling survival be promoted for timber species?

Recommendation 3: **Study breeding of birds in Budongo.** As stated in chapter 4, bird densities may not reflect habitat requirements. What is important is to find out what their breeding requirements are and where they need to nest.

Recommendation 4: **Study the harvesting damage that is currently being created and find ways to minimise it if possible.** A start has been made on this already with a study of the relation between gap size and climber tangles. More can be done on harvesting and conversion methods to minimise the damage to the forest canopy.

- *Recommendation 5:* **Find out the ecological requirements of Nahan's Francolin and other rare species.** If the populations of these species are to be conserved then we must know something of their ecological requirements.
- *Recommendation 6:* **Investigate what the proximate causes are that encourage people to hunt and set snares in Budongo.** Why do people set snares for antelope in Budongo? Is it to obtain money, cultural reasons or is it simply due to poverty? What might be done to encourage hunters to stop their snaring in the forest?
- *Recommendation 7:* **Directors of research in Budongo Forest should have 6 monthly meetings with Uganda Forest Department Staff to present applied results of their research.** Feedback between staff of the Budongo Forest Project and the Uganda Forest Department has been good but not formalised. As more research takes place in Budongo we feel that it is important that regular meetings are had between this project and Forest Department staff (to include the DFO, FO and staff at Headquarters). This should also apply to FORI and Makerere University for their research in Budongo Forest. This should get the findings across to managers quickly.

7.5 Recommendations to funding agencies

Budongo Forest has passed through a period where management inputs have been low during the civil wars and afterwards. However, this forest now has a team of good staff who with a bit of encouragement could return Budongo to the level of long-term sustainable management that existed in the past. The process of encouraging community participation in the management of the forest and/or to receive benefits from the forest is fraught with potential problems. If the Forest Department in Masindi had the resources and manpower to patrol the forest effectively whilst changes in management practices took place it is likely that in future these requirements would not be so great once the local population have accepted the law and realise that the Forest Department wants them to benefit from the forest to some extent, without destroying it.

In the past finances to Budongo have been part of a much larger project (EC or World Bank) and have been channelled through the Forest Department Headquarters in Kampala. There have been problems with it arriving late or not getting through which have led to low motivation by Department staff in Masindi District. Ideally therefore a project would be established in Masindi under the Forest Department Office there, working with the District Forest Officer and reporting to Headquarters in Kampala. Budongo could be established as one of the 'Model Forests' under the Canadian scheme which aims to designate some sort of recognition status to well managed forests. This could provide some incentive to a donor organisation to put money into such a project.

8. ACHIEVEMENTS, PUBLICATIONS AND DISSEMINATION

8.1 Achievements

Besides the research in Budongo Forest, the Budongo Forest Project has been involved in training programmes, ecotourism and education. Several training programmes have occurred at the research site or have used the facilities there for field visits. These include:

1. Training courses in conservation for Forest Rangers and Officers which used the research site for field visits from the Nyabyeya Forest College. All Rangers and Officers in the Forest Department took these courses. Dr Plumptre and Mr Bakuneeta taught parts of the courses also.
2. Training of Makerere University graduates. Four Ugandan graduates carried out their fieldwork at the research site as part of their MSc degrees. All have obtained employment in jobs concerned with conservation and management of Natural Resources.
3. Training of ecotourism guides. All the guides at the two ecotourism sites came and spent two week at the research site to learn tree, bird and primate identification.
4. Training of zookeepers at the Entebbe Wildlife Education Centre. Several of the keepers at this Centre came for a weeks visit to Budongo to see chimpanzees in the wild so that they could relate the behaviours of the captive chimpanzees to wild ones.

The two ecotourism sites that were established in 1992 by the Budongo Forest Project with the help of EC funding have been managed since late 1992 by a Ugandan Tourism Development Officer, C.D. Langoya, and two British Volunteers, C. Herd and C. Long. These sites are both run by the local community and are monitored by Mr Langoya and Dr Long. Tourism is good although it does fluctuate depending on the security situation in the north.

Mr Bakuneeta has been involved in establishing some wildlife clubs in Masindi District, linked with the Wildlife Clubs of Uganda. He regularly attends meetings and gives talks at these.

8.2 Papers

The following publications have been produced in scientific journals or as theses by the project or by people working at the Budongo Forest Project field station.

Bakuneeta, C., Johnson, K., Plumptre, R. & Reynolds, V. (1995) Human uses of tree species whose seeds are dispersed by chimpanzees in the Budongo Forest, Uganda. *African Journal of Ecology* **33,** 276-278

Fairgrieve, C. (1995) *The comparative ecology of blue monkeys (*C. mitis stuhlmannii*) in logged and unlogged forest, Budongo Forest Reserve, Uganda.* Unpublished PhD thesis, Edinburgh University.

Hill, C.M. (1997) Crop raiding by wild vertebrates: the farmers perspective in an agricultural community in western Uganda. *International Journal of Pest Management* **43,** 77-84.

Johnson, K. (1993) *Local use of Budongo Forest's Products.* Unpublished MSc thesis, Oxford University.

Johnson, K. (1996) Local attitudes towards the Budongo Forest, western Uganda. *Indigenous Knowledge and Development Monitor* **4,** 31.

Johnson, K. (1996) Hunting in the Budongo Forest, Uganda. *Swara* **19,** 24-26.

Miller, P.L. (1993) Some dragonflies of the Budongo Forest, western Uganda (Odonata) *Opusc. Zool. Flumin.* **102,** 1-12

Miller, P.L. (1993) Fast, temperature-controlled colour changes in *Chlorocypha straeleni* Fraser (Zygoptera:Chlorocyphidae). *Notul. Odomatol.* **4,** 1-20.

Musamali, P.B. (1996) *The ecology, diversity and relative abundance of small mammals in primary and disturbed forest compartments of Budongo Forest Reserve.* Unpublished MSc thesis, Makerere University.

Owiunji, I. (1996) *The Long-Term Effects of Forest Management on the Bird Community of Budongo Forest Reserve, Uganda.* Unpublished MSc thesis, Makerere University.

Owiunji, I. (in press) Changes in avian communities of Budongo Forest Reserve after 70 years selective logging. *Proceedings of the Pan African Ornithological Congress.* Ghana.

Plumptre, A.J. (1995) The importance of "seed trees" for the natural regeneration of selectively logged tropical forest. *Commonwealth Forestry Review* **74,** 253-258.

Plumptre, A.J. (1996) Changes following sixty years of selective timber harvesting in the Budongo Forest Reserve, Uganda. *Forest Ecology and Management* **89,** 101-113

Plumptre, A.J. (1996) Two nests of Nahan's Francolin in the Budongo Forest Reserve, Uganda. *Bulletin of the African Bird Club* **3,** 37-38.

Plumptre, A.J. & Eilu, G. (1995) *Tropical rainforest regeneration in Uganda.* Proceedings of meeting held at Makerere University, April 1995.

