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BIODIVERSITY OF THE FOUR CORNERS AREA

MONITORING:

A REGIONAL OVERVIEW AND ESTABLISHMENT OF A MONITORING PLOT

compiled by
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THE ZAMBEZI SOCIETY
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LIST OF CONTENTS

MONITORING BIODIVERSITY IN THE FOUR CORNERS AREA

Susan Childes

INTRODUCTION

The process of monitoring is used extensively in a wide range of disciplines, but the same principles apply throughout. It begins with the establishment of baseline information at time zero and follows with a series of repeated measurements to time *n*. Monitoring indicates if a change has occurred, but can only be used to indicate trends when three or more data sets are collected at different times. Useful interpretations of such changes or trends, however, can only be made if the causative factors have themselves been monitored. Understanding the changes in biodiversity, and the reasons for them, is fundamental to the success of conservation actions.

Biodiversity monitoring has several aspects, depending on the scale being used (Childes & Gardiner 1999):

species lists	species abundances	species turnover along a gradient	habitat or landscape
species composition			
alpha diversity		**beta diversity**	**gamma diversity**

At a small scale - the alpha level - changes in relative abundance and species composition (other than those that are seasonal or cyclical) are early indications of changes in the biodiversity status of a system. The absolute numbers of species are perhaps not as important as the relative abundance of the functional groups, e.g. ruderal compared to 'climax' species, generalists compared to specialists. Measuring the changes in species composition and abundance along distinct environmental gradients (beta diversity) will help identify the key environmental factors affecting the species, and their tolerance limits. Habitat or landscape (gamma) diversity is measured at a higher level. Change in the habitat diversity of an area is the culmination of numerous smaller scale changes in alpha and beta diversity.

Variations in species composition and relative abundance results from changes in the ecological processes that affect them. Examples of such processes are fire, herbivory, rainfall and nutrient recycling (Robertson 2004). Monitoring of these ecological processes can occur at a very broad scale, such as global climatic change, or at a detailed level, such as ungulate grazing studies.

A biodiversity monitoring programme that will yield useful scientific results requires:

- the defining of clear goals, including the identification of what to monitor and the role of the major factors influencing the monitored subject,
- the establishment of clearly defined baseline information, including building on previous relevant work,
- the development of appropriate, robust and repeatable monitoring methods,

- ensuring that data are collected by trained or supervised personnel and that the data are stored correctly, e.g. in museums and herbaria.

The Biodiversity Foundation for Africa (BFA) and The Zambezi Society, under a sub-grant from AWF, carried out an assessment of existing biodiversity information on the Four Corners transboundary area. This area covers northwestern Zimbabwe, northern Botswana, the Caprivi Strip in Namibia, southwestern Zambia, and part of southeastern Angola. One activity of the project was to establish what aspects of biodiversity have been, or are currently being, monitored within the area. A second activity was to establish at least one permanent plot and record baseline information on its biodiversity. In an attempt to address the problem that biological field skills are becoming increasingly limited in the region, the BFA provided introductory training in field collection and identification to selected personnel from museums and herbaria from each of the Four Corners countries.

Earlier work by the BFA on a plot of miombo savanna near Kalomo in Zambia, was given the acronym SAVSKILL (Cotterill1995). Here the two objectives of developing standardised techniques to measure biodiversity in African savannas were combined with improving the technical skills to do the work. SAVSKILL was designed with a multidisciplinary approach so that a range of biological taxa could be measured in one area. The present Four Corners biodiversity plot could be considered as an extension of the Kalomo work.

This report is divided into three sections. The first section gives a brief overview of what biodiversity monitoring is being done in the region, while the second section describes and documents the permanent monitoring plot that was established in northwest Zimbabwe. The third section comprises individual reports from each taxonomic group: woody and herbaceous plants, insects and other invertebrates, reptiles and amphibians, birds and mammals.

1. STATUS OF BIODIVERSITY MONITORING

1.1 Introduction

Monitoring biodiversity, particularly of woody plants and large mammals, is by the very nature of the subjects, long term. Since many NGOs operate on relatively short-term budgets, and government agencies such as National Parks and Forestry suffer from diminishing funds, there is an understandable reluctance to undertake long term monitoring. Compounding the problem is the rapid turn over of staff and lack of field expertise in many key institutions. In some cases there is a huge volume of biological data that has already been collected over the years, but these frequently remain only partially analysed. Because of this, many biologists are hesitant to engage in what is often perceived to be 'collection of data for data's sake'. It is axiomatic that it pointless to start a monitoring programme without having clear objectives. And, since most biological monitoring is justified (economically at least) as leading to improved management and conservation, there is also a need to monitor the ecological processes that cause changes in biodiversity. This section gives a brief overview of what biodiversity monitoring is being done and where, concentrating on the national parks and forestry areas. However, it is by no means exhaustive and additions can undoubtedly be made.

The study was done in conjunction with an AWF survey of wildlife monitoring in the CBNRM areas by Lesley Boggs (2003), covering those parts of Botswana and Zimbabwe lying within the Four Corners area, but not those in Namibia or Zambia. Her report provides a useful synthesis of wildlife monitoring outside the national parks and protected areas. She compared the different systems of monitoring in each country and used the information to the identify criteria for developing a comprehensive monitoring programme that could be implemented across the region.

1.2 Methods

In an attempt to ascertain what biodiversity monitoring is currently being carried out in the project area, visits were made to key institutions in Botswana, Namibia, Zambia and Zimbabwe, and meetings held with relevant persons. What is presented here is a summary of the findings; more detailed reports on each country are available. Institutions and organisations visited were:

<u>Botswana</u>

- Harry Oppenheimer Okavango Research Centre, Maun (University of Botswana)
- Department of Biological Sciences, University of Botswana, Gaborone
- Department of Environmental Sciences, University of Botswana, Gaborone
- Department of Wildlife and National Parks, Gaborone and Kasane
- National Museum of Botswana, Gaborone
- EcoSurv, Gaborone (private consulting company)
- Kalahari Conservation Society, Gaborone
- Caracal, Kasane (conservation NGO)
- Private consultants

<u>Namibia</u>

- National Biodiversity Programme, Directorate of Environmental Affairs, Windhoek
- Community-Based Natural Resource Management group, Ministry of Environment, Windhoek
- National Botanical Research Institute, Windhoek
- Directorate of Forestry, Windhoek
- Research and Information Services (RAISON), Windhoek
- Integrated Rural Development and Nature Conservation, Katima Mulilo (NGO)

Department of National Parks, Katima Mulilo
CBNRM Coordinator for MET, Katima Mulilo

Zambia

Livingstone Museum, Livingstone
Zambia Wildlife Authority (ZAWA), Livingstone
ZAWA Head Office, Chilanga
Department of Forestry, Lusaka
Department of Biological Sciences, University of Zambia, Lusaka
Environmental Council of Zambia, Lusaka
Private consultants

Zimbabwe

National Parks and Wild Life Authority (Hwange National Park, Matetsi Safari Area, Victoria Falls)
Forestry Commission of Zimbabwe (Fuller Forest Area, Victoria Falls)
Natural History Museum, Bulawayo
National Herbarium, Harare
Wild Life Unit, Department of Veterinary Services, Harare

1.3 Results and Findings

1.3.1 *General*

An important cross-boundary research programme that involves South Africa, Botswana, Namibia and Zambia is the 'Kalahari Transect' promoted by the International Geosphere-Biosphere Programme. It is designed to explore continental-scale links between climate, biogeochemistry and ecosystem structure and function. Monitoring is one of the features of this research work.

1.3.2 *Botswana*

There appears to be little biodiversity monitoring going on within the Botswana portion of the Four Corners area. The major findings are:

a) There have been fairly regular aerial surveys of elephant (and some other large mammals) by the Department of Wildlife and National Parks. Conservation International has also carryied out counts of elephants in Chobe area, as well as in East Caprivi and southeastern Angola, but has been using a different census technique to the Wildlife Department. There are doubts about comparability of two methods.

b) The Okavango has been relatively well studied and there are several research programmes in the areas. Specifically on monitoring, the occasional AquaRAP programme is carried out by Conservation International. The Botswana Ornithological Society (BOS) and the Southern African Crane Working Group (SACWG) have recently undertaken an aerial survey of Wattled Cranes in the Okavango.

c) The Botswana Ornithological Society undertake occasional counts of waterfowl and flamingo on the Makgadikgadi Pans.

d) It is possible the BONIC programme, linking the University of Botswana with Norwegian universities, has much biological / monitoring data on the Chobe area, but unfortunately these data are not yet available.

e) The Department of Wildlife and National Parks is very keen to establish a biodiversity monitoring plot in Chobe National Park and monitoring schemes elsewhere in the north of the country.

f) The late Richard Bell apparently established vegetation monitoring plots, but no details of site and data recorded were located.