Plumptre, A.J. & Reynolds, V. (1994) The impact of selective logging on the primate populations in the Budongo Forest Reserve, Uganda. *Journal of Applied Ecology* **31,** 631-641

Plumptre, A.J., Reynolds, V. & Bakuneeta, C. (1994) *The contribution of fruit eating primates to seed dispersal and natural regeneration after selective logging* Report to ODA on Project R4738.

Plumptre, A. & Reynolds, V. (1996) Censusing chimpanzees in the Budongo forest. *International Journal of Primatology* **17,** 85-99

Plumptre, A.J. & Reynolds, V. (in press) Nesting behaviour of chimpanzees: implications for censuses. *International Journal of Primatology*

Quiatt, D. (1994) Leaf sponge drinking by a Budongo Forest chimpanzee. *American Primatologist* **33,** 236.

Reynolds, V. (1992) Conservation of chimpanzees in the Budongo Forest Reserve. *Primate Conservation* **11,** 41-43.

Reynolds, V. (1992) Chimpanzees in the Budongo Forest, 1962-1992. *Journal of Zoology, London* **228,** 695-699.

Reynolds, V. (1993) Sustainable forestry: the case of the Budongo Forest, Uganda. *Swara* **16,** 13-17

Rukundo, T. (1997) *The long-term effect of canopy treatment on tree diversity in the Budongo Forest: an evaluation of a 25 hectare permanent plot study.* Unpublished MSc thesis, Makerere University.

Walaga, C. (1993) *Species distribution and the development of the climax vegetation of Budongo Forest Reserve, Uganda.* Unpublished MSc thesis, Makerere University.

Papers that have been submitted to journals are as follows

Owiunji, I. & Plumptre, A.J. (submitted) The effects of selective logging on the bird communities in the Budongo Forest, Uganda: the importance of spatial heterogeneity. *Biological Conservation*

Plumptre, A.J. (submitted) Shifting cultivation along the trans-african highway and its impact on the bird community in the Ituri Forest, Zaire. *Bird Conservation International*

Plumptre, A.J. & Reynolds, V. (submitted) A comparison of the effects of pitsawing and mechanical harvesting of timber on primate populations in the Budongo Forest, Uganda. *Biological Conservation*

Plumptre, A.J. & Owiunji, I. (in press) Puvel's Illadopsis in the Budongo Forest Reserve, Uganda - a new record for East Africa. Submitted to *Scopus*.

Walaga, C. & Plumptre, A.J. (submitted) Soil nutrients and tree species distribution in the Budongo Forest Reserve, Uganda: is soil important for *Cynometra* monodominance? *Journal of Tropical Ecology*

In addition the following have been submitted as chapters for a book on the effects of selective logging on wildlife - proceedings of a conference in Bolivia held in October 1996 (see below).

Plumptre, A.J. & Grieser-Johns, A. (in prep) Changes in primate communities following logging disturbance. In: *The effects of selective logging on wildlife in the tropics*. Eds. R. Fimbel, A. Gajal & J. Robinson.

Plumptre, A.J., Dranzoa, C. & Owiunji, I. (in prep) Changes in bird communities following logging disturbance in the forests of Uganda. In: *The effects of selective logging on wildlife in the tropics*. Eds. R. Fimbel, A. Gajal & J. Robinson.

8.3 Visiting researchers and other research projects

Appendix 4 lists the research projects that have been carried out in Budongo forest at the Budongo Forest Project research site since 1992.

8.4 Meetings attended

The two Co-Directors of the Budongo Forest Project attended or talked at the following meetings/fora since May 1994 to disseminate results of the research in Budongo and to discuss policy issues related to Uganda's forests, tourism and biodiversity:

1. March 1995. Mr Bakuneeta and Dr Plumptre attended Forum V on "the role of NGOs in conservation".

2. April 1995. Mr Bakuneeta presented a paper to the headteachers awareness workshop in Masindi to encourage the establishment of wildlife clubs in Masindi District schools.

3. June 1995. Mr Bakuneeta attended an evaluation workshop for the EC financed Natural Forest Management and Conservation Project.

4. July 1995. Mr Bakuneeta and some of the Budongo Field Assistants were involved in training Tour guides in Murchison Falls National Park.

5. September 1995. Dr Plumptre and Mr Bakuneeta participated in a workshop, drawing up plans for research for the Uganda Wildlife Authority.

6. November 1995. Mr Bakuneeta presented a paper "the importance of Paper Mulberry in the diet of chimpanzees" at the NUFU PRO 18/92 conference at the Uganda Institute of Ecology. Dr Plumptre presented a paper on " the long-term effects of 65 years of selective logging on the Budongo Forest Reserve" at the same conference.

7. November 1995. Mr Bakuneeta presented a paper, "the effects of forest management on wildlife" at the Silver Jubilee Celebrations for the Forest department at Makerere University.

8. February 1996. Mr Bakuneeta spoke at "Vision 2001" for a conservation strategy for Masindi District.

9. February 1996. Mr Bakuneeta spoke about his research on chimpanzees in Budongo at the East African Wildlife Society meeting.

10. May 1996. Mr Bakuneeta spoke at Nyabyeya Primary School on "the importance of wildlife in Budongo Forest".

11. May 1996. Dr Plumptre attended a workshop at Nyabyeya Forest College to determine the "Important Bird Areas" for Uganda under the Birdlife International IBA Programme. The Budongo Forest Project was used as a site to look at various methods of bird censusing.

12. August 1996. Professor Reynolds and Mr Bakuneeta attended and presented posters at the International Congress of Primatology in Wisconsin, USA.

13. September 1996. Dr Plumptre gave a presentation about the 'effects of selective logging on wildlife in Budongo Forest' at the Uganda Forest Department's seminar series and gave recommendations for the management of Budongo for timber and conservation.

14. October 1996. Dr Plumptre gave a presentation on the effects of logging on primates at a workshop on "the effects of selective logging on wildlife in the tropics" held in Santa Cruz, Bolivia.

15. December 1996. I Owiunji gave a presentation of the effects of logging on birds at the Pan African Ornithological Congress in Ghana.

16. January 1997. Professor Reynolds, Dr Plumptre and Mr Bakuneeta gave presentations and participated in working groups at the IUCN chimpanzee population and habitat viability analysis workshop held at Entebbe. This workshop came up with a National Strategy for chimpanzee conservation in Uganda and was organised by Mr Bakuneeta.

In addition there exists an extensive collection of 41 reports that have been made to the Budongo Forest Project from visiting researchers which are available at the Institute of Biological Anthropology, Oxford University or Department of Forestry, Makerere University. These are as follows:

1. Report on visit to Uganda. V. Reynolds, 1990.
2. Report to Boise Fund. C. Bakuneeta, 1990.
3. Progress report. C. Bakuneeta, 1990
4. Report on survey of Kaniyo Pabidi. C. Bakuneeta, 1991.
5. Progress report. C. Bakuneeta, 1991.
6. ODA1 Report, Year 1. A. Plumptre, 1992.
7. General Report, Year 1. A. Plumptre, 1992.
8. NGS Final Report. V. Reynolds, 1992.
9. Chimpanzee parasites in dung. G. Kalema, 1992.
10. ODA1 Report, Year 2. A. Plumptre, 1993.
11. General Report, Year 2. A. Plumptre, 1993.
12. Herbaceous vegetation in Budongo. Dr E. Rogers, 1993.
13. Crop raiding by wildlife: its impact on a farming community in Uganda. Dr C. Hill, 1993
14. Report on Blue Monkey Project. C. Fairgrieve, 1993.
15. Report to ODA. C. Bakuneeta, 1994.
16. Report on uses of forest by local communities. K. Johnson, 1994.
17. ODA1 Final Report, A.Plumptre, C.Bakuneeta, & V. Reynolds, 1994.
18. NGS Final Report. V. Reynolds, 1994.
19. Annual Report to ODA on research plots. D. Sheil, 1994.
20. Squirrel ecology 1st year report. A. Stanford, 1994.
21. Budongo Forest Chimpanzees: composition of feeding groups during the rainy season with attention to the social integration of disabled individuals. D. Quiatt, B. Rutan et al., 1994. XV Congress of Int. Primat. Soc.
22. An observation of leaf sponge drinking by a Budongo Forest Chimpanzee. D. Quiatt & Z. Kiwede, 1994.
23. ODA2 Report year 1. A. Plumptre, 1995.

24. Report on canopy arthropods. T. Wagner, 1995.
25. Blue monkey infanticide. C. Fairgrieve, 1995.
26. Sickness and treatment in W. Masindi District. R. Sutton, D. Bowes-lyon, R. Prince & J. Fergusson, 1995.
27. Butterfly indicator species. P. Boston, 1995.
28. Chimpanzees as optimal foragers: an example from Budongo Forest, Uganda. R. Smith, 1995.
29. Some effects of limb injuries on the chimpanzees of the Budongo forest. R. Smith, 1995.
30.Effects of logging on rodent populations. T. Price, 1995.
31. A study of health care in masindi District. R. Sutton *et al.*, 1996.
32. Micro-demography of local population. Dr H. Marriot, 1996.
33. ODA2 report, year 2. A. Plumptre, 1996.
34. Diversity and biogeography of arthropods, especially beetles in Central african rainforests. T. Wagner, 1996. Int. Congress Ecology.
35. A preliminary acoustic analysis of the inter-population variability in the pant hoot vocalisations of male chimpanzees. J. Wong, 1995.
36. Sonso baboon troop. J. Paterson, 1996.
37. Report on sampling of nest hair from wild chimpanzees. A. Brownlow, 1996.
38. Nesting behaviour patterns in the Sonso Community. A. Brownlow, 1996.
39. Chimpanzee systematics. V. reynolds, 1997.
40. A history of chimpanzee studies in Uganda. V. reynolds, 1997.
41. Estimating chimpanzee populations. A.Plumptre, 1997.

9. REFERENCES

Alder, D. (1991) *Uganda Forestry Rehabilitation Project: data processing for the Budongo Forest inventory*. Report to the Uganda Forest Department.

Alder, D. & Synnott, T.J. (1992) Permanent sample plot techniques for mixed tropical forest. *Tropical forestry papers* **5**, 124pp. Oxford Forestry Institute, Oxford.

Allport, G., Ausden, M., Hayman, P.V., Robertson, P. & Wood, P. (1989) *The conservation of the birds of Gola Forest, Sierra Leone*. ICBP Study Report No. 38, 104pp.

Bakuneeta, C., Johnson, K., Plumptre, R. & Reynolds, V. (1995) Human uses of tree species whose seeds are dispersed by chimpanzees in the Budongo Forest, Uganda. *African Journal of Ecology* **33**, 276-278

Bennun, L., Dranzoa, C. & Pomeroy, D. (in press) The forest birds of Kenya and Uganda. *Journal of East African Natural History*

Bourliere, F. (1985) Primate communities: their structure and role in tropical ecosystems. *International Journal of Primatology* **6**, 1-26.

Brown, L.H. (1971) The relations of the crowned eagle *Stephanoaetus coronotus* and some of its prey animals. *Ibis* **113**, 240-243.

Buckland, S.T., Anderson, D.R., Burnham, K.P., & Laake, J.L. (1993) *Distance sampling: estimating abundance of biological populations*. Chapman & Hall, London.

Butynski, T.M. (1990) Comparative ecology of blue monkeys (*Cercopithecus mitis*) in high- and low-density subpopulations. *Ecological monographs* **60**, 1-26.

Chapman, C.A. & Chapman, L.J. (1990) Density and growth rates of some tropical dry forest trees: comparisons between successional forest types. *Bulletin of the Torrey Botanical Club*. **117**, 226-231.

Chapman, C.A., Chapman, L.J., Wrangham, R.W., Hunt, K., Gebo, D., & Gardner, L. (1992) Estimators of fruit abundance of tropical trees. *Biotropica* **24**, 527-531.

Clarke, B.T. (1989) Real vs apparent distributions of dwarf amphibians: *Bufo lindneri* Mertens 1955: a case in point. *Amphibia-Reptilia* **10**, 297-306.

Connell, J.H. & Lowman, M.D. (1989) Low-diversity tropical rainforests: some possible mechanisms for their existence. *American Naturalist* **134**, 88-119.

Corlett, R.T. & Lucas, P.W. (1990) Alternative seed-handling strategies in primates: seed spitting by long-tailed macaques (*Macaca fascicularis*). *Oecologia* **82,** 166-171.

Dasilva, G.L. (1989) *The ecology of the western black and white colobus (*Colobus polykomos polykomos *Zimmerman 1780) on a riverine island in south-eastern Sierra Leone*. Unpublished D. Phil. thesis, University of Oxford.

Delany, M.J. (1975) *The rodents of Uganda.* Trustees of the British Natural History Museum, London.

Dranzoa, C. (1995) *Bird populations of primary and logged forests in the Kibale Forest National Park, Uganda.* Unpublished PhD thesis, Makerere University.

Earl, D.E. (1992) Wise management of natural tropical forest for timber production, tourism and wildlife. pp 211-219 In: *Wise Management of Tropical Forests 1992. Proceedings of the Oxford conference on tropical forests* Eds. F.R. Miller & K.L. Adam. Oxford Forestry Institute, Oxford.

Edroma, E., Rosen, N. & Miller, P. (in prep.) *The Chimpanzees of Uganda: population and habitat viability assessment.* Report of Workshop held at Entebbe, Uganda. IUCN/CBSG, Apple Valley, MN.

Eisenberg, J.F. & Thorington, R.W. (1973) A preliminary analysis of a Neotropical mammal fauna. *Biotropica* **5,** 150-161

Eisenberg, J.F., Muckenhirn, N.A., & Rudran, R. (1972) The relation between ecology and social structure in primates. *Science* **176,** 863-874.

Eggeling, W. (1947) Observations on the ecology of the Budongo rainforest, Uganda. *Journal of Ecology* **34,** 20-87

Fairgrieve, C. (1995) *The comparative ecology of blue monkeys (*C. mitis stuhlmannii*) in logged and unlogged forest, Budongo Forest Reserve, Uganda.* Unpublished PhD thesis, Edinburgh University.