1.3.3 *Namibia*

a) There is a regional biodiversity monitoring programme, BIOTA, which has fixed sites throughout Namibia. The closest site to the Four Corners area is at Rundu in West Caprivi.
b) Apart from this, there does not appear to be any specific monitoring of plants, although there was reference to regeneration studies of timber species such as *Baikiaea* by Forestry. Fire incidence and fire coverage in the Forestry areas are also apparently recorded.
c) Some wild mammal populations, particularly elephant, are being monitored by NGOs and National Parks.
d) Fish catches are sometimes monitored, but this was from a CBNRM and not a biodiversity perspective.
e) There was no mention of monitoring birds, reptiles and amphibians, or insects.

1.3.4 *Zambia*

a) The main focus of monitoring has been in the Kafue National Park through a joint programme between the NGO Greenforce and ZAWA. The research was limited to the southern sector of the park and followed two main themes - biodiversity surveys of vertebrates, selected invertebrates and plants, and selected species; and site studies. The biodiversity surveys have been applied to a range of taxa: small mammals, amphibia, reptiles, butterflies, dragonflies, beetles, termites, vegetation. The programme ran from 1998-2003. Copies of specific reports are available from ZAWA and Greenforce.
b) There has been a recent (January 2004) aerial survey of large mammals of Sioma Ngwezi National Park by Conservation International.
c) Phase 2 of a Provincial Forestry Action Programme (PFAP) is ongoing in the Southern Province. This programme is essentially aimed at community stewardship of the forests and does not appear to monitor biodiversity.

1.3.5 *Zimbabwe*

a) Current monitoring of plant species in this part of the project area appears to be limited to three plots (Strict Natural Reserves) in Fuller and Ngamo Forests where growth rates of *Baikiaea*, *Pterocarpus angolensis* and *Guibourtia coleosperma* have been recorded over the past 10 years. In addition the Zimbabwe Forestry Commission have a series of permanent sample plots (PSPs) scattered along the Kalahari sands from Bulawayo to Victoria Falls, including two in Fuller Forest and one in Ngamo, specifically designed to monitor growth rates of selected timber species.
b) Recently, vegetation monitoring has focussed on the impact of tourism on the Victoria Falls "rainforest" and adjacent woodlands and is being undertaken by the National Parks Authority, funded through UNESCO. The design and duration of the project is not known.
c) Fire incidence and mapping of fires in National Parks and Forestry Areas was done regularly but the data have not been analysed in any detail. It is not known whether the recording of fires still continues.
d) The impact of elephants on vegetation is being monitored in a series of plots in Hwange National Park The plots were established by A. Conybeare in 1980 and were recorded annually until 1985, then again in 1992 and 2002. There are 9 plots in *Terminalia-Combretum* bushland, 9 plots in *Baikiaea* woodland, and 3 plots in *Acacia-Eragrostis* wooded grassland. Plot sizes varied according to plant density but were essentially belt transects along a 50 m base line. The shrub transects ranged from 50 to 250 m^2 for different species and trees from 2500 to 2750 m^2. Data that were recorded were:

- Shrubs (classified as all woody plants >0.5m<3m height) by species, number of stems, plant height, damage in three categories (elephant, frost, unknown). Fire damage was not measured as there were no fires during period 1980-1985.
- Trees (classified as all plants >3m height) by species, girth, height, damage in four categories (elephant, frost, unknown, bark damage).

e) The north west corner of Zimbabwe has a history of detailed wildlife monitoring through the regular aerial surveys of elephants and other large mammals. Recently, this work has been undertaken by WWF-SARPO in conjunction with National Parks. In addition, game populations in the Matetsi Safari Area and adjacent game ranches are monitored annually by National Parks personnel using the road strip count method. Recording of wildlife species varies according to vegetation type (and hence visibility), but when analysed the data can be used as a scientific basis on which to set hunting quotas. Lately this monitoring has been intermittent.

f) Other monitoring undertaken by National Parks is the measurement of trophy size and quality on key species hunted in the safari area, adjacent forest land and private land. This was developed as an index to track the sustainability of hunting in the area, as well as being a CITES requirement for the export of wildlife trophies by international hunters.

g) Annual game counts at waterholes across Hwange National park are carried out by volunteers through Wildlife and Environment Zimbabwe (formerly the Wildlife Society of Zimbabwe). Recently accumulated results have been analysed by researchers from CIRAD based in Hwange.

h) Raptor populations in the Batoka Gorge have been monitored at irregular intervals over the past 10 years. This programme is undertaken by the Zimbabwe Falconry Club.

i) An indirect form of monitoring the Nile Crocodile populations along the upper Zambezi river is through the annual collection of crocodile eggs from wild nests. Clutch size, number of fertile eggs and locality are recorded. Again, there has only been limited analysis of this data by the Crocodile Research Group.

j) There does not appear to be any monitoring of insects or fish.

k) The only monitoring of wildlife diseases is of *Trichinellosis* in crocodiles.

1.4 Discussion

This report is not comprehensive; additions and corrections are welcomed. However, several points have emerged:

- Biodiversity monitoring occurs to varying degrees throughout the study area, but with little consistency in objectives, methods, and degree of analysis. This complicates the comparison of results from one country to the next.
- There is very limited monitoring of plants, and that which does occur is focussed on aquatic invasive species such as *Salvinia molesta* and *Eichhornia crassipes,* or the economically important timber species such as *Baikiaea*.
- Vegetation monitoring is very limited and often undertaken as an addition to other research work.
- The main monitoring of ecological processes is recording of the incidence of fire and mapping of areas burnt. Even then there are different approaches and little analysis.
- Another ecological feature being monitored in parts of Botswana and Zimbabwe is the impact of elephant on plants and vegetation composition.
- Elephants are the only mammal species systematically monitored throughout the Four Corners area. Monitoring is through aerial surveys.

- The only monitoring of bird species and populations are the aerial surveys of Wattled Cranes in the Okavango, occasional counts of Lesser Flamingoes and other waterbirds in the Makgadikgadi Pans, and the raptor survey in Batoka Gorge.
- The only herpetological monitoring is of the Nile Crocodile on the Zimbabwe side of the Zambezi.
- There does not appear to be any insect monitoring in the Four Corners sections in any country, although there have been surveys following tsetse control programmes in the Okavango, Caprivi and Zambezi Valley.
- Fish and aquatic ecosystem monitoring has been carried out through the AquaRAP programme, but this is focussed on the Okavango.

SECTION 2. ESTABLISHMENT OF A PERMANENT PLOT AND TRAINING IN MONITORING BIODIVERSITY

2.1 Introduction

A major problem in detecting changes in biodiversity over time is usually the lack of baseline data and the relatively long periods (5-10 years) over which such changes have to be detected. Also, in most cases, only particular groups are monitored (trees, birds, large mammals). It is important that a range of biodiversity is recorded in a comparable manner using readily repeatable methods. Systematically recorded data on biodiversity from a fixed, relocatable plot has significant scientific value even in the absence of repeated monitoring.

The two main objectives for this exercise are (a) to find out the composition and relative abundance of a range of biological groups from a site representative of a large part of the Four Corners area, and to see changes in this over time, and (b) to provide some field training for technicians at regional biodiversity institutions.

It is intended to repeat the survey in some years' time to detect any changes in biodiversity composition and abundance. It is also hoped that this plot will act as a pilot for a network of similar plots to be established across the Four Corners transfrontier area.

2.2 Location of Study Site

After several field visits, a site was chosen for this monitoring and training exercise on part of Panda-Masuie Forest Land, some 25 km southeast of Victoria Falls in northwestern Zimbabwe (see Figure 2.1). The Director of the Forestry Commission of Zimbabwe kindly granted permission for the plot to be established on Forestry land. The plot lies on a ridge of red Kalahari sand supporting open woodland dominated by Zambezi Teak (*Baikiaea plurijuga*), and is considered moderately representative of this vegetation type within the Four Corners area. Elephant and other wild animals move freely through the area, although there is controlled hunting on both Forestry Land and adjacent private and state land. The forest forms part of the Matetsi Complex - a mosaic of national parks, safari area, forestry land and private land. The site has been logged in the past (70 years) and there is some nominal protection from illegal tree felling and wildfires. An additional consideration was that the site was accessible and practical logistically.