Ganzhorn, J.U. (1992) Leaf chemistry and the biomass of folivorous primates in tropical forests. *Oecologia* **91,** 540-547.

Gautier-Hion, A., Gautier, J-P. & Maisels, F. (1993) Seed dispersal versus seed predation: an inter-site comparison of two related African monkeys. *Vegetatio* **108,** 237-244.

Goodall, J. (1986) *The chimpanzees of Gombe.* Belknap Press, Harvard University, Cambridge, MA.

Gorchov, D.L., Cornejo, F., Ascorra, C. & Jaramillo, M. (1993) The role of seed dispersal in the natural regeneration of rain forest after strip-cutting in the Peruvian Amazon. *Vegetatio* **108,** 339-349.

Hart J.A. (1978) From subsistence to market: a case study of Mbuti net hunters. *Human Ecology* **6,** 32-53.

Hart J.A. (1986) *Comparative dietary ecology of a community of frugivorous forest ungulates in Zaire.* Unpublished PhD thesis, Michigan State University.

Hart, T.B. (1985) *The ecology of a single-species-dominant forest and a mixed forest in Zaire, Africa.* Unpublished PhD thesis, Michigan State University.

Hart, J.A. & Hart, T.B. (1986) The ecological basis of hunter gatherer subsistence in the Ituri forest, NE Zaire. *Human Ecology* **14,** 29-55.

Hart, T.B., Hart, J.A. & Murphy, P.G. (1989) Monodominant and species-rich forests of the humid tropics: causes for their co-occurrence. *American Naturalist* **133,** 613-633.

Hart, T.B., Hart, J.A., Deschamps, R., Fournier, M., and Ataholo, M. (in press) Changes in forest composition over the last 4,000 years in the Ituri basin, Zaire. In: *The biodiversity of African plants* Ed. L.J.G. Van der Maesen. Proceedings of XIV AETFAT Congress, Wageningen. Academic Press.

Harris, S., Cresswell, W.J., Forde, P.G., Trewhella, W.J., Woollard, T. & Wray, S. (1990) Home range analysis using radio tracking data: a review of problems and techniques particularly as applied to the study of mammals. *Mammal Review* **20,** 97-123.

Howard, P.C. (1991) *Nature Conservation in Uganda's Tropical Forest Reserves.* IUCN, Gland, Switzerland.

Howe, H.F. (1984) Implications of seed dispersal by animals for tropical reserve management. *Biological Conservation* **30,** 261-281.

Isabirye-Basuta, G. & Kasenene, J.M. (1987) Small rodent population in selectively felled and mature tracts of Kibale Forest, Uganda. *Biotropica* **19,** 260-266.

Joern, A. & Lawlor, L.R. (1980) Food and microhabitat utilisation by grasshoppers from arid grasslands: comparisons with neutral models. *Ecology* **61,** 591-599.

Johns, A.D. (1985) Selective logging and wildlife conservation in tropical rainforest: problems and recommendations. *Biological Conservation* **31,** 335-375.

Johns, A.D. (1988) Effects of "selective" timber extraction on rainforest structure and composition and some consequences for frugivores and folivores. *Biotropica* **20,** 31-37.

Johns, A.D. (1989) *Timber, the environment and wildlife in Malaysian rainforests.* Final report to the Institute of South East Asian Biology, University of Aberdeen.

Johns, A.D. (1992) Vertebrate responses to selective logging: implications for the design of logging systems. *Philosophical Transactions of the Royal Society of London* **335,** 437-442

Kalina, J. (1988) *Ecology and behaviour of the black and white casqued hornbill (*B. subcylindricus subquadratus*) in the Kibale forest.* Unpublished PhD thesis, Michigan University.

Karani, P.K. (1994) *Sustainable Management of Tropical Rain Forest in Uganda.* Commonwealth Secretariat, London.

Keith, S., Urban, E.K. & Fry, C.H. (Eds) (1992) *The Birds of Africa. Volume 4: Broadbills to Chats.* Academic Press, London.

Kenward, R.E. & Hodder, K.H. (1996) *Ranges V: an analysis system for biological location data.* Institute of Terrestrial Ecology, Wareham, UK.

Kingdon, J. (1990) *Island Africa.* Collins, London.

Kityo, P. & Plumptre, R. A. (in press) *The Uganda Timber Users' Handbook: A guide to better timber use.* Commonwealth Secretariat, London.

Krebs, C.J. (1989) *Ecological Methodology.* Harper Collins, New York.

Langdale-Brown, L., Osmaston, H.A. & Wilson, J.G. (1964) *The vegetation of Uganda and its bearing on land use.* Government of Uganda, Entebbe.

Laws, R.M., Parker, I.S.C., & Johnstone, R.C.B. (1975) *Elephants and their Habitats.* Clarendon Press, Oxford.

Lwanga, J.S. (1994) *The Role of Seed and Seedling Predators and Browsers in the Regeneration of Two Forest Canopy species (* Mimusops bagshawei *and* Strombosia scheffleri*) in Kibale Forest Reserve, Uganda.* Unpublished PhD thesis, University of Florida.

Mackworth-Praed, C.W. & Grant, C.H.B. (1960) *Birds of Eastern and North Eastern Africa. Volumes I and II.* Second edition, Longman, London.

Maisels, F.G., Gautier, J-P., Cruickshank, A. & Bosefe, J-P. (1993) Attacks by crowned hawk eagles (*Stephanoaetus coronatus*) on monkeys in Zaire. *Folia Primatologica* **61,** 157-159.

Malenky, R.K. & Wrangham, R.W. (1994) A quantitative comparison of terrestrial herbaceous food consumption by *Pan paniscus* in the Lomako Forest, Zaire, and *Pan troglodytes* in the Kibale Forest, Uganda. *American Journal of Primatology* **32,** 1-12.

Musamali, P.B. (1996) *The ecology, diversity and relative abundance of small mammals in primary and disturbed forest compartments of Budongo Forest Reserve.* Unpublished MSc thesis, Makerere University.

Oates, J.F., Whitesides, G.H., Davies, A.G., Waterman, P.G., Green, S.M., Dasilva, G.L. & Mole, S. (1990) Determinants of variation in tropical forest primate biomass: new evidence from West Africa. *Ecology* **71,** 328-343.

Osmaston, H.A. (1959) *Working plan for the Bugoma forest, 1960-1970.* 77pp. Uganda Forest Department, Government Printers, Entebbe.

Owiunji, I. (1996) *The Long-Term Effects of Forest Management on the Bird Community of Budongo Forest Reserve, Uganda.* Unpublished MSc thesis, Makerere University.

Pannell, C.M. (1989) The role of animals in natural regeneration and the management of equatorial rainforests for conservation and timber production. *Commonwealth Forestry Review* **68,** 309-313.

Philip, M.S. (1964) *Working Plan for Budongo Central Forest Reserve '1964-74, Third revision.* Uganda Government Printer, Entebbe, Uganda.

Plumptre, A.J. (1995) The importance of "seed trees" for the natural regeneration of selectively logged tropical forest. *Commonwealth Forestry Review* **74,** 253-258.

Plumptre, A.J. (1996) Changes following sixty years of selective timber harvesting in the Budongo Forest Reserve, Uganda. *Forest Ecology and Management* **89,** 101-113

Plumptre, A.J. & Reynolds, V. (1994) The impact of selective logging on the primate populations in the Budongo Forest Reserve, Uganda. *Journal of Applied Ecology* **31,** 631-641

Plumptre, A.J., Reynolds, V. & Bakuneeta, C. (1994) *The contribution of fruit eating primates to seed dispersal and natural regeneration after selective logging* Report to ODA on Project R4738.

Plumptre, A. & Reynolds, V. (1996) Censusing chimpanzees in the Budongo forest. *International Journal of Primatology* **17,** 85-99

Plumptre, A.J. & Reynolds, V. (in press) Nesting behaviour of chimpanzees: implications for censuses. *International Journal of Primatology*

Priede, I.M. & Swift, S.M. (1992) *Wildlife Telemetry: remote monitoring and tracking of animals.* Ellis Horwood, New York.

Prins, H.H.T. (1996) *Ecology and behaviour of the african buffalo: social inequality and decision making*. Chapman & Hall, London.

Pulliam, H.R. (1988) Sources, sinks and population regulation. *American Naturalist* **132,** 652-661.

Rukundo, T. (1997) *The long-term effect of canopy treatment on tree diversity in the Budongo Forest: an evaluation of a 25 hectare permanent plot study*. Unpublished MSc thesis, Makerere University.

Schnabel, Z.E. (1938) The estimation of the total fish population of a lake. *American Math. Mon.* **45,** 348-52.

Sheil, D. (1996) *The ecology of long term change in a Ugandan rainforest.* Unpublished D.Phil. thesis, University of Oxford.

Sinclair, A.R.E. & Arcese, P. (1995) *Serengeti II: Dynamics, Management and Conservation of an Ecosystem.* University of Chicago Press, Chicago.

Skorupa. J.P. (1988) *The effect of selective timber harvesting on rain forest primates in Kibale Forest, Uganda.* Unpublished PhD thesis, University of California.

Skorupa, J.P. (1989) Crowned eagles *Stephanoaetus coronatus* in rainforest: observations on breeding chronology and diet at a nest in Uganda. *Ibis* **131,** 294-298.

Stephenson, P.J. & Newby, J.E. (1997) Conservation of the Okapi Wildlife Reserve, Zaire. *Oryx* **31,** 49-58.

Struhsaker, T.T. (1975) *The red colobus monkey.* University of Chicago Press, Chicago.

Struhsaker, T.T. (1981) Polyspecific associations among tropical rainforest primates. *Zeitschrift fur Tierpsychologie* **57,** 268-304

Struhsaker, T.T. & Leakey, M. (1990) Prey selectivity by crowned hawk-eagles on monkeys in the Kibale Forest, Uganda. *Behavioural Ecology and Sociobiology* **26,** 435-443.

Synnott, T.J. (1985) A checklist of the flora of Budongo Forest Reserve, Uganda with notes on ecology and phenology. *CFI Occasional Paper* **27.** Oxford Forestry Institute, Oxford.

Ter Braak, C.J.F. (1986) Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. *Ecology* **67,** 1167-1179.

Ter Braak, C.J.F. (1988) CANOCO-an extension of DECORANA to analyse species-environment relationships. *Vegetatio* **75,** 159-160.

Ter Braak, C.J.F. (1987-1992) *CANOCO-a Fortran program for canonical community ordination.* Microcomputer power, Ithaca, New York.

Thomas, S.C. (1991) Population densities and patterns of habitat use among anthropoid primates of the Ituri Forest, Zaire. *Biotropica* **23,** 68-83.

Tondeur, G. & Bergeroo-Campagne, B. (1955) Shifting agriculture in the Belgian Congo. *Unaslyva* **9,** 67-71.

Van der Meer, P.J. & Bongers, F. (1996) Patterns of tree-fall and branch-fall in a tropical rain forest in French Guiana. *Journal of Ecology* **84,** 19-29.

Waterman, P.G., Ross, J.A.M., Bennett, E.L., & Davies, A.G. (1988) A comparison of the floristics and leaf chemistry of the tree flora in two Malaysian rain forests and the influence of leaf chemistry on populations of colobine monkeys in the Old World. *Biological Journal of the Linnean Society* **34,** 1-32

Wilkie, D.S. (1987) *Impact of swidden agriculture and subsistence hunting on diversity and abundance of exploited fauna in the Ituri forest of NE Zaire.* Unpublished PhD thesis, University of Massachusetts.

Wilkie, D.S. (1989) *Human settlement and forest composition within the proposed Okapi rainforest reserve in northeastern Zaire: creating the first thematic map of the Ituri forest using digital analyses of Landsat TM imagery.* Final report to WWF, WCS and NSF. WWF project 3249.

Willson, M.F. & Whelan, C.J. (1990) Variation in postdispersal survival of vertebrate-dispersed seeds:effects of density, habitat, location, season and species. *Oikos* **57,** 191-198.

Whittaker, R.J. & Jones, S.H. (1994) The role of frugivorous bats and birds in the rebuilding of a tropical forest ecosystem, Krakatau, Indonesia. *Journal of Biogeography* **21,** 245-258.

Whitesides, G.H., Oates, J.F., Green, S.M. & Kluberdanz, R.P. (1988) Estimating primate densities from transects in a West African rainforest: a comparison of techniques. *Journal of Animal Ecology* **57,** 345-367.

Worton, B.J. (1989) Kernel methods for estimating the utilisation distribution in home range studies. *Ecology* **70,** 164-168.

Wrangham, R.W., Rogers, M.E. & Isabirye-Basuta, G. (1993a) Ape food density in the ground layer in Kibale Forest, Uganda. *African Journal of Ecology* **31,** 49-57.

Wrangham, R.W., Conklin, N.L., Etot, G., Obua, J., Hunt, K.D., Hauser, M.D. & Clark, A.P. (1993b) The value of figs to chimpanzees. *International Journal of Primatology* **14**, 243-256.

Wrangham, R.W., Chapman, C.A. & Chapman, L.J. (1994) Seed dispersal by forest chimpanzees in Uganda. *Journal of Tropical Ecology* **10**, 355-368

Wrangham, R.W., Chapman, C.A., Clark-Arcadi, A.P. & Isabirye-Basuta, G. (1996) Social ecology of Kanyawara chimpanzees: implications for understanding the costs of great ape groups. In: *Great Ape Societies*. Eds: W.C. McGrew, L.F. Marchant & T. Nishida. Cambridge University Press, Cambridge.

Appendix 1. The small mammal species trapped in Budongo by Paul Musamali.