2.3 Participants

The training course was aimed primarily at technician level and participants were selected from a number of regional institutions involved in biodiversity recording. Selection was based on a representation of skills across the appropriate biological groups as well as on institution and country. A total of 20 trainees took part in the training programme from the 11-16 January 2004. Lecturers and trainers were from the BFA, Natural History Museum (Bulawayo), National Herbarium (Harare) and BirdLife Zimbabwe (see Appendix 1 for a list of participants, trainers and institutions). Accommodation was at the nearby Africa Centre for Holistic Resource Management (ACHRM) on Dibangombe Ranch. Field equipment was loaned by the BFA, Natural History Museum and National Herbarium, and vehicles were provided by individuals from the BFA, the Natural History Museum, the Forestry Commission and the ACHRM.

2.4 Permanent Plot

A one hectare plot was permanently marked in the northeastern corner of Panda Masuie Forest, near the old fire tower (see Figure 3.1 and Section 3.1). It formed the focus for surveys of plants, insects (split into butterflies and other insects), amphibians, reptiles, birds and mammals in the area. The field techniques used were similar to those developed by the BFA during a similar study in Kalomo,

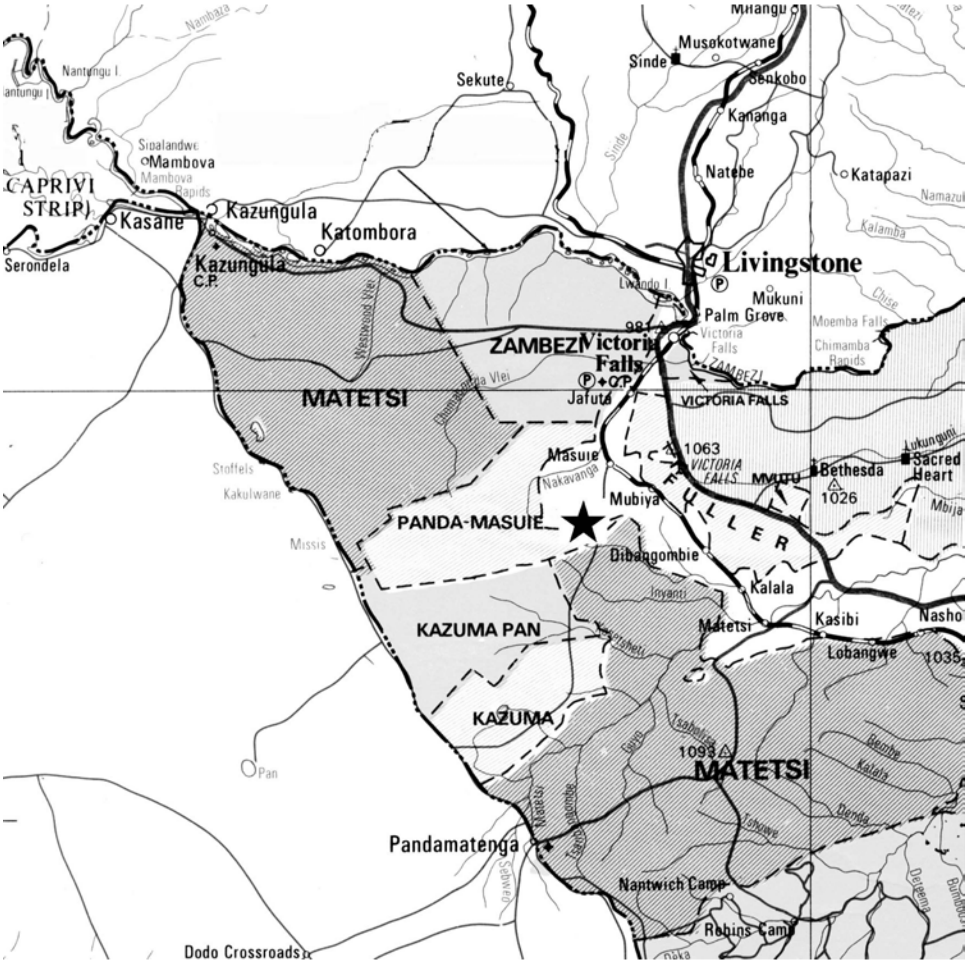

Figure 2.1. Location of monitoring plot (i) in Panda Masuie Forest, south of Victoria Falls, Zimbabwe.

southern Zambia in 1994 (Cotterill 1995), modified according to local conditions and following discussions between the trainers and the students. Students were initially grouped according to their disciplines, but on following days they rotated through the groups to gain an understanding of the various methods used by other groups. Slide shows, lectures and discussions were held each evening. Each taxonomic group prepared their own report under the guidance of the respective trainers, and are given in the following sections. Each report describes the methods used, a summary of the results and recommendations for future monitoring surveys. Checklists of species collected or sighted are given in the appendices.

2.5 Summary of Major Findings and Recommendations

Plants and Vegetation

- Although the plot measured 100 x 100 m (1 hectare), there was only time to make detailed records from one 50 x 50 m subplot. The plot needs to be re-visited to complete the data collection.
- A total of 31 woody species, 8 grasses and 38 other herbaceous species were recorded.
- The extrapolated basal area of all woody plants was 12.25 m² per hectare, of which 45% was *Baikiaea plurijuga*.
- *Panicum maximum* was the dominant grass species.

Insects (Coleoptera, Orthoptera, Hymenoptera and Diptera)
- Of the 28 insect species identified so far (Hymenoptera and Diptera have not yet been identified), the majority were beetles, with the two flightless tenebronid beetles and the giant dung beetle being the most common.
- There were 11 species of short-horned grasshopper.
- The survey time needs to be longer in order to reduce the sampling errors linked to the different life cycles and seasonality of the species.
- Species identification in the field is often difficult, so monitoring should focus on indicator taxa.
- The plot size of 100 x 100 m was too small for adequate sampling of the insect fauna.

Insects (Lepidoptera)
- Two sampling methods were tested - transect walk and random walk.
- *Eurema brigitta* was the most dominant species, followed by *Belenois aurota*. Both species are widespread and common.
- No rare or unusual species were found.
- Late October/early November, just prior to the rains, is a better time for sampling butterflies and other insects.
- Monitoring should be for a longer period so that more time can be spent on the transect walk method and all the possible species are recorded.
- The permanent plot was often crowded with several groups working in the same place.

Herpetofauna (Reptiles and Amphibians)
- Only 8 reptile species, including only one snake, were found. This was due to the timing of the field work. The long grass provided too much cover for snakes and tortoises to be found.
- 3 amphibians were found and this is probably all that occur in the area.
- Sampling time was too short.
- The late dry season, just prior to the rains is the best time to sample reptiles and amphibians.

Birds
- A total of 37 species were recorded in the transects.
- In the QDS, 102 species were recorded, of which 12 were Palaearctic migrants.
- The sampling period was too short and not all the possible species were recorded. The period needs to be increased to at least 5 days.
- It is important to acquaint the observers with the birds prior to the sampling. This reduces the number of unidentified species and mis-identifications.
- The early rainy season may be a better time to sample the birds as this is when many species are starting to breed and the migrants have arrived.

Mammals
- There was no sampling of small mammals due to logistical problems. This needs to be rectified. A fixed grid system of traps is considered to be the most appropriate method.
- A checklist of large mammals in the QDS was compiled from observations of spoor, droppings, burrows, sightings and discussions with wildlife experts from the ACHRM.
- A total of 51 large mammal species are known to occur in the area, including 5 large carnivores.

SECTION 3. INDIVIDUAL REPORTS ON THE PANDAMASUIE MONITORING PLOT

3.1 PLANT MONITORING

Jonathan Timberlake & Anthony Mapaura

3.1.1 Methods

After a reconnaissance visit to the Panda Masuie Forest Area, a site close to the main track through the forest area was chosen. It has a reasonable density of larger *Baikiaea* trees, and the shrub cover is not particularly dense (dense shrub cover indicates disturbance). Evidence of burning or logging is "normal" for the area.

A corner peg was placed about 20 m in from the track and the plot was marked out lying parallel to it. Both tape and compass and the 3-4-5 rule were used to get a right angle. Each side was 100 m in length, giving a total area of one hectare (Figure 3.1). Metal fencing stakes were hammered deep into the ground at each 50 m interval so that elephants would not pull them out. GPS readings (Garmin 12, WGS 84 datum) were taken at each corner (Table 3.1).

Table 3.1. GPS location points for Panda Masuie plot (Garmin 12, WGS 84 datum).