A. **Order Insectivora**
Family Soricidae: shrews

Crocidura dolichura (Peters 1876)
Scutisorex somereni (Thomas 1910)

B. **Order Rodentia**
Family Cricetidae: Cricetid rats

Cricetomys gambianus (Waterhouse 1840)
Deomys ferrugineus (Thomas 1926)

Family Muridae: mice and rats

Hylomyscus stella (Waterhouse 1838)
Lemniscomys striatus (Linnaeus 1758)
Lophuromys flavopunctatus (Thomas 1888)
Lophuromys sikapusi (Temminck 1853)
Malacomys longipes (Milne Edwards 1877)
Mus minutoides (Smith 1834)
Praomys jacksoni (de Winton 1897)

Family Myoxidae: dormice

Graphiurus murinus (Desmarest 1822)

Appendix 2. The bird species (Keith *et al.* 1992) and total numbers seen for all point counts in each compartment with their "habitat category" (Bennun *et al.* (in press). Species richness and total number of birds seen is given for each compartment.

Species	N15	K11-13	N3	W21	B1	Habitat
	Unlogged		1950	1965	1985	category
Number of point counts[a]	500	400	500	400	400	
Accipitridae						
African Harrier Hawk *Polyboroides typus*			1			f
Phasianidae						
Nahan's francolin *Francolinus nahani*	4		2		2	F
Scaly francolin *Francolinus squamatus*					1	F
Numididae						
Crested guineafowl *Guttera pucherani*	6	6	24		14	F
Rallidae						
Buff-spotted pygmy crake *Sarothrura elegans*	2		4	4		F
White spotted pygmy crake *Sarothrura pulchra*				3		F
Columbidae						
Lemon dove *Columba larvata*			-	-	-	F
Afep pigeon *Columba unicincta*	5		-	-	-	F
Tambourine dove *Turfur tympanistria*	26	7	11	21	16	F
Green pigeon *Treron calva*	3	2	-	-	4	F
Psittacidae						
Grey parrot *Psittacus erithacus*			3	4		F
Musophagidae						
Great blue turaco *Corythaeola cristata*				5		F
Black-billed turaco *Tauraco schuetti emini*	2		4	9		F
Cuculidae						
White-browed coucal *Centropus superciliosus*			1	-		f
Dusky long-tailed cuckoo *Cercococcyx mechowi*	1	2	6	16	3	F
Yellowbill *Ceuthmochares aereus*	6	4	9	18	10	F
African Emerald cuckoo *Chrysococcyx cupreus*	1	4	1	-	-	F
Klaas cuckoo *Chrysococcyx klaas*		-	1	-	-	f
Black cuckoo *Cuculus clamosus*	1	-	-	-	-	f
Red-chested cuckoo *Cuculus solitarius*	11	11	10	6	1	F
Trogonidae						
Narina's trogon *Apaloderma narina*	3	5				F
Alcedinidae						
Shining-blue kingfisher *Alcedo quadribrachys*		-		1		F
Chocolate-backed kingfisher *Halcyon badia*	3	-	2	4	4	F
Blue-breasted kingfisher *Halcyon malimbica*	11	12	3	12	5	F
Dwarf kingfisher *Ceyx lecontei*		-	2	4	3	F

Pygmy kingfisher *Ceyx picta*	1					f
Meropidae						
White-throated bee-eater *Merops albicollis*	2					f
Coraciidae						
Blue-throated roller *Eurystomas gularis*					2	F
Bucerotidae						
White-thighed hornbill *Ceratogymna albotibialis*	117	11	86	19	74	F
White-tailed hornbill *Ceratogymna fistulator*	-	-	-	-	6	F
Black and white casqued hornbill *Ceratogymna subcylindricus*	1	2	4	5	6	F
Pied hornbill *Toctus fasciatus*					3	F
Capitonidae						
Yellow-billed barbet *Trachyphonus purpuratus*	1	1	1	2		F
Hairy-breasted barbet *Tricholaema hirsuta*			1			F
Yellow-rumped tinkerbird *Pogoniulus bilineatus*				2		F
Speckled tinkerbird *Pogoniulus scolopaceus*	4	1	8	4	3	F
Yellow-throated tinkerbird *Pogoniulus subsulphureus*	12	2	20	9		F
Yellow spotted barbet *Buccanodon duchaillui*	-	1	1	-		F
Picidae						
Brown-eared woodpecker *Campethera caroli*		1				F
Buff-spotted woodpecker *Campethera nivosa*			6		1	F
Yellow-crested woodpecker *Dendropicos xantholophus*	12	10	19	12	16	F
Eurylaimidae						
African broadbill *Smithornis capensis*		2	1			F
Red-sided broadbill *Smithornis rufolateralis*					1	F
Oriolidae						
Western black-headed oriole *Oriolus brachyrhynchus*	29	10	17	1	2	F
Timaliidae						
Scaly-breasted illadopsis *Trichastoma albipectus*	13		7	7	6	F
Brown illadopsis *Trichastoma fulvescens*	3	2	18	15	10	F
Pale-breasted illadopsis *Trichastoma rufipennis*	1				2	F
Pycnonotidae						
Cameroon sombre greenbul *Andropadus curvirostris*	1	4	11	5	3	F
Slender-billed greenbul *Andropadus gracilirostris*		7	4	4	5	F
Little grey greenbul *Andropadus gracilis*	5		6	4	3	F

Yellow-whiskered greenbul *Andropadus latirostris*	70	60	45	21	15	F
Little greenbul *Andropadus virens*	91	20	133	105	60	F
Honeyguide greenbul *Baeopogon indicator*	4	-	-	2	1	F
Bristlebill *Bleda syndactyla*	26	9	17	8	11	F
Yellow-throated leaflove *Chlorocichla flavicollis*	-	-	5	-	-	f
Red-tailed greenbul *Crinigar calurus*	96	43	62	38	25	F
Spotted greenbul *Ixonotus guttatus*	112	2	8	14	18	F
Nicator *Nicator chloris*	22	48	27	36	24	F
White-throated greenbul *Phyllastrephus albigularis*	89	96	56	45	53	F
Icterine greenbul *Phyllastrephus icterinus*	62	-	5	2	2	F
Xaviers greenbul *Phyllastrephus xavieri*	16	-				F
Turdidae						
Fire-crested alethe *Alethe diademata*	17	9	12	14	11	F
Brown-chested alethe *Alethe poliocephala*			4			F
Blue-shouldered robin chat *Cossypha cyanocampter*	-		-	-	1	F
Red-capped robin chat *Cossypha natalensis*	-		-	-	-	F
Rufous thrush *Neocossyphus fraseri*	66	24	15	16	12	F
White-tailed ant thrush *Neocossyphus poenis*			-		-	F
Red-tailed ant thrush *Neocossyphus rufus*	3		-		2	F
Forest robin *Stiphrornis erythrothorax*	4	5	8	3	3	F
Northern olive thrush *Turdus abyssinicus*		2				F
Sylviidae						
Black-throated apalis *Apalis jacksoni*	-	1	-		-	F
Black-capped apalis *Apalis nigriceps*	14	6	16	8	23	F
Buff-throated apalis *Apalis rufogularis*	2	2	1	2	4	F
Grey-backed camaroptera *Camaroptera brachyura*		1	2			f
Olive-green camaroptera *Camaroptera chloronota*	10	5	10	27	13	F
Brown-crowned eremomela *Eremomela badiceps*	26	10	24	49	68	F
Green Hylia *Hylia prasina*	40	47	42	35	37	F
Yellow longbill *Macrosphenus flavicans*	1	-	-	3	2	F
Green crombec *Sylvietta virens*	4	6	-	6	1	F
Muscicapidae						
Forest flycatcher *Fraseria ocreata*	14	10	3	25	14	F
Shrike flycatcher *Megabyas flammulata*	-	-		1	2	F
Dusky-blue flycatcher *Muscicapa comitata*	3	-	2	-	1	F
Jamesons wattle-eye *Platysteria blisetti*	5	3	1	10	8	F
Chestnut wattle-eye *Platysteria castanea*	48	6	41	32	39	F
Chestnut-capped flycatcher *Erythrocercus mecalli*	31	6	4	3	15	F
Red-bellied paradise flycatcher *Terpsiphone rufiventer*	75	121	23	10	6	F
Paradise flycatcher *Terpsiphone viridis*	-	-	-	2		f
Dusky-crested flycatcher *Trochocoreus nigromitralus*	8		4	4	1	F