Peg 1	18º09.990' S / 25º44.382' E
Peg 7	18º10.015 S / 25º44.397' E
Peg 9	18º10.026' S / 25º44.372'E
Peg 10	18º10.017' S / 25º44.337' E

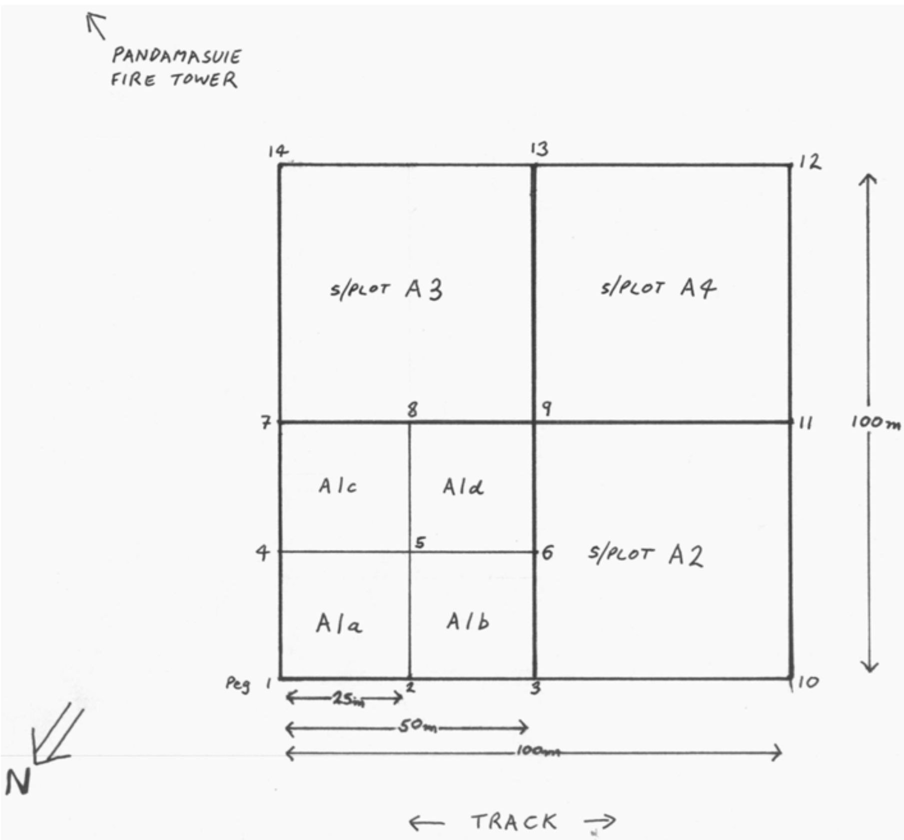

Figure 3.1. Layout of biodiversity monitoring plot, Panda Masuie Forest.

Time only allowed for one 50 x 50 m subplot to be recorded in detail. Recording was done on a 25 x 25 m sub-subplot basis, with temporary stakes put in at these distances.

Following a similar procedure to that used for the BFA monitoring plot at Kalomo, southern Zambia (based on Smithsonian Institution/Man and Biosphere standards, see Cotterill 1995), and on techniques used by the Zimbabwe Forestry Commission for the establishment of Permanent Sample Plots (Mkosana & Kwesha 1994), the parameters recorded were:

- diameter of all woody plants greater than 5 cm dbh (measured at 1.3 m from ground level)
- position of each tagged woody plant
- plant species present (woody and herbaceous).

In addition, cover-abundance values on non-woody species and non-tagged individuals of woody species were recorded.

Foresters often use a much higher stem diameter figure as they are interested in timber, and ecologists sometimes use a figure as small as 3 cm dbh, below which stems are almost too thin to effectively label. In this case 5 cm dbh was chosen as it was estimated it would give enough recorded stems in the plot for good data resolution without taking too many days recording.

Each woody plant with a diameter greater than 5 cm at 1.3 m (diameter at breast height, dbh) was marked using a small c.3 x 3 cm aluminium tag nailed into the trunk. Using a metal stamp, tags were numbered sequentially with the code "A001" ..., etc. If another plot is established in the vicinity it will become Plot B. For stems that were too small to effectively be nailed, the metal tag was loosely tied to a major branch using thin gauge wire. Diameters were measured using commercial forestry diameter tapes; the species was also noted. Numbering was done by starting in one corner and moving parallel to the baseline in swathes of about 5 m until the 50 m peg was reached, then returning in another 5 m swathe further in.

The positions of each tagged tree or large shrub were determined by running two 50 m tapes from the markers at 25 m intervals, along the baseline (see Figure 3.1). The distances at which each tape met the base of the plant (the mid-trunk point in the case of larger trees) were noted. Positions can later be mapped, although this was not done during the field exercise.

For each species in each of the four sub-subplots (1a to 1d), the cover-abundance value was visually assessed using a modified Braun-Blanquet scale (Table 3.2).

Table 3.2. Modified Braun-Blanquet Scale

Species frequency & estimated aerial cover	**Braun-Blaquet symbol**
Few, with small cover	0
Numerous, but less than 5% cover, or scattered with up to 5% cover	1
Any number with 5-25% cover	2
Any number with 26-50% cover	3
Any number with 51-75% cover	4
Any number with more than 75% cover	5

Woody plants more than 5 cm diameter were not assessed for cover-abundance owing to their relative large size compared to plot area. Plants were regarded as woody if they are included in Drummond (1975). In addition, a checklist of species within the whole one hectare plot was made (Appendix 5).

3.1.2 Results

Woody plant data were entered into a spreadsheet with individual numbered trees on one axis and diameters and positions on the other. Using the formula (diameter/2) x 2 x 3.142 in the spreadsheet the basal area was obtained (Appendix 2). This table was also rearranged to give totals by species (Appendix 3). Finally, Appendix 4 gives the positions of each tree by sub-subplot. These have not yet been mapped graphically.

There were 66 individual trees or large shrubs labelled of 12 different species, some having more than one stem (greatest number was four stems). Total basal area for all woody plants of 5 cm dbh and above was just over 3.06 m^2 in the subplot (Appendix 2), giving an extrapolated total of 12.25 m^2 per hectare. Of this, 5.5 m^2 (45%) was *Baikiaea*, comprised of 20 individuals (or 30% of the total). This figure compares to 7.55 m^2 in the Kalomo miombo plot (unpublished data, J. Timberlake).

The full species list with authorities is shown in Appendix 5 and comprises 31 woody species, 8 grass species and 38 other herbaceous species.

Cover-abundance of woody and herbaceous species is also shown in Appendix 5. Only woody plants less than 5 cm dbh (i.e. those that had not been numbered) are included here. The grass *Panicum maximum* is seen to be particularly important in all four sub-subplots.

3.1.3 Future Monitoring

Recording should be done again in about five years time. Most tags should still be present, and the opportunity can be taken to re-label trees if necessary. Growth rates are such that there should have been some recruitment into the minimum size class measured (5 cm dbh), some diameter increment growth, and some mortality, sufficient to get an indication of growth rates and population dynamics.

All parameters should be measured in as near as possible the same manner, with dbh measured at the same height from the ground of 1.3 m.

3.1.4 Participants

The following people were involved in the recording of plant data: Jonathan Timberlake (BFA, Bulawayo), Anthony Mapaura (National Herbarium, Harare), Christopher Chapano (National Herbarium, Harare), Andrew Mangwarara (National Herbarium, Harare), Kolethi Gumbo (Chesa Research Station, Zimbabwe Forestry Commission, Bulawayo), Jerifanos Bope (Zimbabwe Parks and Wildlife Management Authority, Victoria Falls), Kwanele Kanengoni (Zimbabwe Parks and Wildlife Management Authority, Hwange Main Camp), Daniel Mafokate (Botswana National Herbarium, Gaborone), Mbaki Muzila (University of Botswana Herbarium, Gaborone), Bongani Sethebe (Okavango Research Centre, Maun), and Biseck Sakala (Livingstone Museum, Zambia).

3.2 INSECT FAUNA: ENTOMOLOGY

Mukai Mawanza

3.2.1 Introduction

Insects and other invertebrates form the most diverse group of animals on earth and collectively, they are major energy conduits and are agents of nutrient cycling and plant pollination in various ecosystems (Samways 1989, New 1998). They can be used for conservation assessment and ecological monitoring in selected habitats or ecosystems for the following reasons: insects have short lifecycles, have high rate of population increase, high habitat specificity and hence can rapidly respond to environmental disturbance.