Malaconotidae						
Tropical boubou *Laniarius ferrugineus*					1	f
Sturnidae						
Purple-headed glossy starling *Lamprotornis purpureiceps*	21	13	17		7	F
Splendid glossy starling *Lamprotornis splendidus*		2		2		F
Nectariniidae						
Collared sunbird *Anthroptes collaris*		2	2		1	F
Olive-bellied sunbird *Nectarinia chloropygia*		1			1	F
Blue-throated brown sunbird *Nectarinia cyanolaema*	-	-	8	2		F
Grey-headed sunbird *Nectarinia fraseri*	13	16	8	7	9	F
Olive sunbird *Nectarinia olivacea*	55	31	64	36	45	F
Little green sunbird *Nectarinia seimundi*	-	-	2	3	1	F
Green-headed sunbird *Nectarinia verticalis*	4	2	1	2	4	F
Variable sunbird *Nactarinia venusta*			4		1	f
Ploceidae						
Grosbeak weaver *Amlyospiza albifrons*	4	1	5	-	4	f
Crested malimbe *Malimbus malimbicus*	26	4	23	13	5	F
Red-headed malimbe *Malimbus rubricollis*	6	3	7	1	1	F
Black-headed weaver *Ploceus cucullatus*					2	f
Vieillots black weaver *Ploceus nigerrimus*	2	1	4	1		F
Compact weaver *Ploceus superciliosus*	2					f
Estrildidae						
Grey-headed negrofinch *Nigrita canicapilla*	2	2				F
Black-bellied seed cracker *Pyrenestes ostrinus*			1			F
Green-backed twinspot *Mandingoa nitidula*			2			F
Total number of birds seen	1387	731	1012	786	762	
Total number of species	73	62	72	64	71	
Percentage of FF species	59	58	61	66	59	
Percentage of F species	34	39	32	31	34	
Percentage of f species	7	3	7	3	7	

*100 points in each compartment visited 4 or 5 times

Appendix 3 The species caught and number of captures for each of the three study sites in the Ituri Forest, Zaire.

Species	Monodominant (Lenda)	Mixed (Apharama)	Secondary (Babukeli)
African Goshawk			
Chestnut-flanked Sparrowhawk	-		1
Blue-headed Dove	4		1
Dwarf Kingfisher	1	4	
Malachite Kingfisher	1	4	3
Pygmy Kingfisher			
Red-rumped Tinkerbird			
Speckled Tinkerbird	-		1
Brown-eared Woodpecker	2	-	3
Buff-spotted Woodpecker	2	1	-
Square-tailed Roughwing Swallow	1		
Cameroon Sombre Greenbul	1	1	4
Eastern Bearded Greenbul	-	3	
Icterine Greenbul		8	-
Little Greenbul		2	59
Red-tailed Greenbul		1	7
Sassi's Olive Greenbul		3	
White-bearded Greenbul			1
White-throated Greenbul	-	-	3
Xavier's Greenbul	4	3	-
Yellow-whiskered Greenbul	12	13	17
Yellow-throated Nicator	-	-	1
Green-tailed Bristlebill	13	15	7
Red-tailed Bristlebill	30	24	21
Northern-bearded Scrub Robin	2	2	
Brown-chested Alethe	69	14	-
Fire-crested Alethe	19	57	35
Akalat	19	4	-
Forest Robin	15	33	10
Rufous Thrush	-	1	
Red-tailed Antthrush	7	-	
White-tailed Antthrush	7	5	1
Black-eared Ground Thrush	1	-	1
Crossley's Ground Thrush	1		
Forest Ground Thrush	2	-	
Grey Ground Thrush	-	1	
Black-faced Warbler	1		

Olive-green Camaroptera	1	2	5
Green Hylia	2	8	17
Dusky-crested Flycatcher	12	7	-
Grey-throated Flycatcher	-	-	1
Red Bellied Paradise Flycatcher	4	4	
Rufous-vented Paradise Flycatcher	1	2	
Sooty Flycatcher	-	-	1
Yellow-footed Flycatcher		1	
Chestnut Wattleye	-	-	3
Yellow-bellied Wattleye	16	2	
Brown Illadopsis	21	8	4
Pale-breasted Illadopsis	3	2	3
Scaly-breasted Illadopsis	7	7	1
Capuchin Babbler	7	2	
Grey-headed Sunbird			
Blue-throated Brown Sunbird	-	-	2
Olive Sunbird	92	95	152
Blue-billed Malimbe	-	2	2
Red-fronted Antpecker		2	5
Chestnut-breasted Negrofinch		-	1
Green-backed Twinspot	-	-	2
Grant's Bluebill	18	1	
Total:	400	346	377

Appendix 4. Visiting researchers and the projects they carried out.

A. *Local community uses of Budongo Forest. K. Johnson, Oxford University.* This project carried out in 1991, looked at the uses people make of Budongo Forest and was written up as an MSc thesis.

B. *The ecology of Blue monkeys in unlogged and logged forest - Mr C. Fairgrieve, Edinburgh University. Supported by SERC.*
This study was for the degree of Doctor of Philosophy at Edinburgh University. Mr Fairgrieve arrived in January 1993 and worked with four groups of blue monkeys, two in an area logged in 1950 and two in the Nyakafunjo Nature Reserve which had not been logged. Data on the ranging behaviour in relation to food availability were collected and seed dispersal was studied by collecting faecal samples. This research was written up as a PhD and examined at Edinburgh University.

C. *The relationship between soil nutrients and tree species composition in Budongo Forest - Mr. C. Walaga, Makerere University. Supported by USAID.*
Mr Walaga graduated with his MSc from Makerere University in January 1995. Soils from 168 sites in the forest were collected and analysed at Makerere for: Nitrogen; Phosphorus; Sodium; Potassium; Magnesium; Calcium; Organic matter; Sand,Clay and Silt content and Ph. Vegetation data from these sites have already been collected by Dr Plumptre as part of his study and tree species were related to these soil nutrients using multivariate analyses. These showed that the soil nutrients measured could explain only about 10% of the variation in tree species distribution although this was significantly better than random. *Cynometra alexandrii* was not associated with any soil nutrient.