Due to the diversity of insects in form, habit, habitat and function, a number of different collecting methods have been developed to sample them (Southwood 1978). This report outlines some of the methods used to gather information on insect fauna in Panda Masuie Forest for the purposes of monitoring.

3.2.2 Methods

Given the vast diversity of insects, lack of taxonomic expertise for most groups and the time factor, sampling effort was focussed on selected groups that are popularly known for being bio-ecologically informative in terms of their abundance, species richness, taxonomic tractability and their suitability to reflect the ecological quality of the area. The groups mostly considered were butterflies (Lepidoptera: Rhopalocera), grasshoppers (Orthoptera), and beetles (Coleoptera). Attention was also given to any other species encountered during the sampling since their information contributes to a better knowledge of the area's ecosystem.

One group of collectors focussed on species counts on butterflies (see Section 3.3) while the other focussed on general collection of Coleoptera, Orthoptera and other groups present (Section 3.2). The sampling was done within the demarcated 1 hectare plot. The weather was generally warm with some occasional rainshowers received during the late afternoons.

Orthoptera and Coleoptera

Collecting and recording of grasshopper and beetle fauna in the study plot was done along four parallel band-transects each approximately 20 m wide and 100 m long. Hand-netting, hand-picking and visual observations were a combination of techniques used to collect and record the insects. Grasshoppers were collected by sweeping through the grass using hand nets, and most beetles encountered were picked up by hand. Names of species which could be readily identified in the field were recorded, and the specimen released alive. Some specimens which required further identification were collected, killed and packed in paper envelopes or wrapped between sheets of cotton wool. Each transect took an average of 45 minutes to walk over and the exercise was repeated twice each day, firstly in the late morning and secondly in the afternoon. Most insects are active during warmer periods of the day hence the timing of the sampling activity.

Ground-crawling beetles and crickets were also recorded from four pitfall traps set along the edge of the plot set by the Herpetology team. Recording of insects caught was done in the early morning of each day.

Butterflies and Cetoniini beetles

A total of five trap nets were hung from trees and were baited with rotten banana fruit. These were positioned linearly across the mid of the plot at 15 m intervals. The target groups were Nymphalid butterflies and Cetoniini beetles. Traps were checked after a minimum of three hours and the species caught were recorded and released alive. An extra 10 traps were also set by the other group of collectors and the results for the trap catches were pooled. Beetles specimens were killed and collected for further identification at the Natural History Museum in Bulawayo.

Hymenoptera and Diptera
Two Malaise traps were pitched, one in each half of the plot. Since most flying insects tend to fly along clearings in the vegetation, each trap was placed across this path. The targeted groups of insects were mostly flying Hymenoptera and Diptera. Methyl alcohol (70%) was used as the killing and preserving agent in the collecting bottles. The caught insects were collected each day after a period of at least 12 hours. The specimens were taken for identification at the Natural History Museum of Bulawayo.

3.2.3 Results
A total of 28 insect species (excluding butterflies) were identified with the majority being beetles (Coleoptera). Although intensive species counts were not done due to identification problems, some general observations were made on the relative abundance of taxa found present. Results on species found for each group are presented in Table 3.3.

Coleoptera
Fifteen species of beetles were recorded and represented by seven families. The two flightless Tenebronid ("toktokkie") species found were the most abundant on the forest floor of the study plot. Most Tenebronid species are scavengers, feeding on dead plant or animal remains and they are widespread in arid areas. The giant dung beetle, *Pachylomerus femoralis* was also common. The result does not reflect the richness and abundance expected of species of beetles in the study area mainly due to the timing of the sampling period.

Table 3.3. Number of Insect species for the focal taxa recorded in the study site.

Order	Family	No. species
Coleoptera	Carabidae	2
	Tenebrionidae	2
	Scarabaeidae	6
	Cerambycidae	1
	Elateridae	1
	Histeridae	1
	Lycidae	2
Orthoptera	Acrididae	11
	Sternopelmatidae	1
	Gryllidae	1
TOTAL		28

Orthoptera
A higher diversity of members of this taxon was expected, but an insignificant number of 13 species was recorded, predominantly represented by the short-horned grasshoppers (Acrididae). Most Orthoptera would be juveniles by the time samples were taken. March to April is the appropriate

period one could obtain a more representative species composition and diversity of this group in the area.

Hymenoptera and Diptera
The collection from the Malaise trap yielded 100 specimens belonging to two families of Hymenoptera and 384 specimens of Diptera, representing 14 families (Appendix 7). Most of specimens need further identification.

3.2.4 Problems Encountered and Possible Solutions

Unlike vertebrates, which can be detected over reasonably short surveys, surveys of insects to provide comprehensive data for monitoring purpose needed longer time to reduce sampling errors linked with differing species phenologies and seasonality. Several surveys should be done, especially during the wet season when most insects are mature and when food is abundant.

Most taxa of invertebrates cannot be identified to species level while they are alive in the field, hence estimates on abundance can be difficult without collecting and killing specimens for further identification in the laboratory. Killing might result in the destruction of some rare taxa. A sampling of targeted indicator taxa, which are easy to collect and identify, is recommended.

A monitoring plot of 1 hectare is too small for insects since most species are highly mobile, hence monitoring results may vary widely at different times and this may not be a reflection of ecological status of the area.

3.3 BUTTERFLY MONITORING

Alan J. Gardiner

3.3.1 Introduction

One of the activities under the Four Corners project was the technician-training course in biodiversity monitoring and the establishment of a monitoring plot. The plot was in Panda Masuie Forest south west of Victoria Falls. A single course was run covering as many biological groups as possible. This section covers the methods and results obtained for the invertebrates, in particular the butterflies. The advantages and disadvantages of using butterflies for environmental monitoring or as an indicator group has been discussed in a number of papers (including Gardiner 1997, New 1997 & Oostermeijer & Swaay 1998).

3.3.2 Materials and Methods

A permanent plot of 100 x 100 m was set up at a site on Panda Masuie Forest on Kalahari sands. From 13-15 January 2004 sampling of butterflies was carried out using two methods - a transect method (modified from Gardiner 1995) and a modified timed species count (Pomeroy 1992).

The transect method used an observer, a recorder and a timekeeper. A swath of 10 m was walked in a north-south direction, starting on the west edge of the plot. The observer was already familiar with the fauna from the area and only species difficult to identify were collected. The timekeeper noted the time at the beginning of the transect. When the transect began the timekeeper also started a stopwatch, which was stopped whenever a species was collected resuming again after collection of the specimen. Difficult species were identified later. The recorder kept note of all species and number of specimens seen in the transect. In this way a number of walks were done along the length of the transect.

The second method was to do a modified timed species count. This was done by walking randomly within the plot and neighbouring area (not more than 100 m on any side of the plot) for a fixed length of time of 10 minutes. When a species was seen it was noted but if more than one individual was seen at the same time only the presence and not the abundance was recorded. If a species was collected for identification the watch was stopped and started again after collection.

Analysis

Each transect or 10-minute random walk was taken as a sampling unit. Species accumulation curves were obtained, for both methods, by plotting accumulated number of species against walks and by using the software programme EstimateS with samples randomized 50 times (R.K. Colwell 1997, http://viceroy.eeb.uconn.edu/estimates). The data has been presented as species against walk number. For a fauna that is not diverse this is probably the best way of presenting the data (Willott 2001). In EstimateS, the ICE estimator, which uses the incidence of rare species in samples, was chosen for estimating total species richness.

Abundance plots are presented for the two methods. For abundance the two methods can only be compared in relation to one another (their pattern) and not the actual numbers. Only the transect method can be used for actual abundance as numbers per hectare can be calculated.

3.3.3 Results

A total of 35 species and 717 individuals were recorded from the study site (plot and 100 m on either side of it). The total number of species obtained by the transect method was 26 while an additional 6 species were obtained by the random walk. However, 28 minutes more was spent on the random walks (Table 3.4).

Table 3.4. Total number of species, individuals and samples for the two methods used. The total time spent on each method is also provided.

	No. species	No. indivs.	No. samples	Total time (min)
Transect walk	26	313	14	62
Random walk	32	404	9	90

The species accumulation curves indicate that neither method reached its asymptote although the transect method appears very close (Figure 3.2). The ICE species richness indicator (Figure 3.3) suggests the number of species can be estimated for the transect method but not for the random walk. The number of species estimated for the transect method was 32.

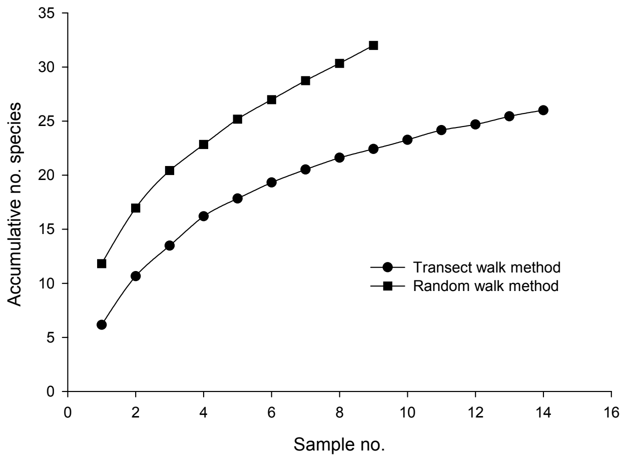

Figure 3.2. Observed accumulative species curves for the two sampling methods, the curves smoothed by randomising sample order 50 times.

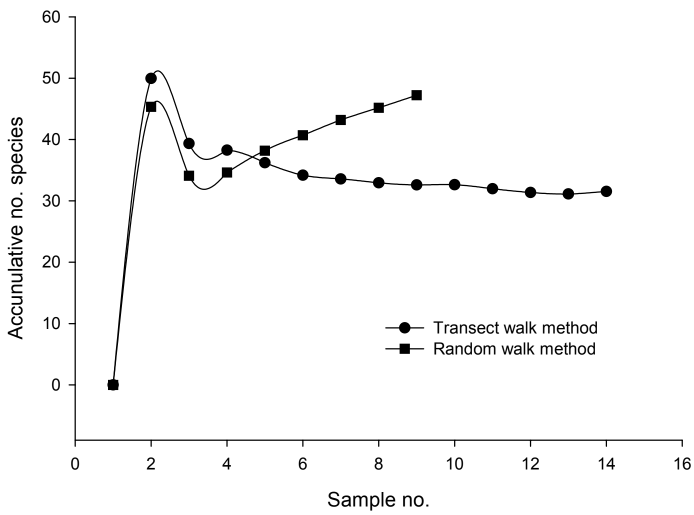

Figure 3.3. Species accumulation curves estimated using the Incidence-based Coverage Estimator (ICE).

The abundance graphs (Figure 3.4) give the standard invertebrate abundance distribution with the community dominated by a few species and a larger number of less abundant species. Both methods had *Eurema brigitta* as the most dominant species; the next most abundant was *Belenois aurota*. There is some similarity in the two methods when looking at the ten most abundant species. There is less similarity with the rarer species, as would be expected.

(a)

(b)

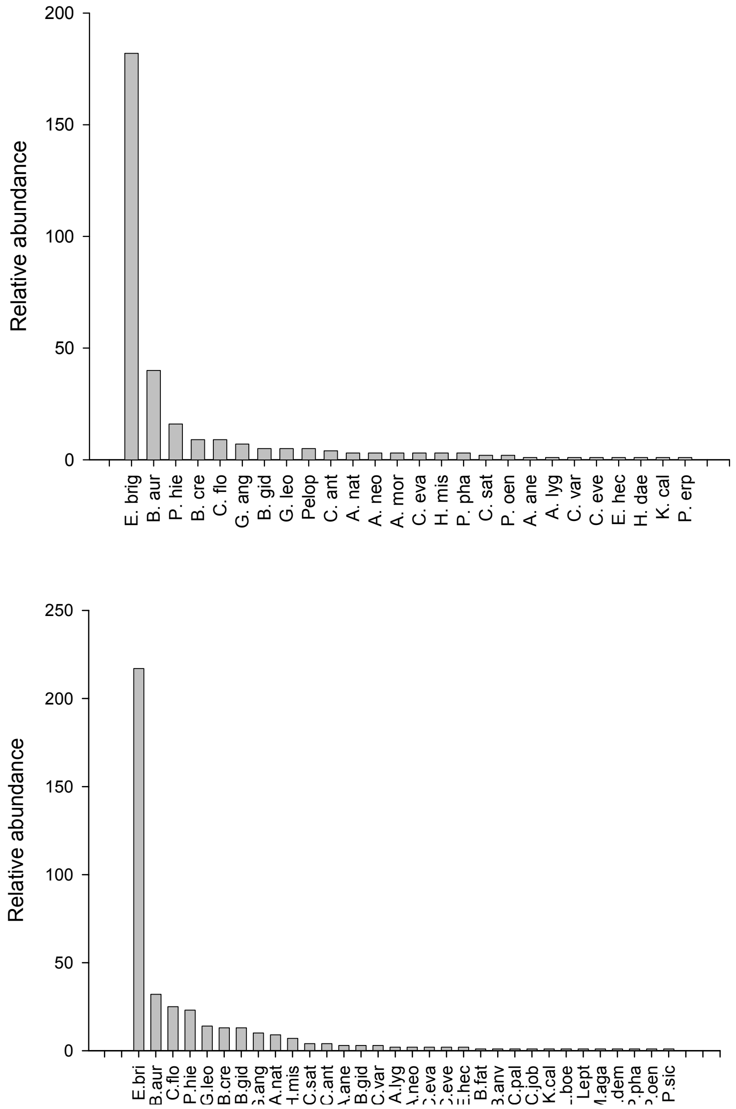

Figure 3.4. Relative abundance of species using (a) the transect method, and (b) the random walk method. See Appendix 7 for species names.

3.3.4 Discussion

It would be preferable not to have all the groups monitored at the same time because of differences in suitability of the period for the different biological groups. Taking into account the climate of the Four Corners area, for butterflies, and most other invertebrates, late October to early November (just prior to the rains) or April (just after the rains) would be the most suitable period for sampling. Monitoring should also take place over a longer time period. Unfortunately these requirements are often not met due to budgetary limitations.

More time should have been spent on the transect method, although the result of about 32 species for the plot is probably quite close to the truth for that time of year. The random walk method took into account a larger area and so if one were looking for the total number of species for the landscape it would be higher. Unfortunately more random walks are required to get an estimate of this. The fauna was dominated by a few very common widespread species. All the species observed are widespread and no particularly rare or interesting species were found.

3.4 HERPETOLOGY MONITORING

Don Broadley

3.4.1 Materials and Methods

The herpetofauna of the area surrounding the permanent vegetation monitoring plot (18º 10' S: 25º 44' E) was sampled by both active and passive collecting techniques. Active collecting mainly consisted of stripping loose bark off logs, rolling them over and digging beneath them. We also demolished those that had been partially eaten by termites. A few lizards were collected on tree trunks. Passive collecting was by means of pitfall traps linked by plastic drift fences. Two arrays comprised five and six 20 litre plastic buckets respectively, in each case a central one connected to the radiating peripheral ones by six metres of plastic sheeting 35 cm high, with 5 cm below ground level. The two arrays were about 20 m apart, separated by a large fallen tree. Two additional small arrays each comprised two 5 litre buckets connected by nine metres of 15 cm high plastic lawn divider, but these only trapped one skink and some beetles.

3.4.2 Results

The following reptile and amphibian species were collected in and around the monitoring plot.

REPTILES

Chamaeleo dilepis Leach — Common Flap-neck Chameleon

One male was collected within the vegetation monitoring plot on a small tree.

Lygodactylus capensis (A. Smith) — Cape Dwarf Gecko

Two were collected on tree trunks, others were seen on logs.

Typhlacontias rohani Angel — Kalahari Burrowing Skink

Six specimens of this small limbless skink were found when digging holes for pitfall traps (which trapped three) or under logs. A tissue sample was taken for DNA sequencing.

Trachylepis wahlbergii (Peters) — Wahlberg's Skink

Two specimens were shot on tree trunks, one was under loose bark and another in a pitfall trap.

Lygosoma sundevallii (A. Smith) — Sundevall's Writhing Skink

Seven specimens were taken under logs. A tissue sample (tail) was taken.

Panaspis maculicollis Jacobsen & Broadley — Spotted-neck Snake-eyed Skink

This was the commonest fossorial skink, 10 were caught in pitfall traps or found by digging under and around logs, several others escaped into the dense ground cover. A tissue sample (tail) was taken.

Zygaspis quadrifrons (Peters) — Kalahari Round-snouted Worm-lizard

Two of these small amphisbaenians were collected by digging around logs.

Dispholidus typus (A. Smith) — Boomslang

The only snake seen was a male Boomslang which was shot with .22 dust shot, but it escaped in the long grass.