D. *Analysis of parasites in chimpanzee faeces. G. Kalema, University College, London.* This study identified the common intestinal parasites found in chimpanzees in Budongo Forest.

E. *The effects of crop raiding on the local population by wild animals - Dr K. Hill, Durham University. Supported by Boise fund.*

Dr Hill carried out a years study of crop raiding around Budongo looking at the different problems faced by villagers at differing distances from the forest. Baboons and Wild pigs caused the bulk of the damage although many other species will enter fields adjacent to the forest.

F. *The effects of squirrels on forest regeneration in the Budongo Forest Reserve - A. Stanford, Bristol University. Supported by Bristol University*

Ms Stanford has been censusing and radiotracking squirrels in the region around the research station (logged in 1950) and in the unlogged Nature Reserve for her doctoral research. The research aims to investigate whether squirrels in the tropics have the same sort of impact on seedlings as squirrels do in plantations in temperate regions. All the data are collected and she has returned to Bristol University to write up.

G. *The effects of selective logging on the bird communities in the Budongo Forest Reserve - I. Owiunji. Supported by WCS and USAID*

Mr Owiunji investigated the differences in the bird communities in five compartments of Budongo Forest, two of which were unlogged and three logged at different times since 1950. His results show that frugivorous birds benefit from selective logging whilst certain insectivores, particularly sallying species and ground feeding species do not do well. His MSc thesis has just been examined.

H. *The effects of selective logging on the small mammal communities in Budongo Forest - P. Musamali. Supported by WCS and USAID.*

Mr Musamali investigated the differences in the small mammal communities in the same five compartments as Mr Owiunji. His findings show high numbers of *Praomys jacksonii* and *Praomys hylomyscus stella* in undisturbed forest when compared with disturbed forest.

I. *The social behaviour of male chimpanzees in a habituated community in Budongo - N. Newton-Fisher, Cambridge University. Supported by L.S.B. Leakey Foundation.*

Mr Newton-Fisher carried out his PhD fieldwork at Budongo where he investigated aspects of social behaviour in the habituated community of chimpanzees that are studied by Mr C.

Bakuneeta. He has returned to Cambridge University to write up his results.

J. *The effects of snare injuries on the behaviour of chimpanzees - Professor D. Quiatt. University of Colorado.*

Professor Quiatt visited the Budongo Forest Project for two three month periods in 1993 and 1994 to investigate how snare injuries which are common in the habituated community affect the social status and daily activity patterns of the injured chimpanzees. A report was sent in in and the results were presented as a paper at the International Primate Society meeting in Madison, Wisconsin in August 1996.

K. *The effects of the timing of arboricide treatment on the subsequent structure and composition of the forest - an evaluation of RP50 - T. Rukundo, Makerere University. Funded by GEF.*

Mr Rukundo reopened the boundaries of Research Plot 50 which was established in the 1950s to evaluate the effects of the different timings of arboricide treatments. RP50 is a plot 500 x 500 metres with 25 sub-plots of 100 x 100 metres. Four treatments were tested in a latin square design leaving one sub-plot for a control on each row of the main plot. His findings show that there is no detectable difference between treatment timings but there is a difference between the control sub-plots and the treated sub-plots in forest structure and liana density.

L. *A study of insect diversity on the same tree species in logged and unlogged forest - T. Wagner, Museum Koenig, Bonn.*

Mr Wagner came to the Budongo Forest Project in the summer of 1995 and in January 1997 and "fogged" the crowns of several species of tree with pyrethrum. Collections made of the insects and other arthropods are being analysed in Bonn to see what differences occur between logged and unlogged forest in the same tree species.

M. *A study of butterfly diversity with respect to logging - P. Boston, Oxford.*

Mr Boston spent three months at the Budongo Forest Project in 1995, another two months in 1996 and employed a field assistant from May 1995 to March 1996 trapping butterflies in the N15 Nature reserve and in compartment N3, logged in 1950. He is currently analyzing his results to look at differences in abundance and species richness between these two sites.

N. *The analysis of chimpanzee pant-hoot vocalisations and comparisons with those of the Gombe chimpanzees - J. Wong, Oxford University.*
Ms Wong recorded the pant-hoots of the males in the Sonso community for her MSc thesis and compared them with pant-hoots of males at Gombe to look for differences in dialects. These showed statistically significant differences in the build up phase of pant-hoots between the two sites.

O. *An analysis of the aetiology injuries to limbs of chimpanzees in the Sonso community - J. Waller, Oxford University.*
Mr Waller carried out this study for his MSc thesis in the summer of 1995. He described the superficial appearance and underlying anatomy of a number of kinds of hand and foot injury. A physiological analysis revealed a number of neural processes underlying the various muscular contractures seen. Most injuries appear to be caused by snares and leg-hold traps.

P. *A study of the effects of the forest edge on the understorey bird community in Budongo Forest. K. Mork & R. Solvang, Agricultural University of Norway*
A study was made of the edge effects of the large clearing in the forest at Budongo sawmills upon the understorey bird community in January - March 1996. Findings showed that frugivore-insectivores were more common near the edge and leaf-gleaning insectivores more common in the interior.

Q. *A study of baboon feeding ecology. J. Paterson & S. Paterson, University of Calgary, Canada.*
A study was made of baboon diets in a forested environment around the Sonso research site in late 1996. Results are currently being analysed and a follow-up visit is being planned.

R. *A study of health care in the local community adjacent to the Budongo forest. R. Sutton, D. Bowes-Lyon, R. Prince and J. Fergusson. University of Oxford.*
A short summer project looking at the primary health care received by people living in

villages around Budongo Forest was made in 1996.

S. *A study of population demography in local communities. H. Marriott, Oxford University.* A short summer project investigated the demography and causes of child mortality in the villages around Budongo Forest.

T. *Parasites in chimpanzees in Budongo. M. Barrows, Glasgow University.* A short summer project investigated the parasite loads found in chimpanzees in ther Sonso community.

U. *Amphibian diversity in Budongo Forest. M. Starkey, L. Aukland, R. Ingle & S. Jones, Oxford University.* This project looked at amphibian diversity during the summer of 1996 in logged and unlogged areas of Budongo Forest.

V. *Analysis of long-term change in Budongo Forest Permanent plots. D. Sheil, Oxford University.* Dr Sheil analysed long-term growth data of trees in Eggelings's plots established in 1933. This work was written up as a PhD thesis and shows that recruitment has changed in Budongo Forest since the elephants have been exterminated from the forest.

W. *Acoustic analysis of chimpanzee vocalisations. H. Notman, Oxford University.* H. Notman built upon the work carried out by J. Wong (above) looking at the pant-hoot vocalisations by male chimpanzees.

X. *Hunting of wildlife in Budongo Forest. L. Bannon.* This project carried out in late 1996 investigated the extent of hunting and buying of bushmeat in and around Budongo Forest Reserve and is currently being analysed.