AMPHIBIANS

Bufo poweri Hewitt — Kalahari Toad

Five subadults were taken in pitfall traps following showers. In morphology they are somewhat intermediate between *B. poweri* and *B. garmani* (which is usually found on harder substrates), but the dorsal blotches are brown as in specimens from Hwange National Park: these blotches are red or maroon in *B. garmani.* A tissue sample was taken.

Breviceps adspersus Peters — Bushveld Rain Frog

One specimen was dug up from beneath a rotten log.

Tomopterna cryptotis (Boulenger) — Tremolo Sand Frog

One specimen was taken in a pitfall trap after rain. It is assigned to *T. cryptotis* on the basis of its reduced webbing and Kalahari sand habitat, but in other morphological characters and colouration it agrees with *T. marmorata*, which is usually found in riparian habitats.

3.4.3 Discussion

The variety of reptile species collected was disappointing. To a large extent this was due to the short-term operation being carried out relatively late in the season, when the vegetation (particularly *Panicum* grass) was thick, so that tortoises and snakes would be difficult to spot. However, the lack of thick-toed geckos (*Pachydactylus* spp.), which are found under loose bark and under logs, was surprising, *P. turneri, P. oshaughnessyi* and *P. punctatus* were all expected to occur. The absence of plated lizards (*Gerrhosaurus*) and lacertids (*Heliobolus, Ichnotropis* and *Nucras*) was also remarkable. These fast-moving lizards are normally seen running across the roads and can be tracked down and dug out of their burrows. The relatively high number of fossorial (burrowing) species (3 skinks and 1 amphisbaenid) show adaptation to the long dry season and sandy substrate.

The three species of amphibians taken probably represent the full quota of species for this area. *Breviceps adspersus* is a typical inhabitant of Kalahari sand regions, as its tadpole undergoes direct development within the egg. *Bufo* and *Tomopterna* both require pans to breed in and there seem to be none close to the monitoring plot, which is on a ridge.

A better time for sampling the herpetofauna of the area would be the late dry season, just as the rains begin and the insects are hatching. This is also when the reptiles have warmed up after their hibernation and the amphibians come out of their burrows and commence breeding with the sudden arrival of moisture.

3.5 BIRD SURVEY AND MONITORING

Ngoni Chiweshe, Clare Mateke & Peter Mundy

3.5.1 Introduction

Several monitoring methods for birds have been used in Africa: a recent unpublished review noted eight (Mundy 1998). As we understood it in this work, monitoring involves both counting individuals and also identifying to species. Whereas the latter activity, called 'atlassing', has become very popular in Africa during the last 20 years, censusing has lagged behind. Various publications have appeared trying to rectify this (e.g. Pomeroy 1992), and Mundy (1998) has reviewed the topic.

In some of the projects undertaken by the BFA, counting organisms has been an activity in addition to documenting the biodiversity. The first major effort, in terms of a methodological exercise, was made by the BFA in southern Zambia in 1994 (Cotterill 1995), and birds were included (Hustler 1995). So far nothing further has been done at that site. The opportunity was therefore taken in the Four Corners project to start a monitoring programme. The present report gives our methods and results for birds.

3.5.2 Methods

The monitoring plot was set up in open *Baikiaea* woodland, and we therefore looked for a method suitable for such a habitat. Fortunately birds are fairly conspicuous in open woodland and also use their voices, so no special techniques are required, just sharp eyes and sharp ears.

As an initial team of five (the authors plus Sue Childes and Boniface Magwezi) the first two hours were spent designing the method starting from first principles. We decided not to do night time work due to the possible presence of elephants and logistical problems. Secondly we decided to do only one count per day, in the early hours of the morning, starting just after dawn, as this is the period when most woodland birds are at their most active. Finally we used two methods: one that counted the individual birds along transects, and the other which noted the diversity of species in the whole area by searching and observing, called 'atlassing'.

The vegetation type was fairly uniform, with the exception of a small (0.1 ha) that comprised an invasion of *Terminalia* woodland by point F. On the afternoon of 13 January, we walked the first transect together (in the showering rain) to test the method, It took us 33 minutes in the mid-afternoon.

The bird-sampling plot was chosen after having climbed a nearby fire tower that enabled us to see the extent of the targeted vegetation type, the *Baikiaea* woodland on a ridge of Kalahari Sand. Three transects, 200 m apart and averaging 730 m long, were marked with a GPS. They were placed and measured using a car speedometer and double-checked using the GPS. The three transects started from one permanent road and ended at the other road. We used existing permanent roads as a guide to marking the beginning and end of each transect, in order to make the transects easy to find. The first transect (A to B) is in line with the north-eastern edge of the biodiversity monitoring plot and the other two run parallel to it.

The team comprised three observers and a recorder. Because of the denseness of the sampling plot (both the tree canopy and undergrowth) at the time of the sampling period, the full search area for the observers was restricted to 50 m wide. The outer observers walked at a distance of 25 m apart, with the central observer and the recorder walking along the transect line. This meant that the outer observers were walking at 12.5 m parallel to the transect line. Observers walked slowly (< 1.5 km/h) along transects, showing each other the birds seen along the way so as to reduce the chances of double counting. Only those birds seen or heard calling within the overall transect width and in front of the observers were recorded; high flyers were ignored. The start and finishing time for each transect was recorded and the weather condition was also recorded for the sampling period.

Table 3.5. GPS coordinates for bird transects.

Transect	Point	Coordinates
1	A	$18^0$09.977'S; $25^0$44.376'E
	B	$18^0$10.354'S; $25^0$44.599'E
2	C	$18^0$10.351'S; $25^0$44.448'E
	D	$18^0$10.016'S; $25^0$44.268'E
3	E	$18^0$10.057'S; $25^0$44.165'E
	F	$18^0$10.389'S; $25^0$44.244'E

The sampling started at point A on Day 1 (14 January), and was reversed (starting at point F) on the second day (15 January). This was done so as to have unbiased data sets.

A checklist of birds for the quarter-degree square (QDS 1825 B2) incorporating the sampling plot was compiled. The bird species were marked according to the habitat and soil type at which they were encountered, mainly in the *Baikiaea* (Kalahari sands) and mixed woodland/open shrubland (basalt area), the two main habitats within the study area. This was aimed at recording all the species of birds that utilize the general area.

3.5.3 Results

The results of the transects are presented in Tables 3.6 and 3.7. The average time spent per transect was 36 minutes (range 30-43 minutes) with transect lengths ranging between 690 m and 770 m. The combined list seen during the two sampling days came to 37 species, which produced a total of 203 individual birds, including 11 unidentified to species. This gave an average of 0.94 birds per minute. About the same number of birds was seen each morning.

Table 3.6. Avian sampling results for Day 1 (14 Jan 2004). Weather partly cloudy (2/8 cloud cover), warm and calm.

Species		**Transect 1**	**Transect 2**	**Transect 3**
English name	***Scientific name***	06h33-07h03	07h14-07h46	07h59-08h28
		770 m	730 m	690 m
Swainson's Francolin	*Francolinus swainsonii*			4
Cape Turtle Dove	*Streptopelia capicola*	5	2	1
Green-spotted Dove	*Turtur chalcospilos*	1	1	
Pennant-winged Nightjar	*Macrodipteryx vexillaria*			1
European Bee-eater	*Merops apiaster*	10		
Striped Kingfisher	*Halcyon chelicuti*	1		2
African Hoopoe	*Upupa epops*	2	1	
Grey Hornbill	*Tockus nasutus*	1	1	

Golden-tailed Woodpecker	*Campethera abingoni*	1	1	
Fork-tailed Drongo	*Dicrurus adsimilis*		2	
Black Flycatcher	*Melaenornis pammelaina*		1	
Yellow-bellied Bulbul	*Chlorocichla flaviventris*		1	
Southern Black Tit	*Parus niger*	1	2	
Kurrichane Thrush	*Turdus libonyana*		1	
White-browed Scrub Robin	*Erythropygia leucophrys*	2		
Stierling's Barred Warbler	*Camaroptera stierlingi*			1
Spotted Flycatcher	*Muscicapa striata*		1	
Chinspot Batis	*Batis molitor*		2	
Brubru	*Nilaus afer*	1	1	
Plum-coloured Starling	*Cinnyricinclus leucogaster*	4		
Scarlet-chested Sunbird	*Nectarinia senegalensis*		1	2
Yellow-throated Sparrow	*Petronia superciliaris*		10	3
Grey-headed Sparrow	*Passer griseus*	3		
White-winged Widow	*Euplectes albonotatus*	9		
Blue Waxbill	*Uraeginthus angolensis*	1		
Yellow-eyed Canary	*Serinus mozambicus*			1
Golden-breasted Bunting	*Emberiza flaviventris*		6	2
Unidentified species		1	3	
Totals (27+ species)		**43**	**37**	**17**
Species per transect		14+	16+	9

Table 3.7. Avian sampling Day 2 (15 Jan 2004). Weather overcast (8/8 cloud cover) but calm.

Species		**Transect 1**	**Transect 2**	**Transect 3**
English Name	***Scientific Name***	06h32-07h11	07h17-08h00	08h04-08h47
		770 m	730 m	690 m
Lizard Buzzard	*Kaupifalco monogrammicus*		1	2
Cape Turtle Dove	*Streptopelia capicola*	1	2	1
Rufous-cheeked Nightjar	*Caprimulgus rufigena*			2
Striped Kingfisher	*Halcyon chelicuti*	1		1
African Hoopoe	*Upupa epops*			1
Slender-billed Honeyguide	*Prodotiscus zambesiae*	1		
European Swallow	*Hirundo rustica*	6		1
Fork-tailed Drongo	*Dicrurus adsimilis*		3	3

Black Cuckooshrike	*Campephaga flava*		1	
African Golden Oriole	*Oriolus auratus*		2	2
Paradise Flycatcher	*Terpsiphone viridis*	3	2	1
Southern Black Tit	*Parus niger*		2	
Kurrichane Thrush	*Turdus libonyana*			2
White-browed Scrub Robin	*Erythropygia leucophrys*		1	
Willow Warbler	*Phylloscopus trochilus*		3	1
Spotted Flycatcher	*Muscicapa striata*	3	1	2
Black Flycatcher	*Melaenornis pammelaina*			1
Chinspot Batis	*Batis molitor*		3	2
Red-billed Helmet Shrike	*Prionops retzii*			3
Plum-coloured Starling	*Cinnyricinclus leucogaster*		1	2
Scarlet-chested Sunbird	*Nectarinia senegalensis*	3	2	2
Yellow-throated Sparrow	*Petronia superciliaris*	2	7	9
Yellow-eyed Canary	*Serinus mozambicus*	3	1	
Black-eared Canary	*Serinus mennelli*		2	
Golden-breasted Bunting	*Emberiza flaviventris*	1		3
Unidentified species		3	2	2
Totals (25+ species)		**27**	**36**	**43**
Species per transect		10+	16+	19+

Figure 3.5 shows the cumulative species graph. One should really continue counting birds in transects until the curve flattens out horizontally, implying no new species (or negligibly few). It is clear from this graph that the curve is not showing signs of flattening yet, and would require a few more observation days to do so. Our sampling period was very short.

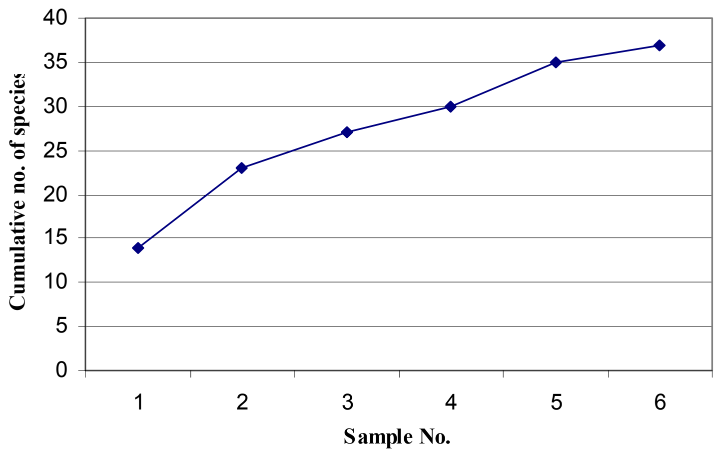

Figure 3.5. Cumulative species graph for birds observed at Pandamasuie Forest.

The four days of checklist for the QDS came to 102 species, with 54 of the species having been recorded in the Kalahari sands and 48 in the basalt (mixed woodland, dominated by *Colophospermum mopane* trees) (Appendix 6). Only 12 of the species were Palaearctic migrants, which suggests that the majority of the species are resident in the area.

3.5.4 Discussion

This method can be modified to be carried out three times per day, that is (a) from sunrise to 08h30, (b) mid-morning (09h00-12h00), and (C) at dusk (16h00 to sunset). It is important to sample the area during the very early morning and late evening so the crepuscular and nocturnal birds are counted. Identification of calls of these birds becomes important when visibility is poor, and the use of tape-recorded calls to elicit responding calls may be useful. The number of days should be increased to five so as to get sufficient data per sampling period. The number of observers could be reduced to two plus a recorder so as to reduce disturbance to birds. Observers should acquaint themselves with the bird life in the study area first, preferably for two days, before the actual data collection starts. This helps to reduce the chances of having high numbers of misidentifications and unidentified species. In order to reduce the time spent travelling to the study site, and to maximise the chances of recording nocturnal species, it may be worthwhile camping overnight close to the site.

Bird numbers and distribution fluctuate according to the season and ideally the site should be visited during the dry season, early rainy season (when many birds are starting to breed and are therefore very vocal and visual), and late rainy season. Bird parties are a common phenomenon in winter and the sampling methods may need to be adjusted to take this into account.

3.5.5 Acknowledgements

This survey was funded by the AWF Four Corners Project. The birding group was made up of the three writers plus Sue Childes and Boniface Magwizi. We thank the Biodiversity Foundation for Africa for their technical and logistical support, and our hosts, the Africa Centre for Holistic Resource Management, for their warm welcome, accommodation and care during our stay.

3.6 MAMMALS

Clare Mateke

3.6.1 Introduction

The original plan for the mammals was to provide baseline data on the species richness and abundance of the small mammals of the area. However, due to logistical problems, including lack of sampling equipment, it was not possible to assess the small mammal population. Nevertheless, during the three-day study period, note was taken of any evidence of the presence of medium to large mammals. This report therefore provides baseline data on the medium to large mammals in the area.

3.6.2 Methods

During fieldwork with other groups, the author took note of any evidence of mammals in study area and the surrounding area. These included the presence of spoor, droppings, burrows, and visual records of the animals themselves. To supplement this material, the author interviewed two local wildlife experts to find out what species are known to be present in the area.

3.6.3 Results

The results, presented in Table 3.8, consist of a species list of medium to large mammals, based on evidence during the 3-day study as well as visual records over the last two to three years. Although small mammals, including rodents and bats, were obviously present, as shown by evidence of rodent burrows, and confirmed by the local people interviewed, it was not possible to list the species, as these had not been studied.

The study area and much of the surrounding area is under government or private protection. Some parts allow professional hunting under licence. The results showed a high diversity of large mammals present in the area, including almost all the large southern African carnivores and thirteen antelope species.

Table 3.8. List of medium and large mammals occurring near the permanent plot on Kalahari sand (*Baikiaea* woodland) and in the surrounding basalt/clay area (Mopane woodland).

Scientific Name	**Common Name**	**Sighted**	**Spoor**	**Faeces**	**Burrows**	**Known to occur**
Papio ursinus	Chacma baboon	*				*
Cercopithecus aethiops	Vervet monkey					*
Galago moholi	Lesser bushbaby					*
Lepus saxatilis	Scrub hare					*
Paraxerus cepapi	Tree squirrel					*
Pedetes capensis	Spring hare					*
Hystrix africaeaustralis	Porcupine		*			*
Canis mesomelas	Black-backed jackal					*
Canis adustus	Side-striped jackal					*
Lycaon pictus	Painted hunting dog					*
Aonyx capensis	Cape clawless otter		*			*
Mellivora capensis	Honey badger					*
Ictonyx striatus	Striped polecat					*
Mungos mungo	Banded mongoose					*
Galerella sanguinea	Slender mongoose	*				*

Ichneumia albicauda	White-tailed mongoose					*
Helogale parvula	Dwarf mongoose					*
Cynictis penicillata	Yellow mongoose					*
Genetta genetta	Small spotted genet					*
Genetta tigrina	Large spotted genet					*
Civettictis civetta	Civet			*		*
Crocuta crocuta	Spotted hyaena		*			*
Proteles cristatus	Aardwolf					*
Felis lybica	African wild cat					*
Felis serval	Serval		*			*
Felis caracal	Caracal					*
Acinonyx jubatus	Cheetah					*
Panthera leo	Lion					*
Panthera pardus	Leopard					*
Orycteropus afer	Ant bear				*	*
Loxodonta africana	Elephant	*	*	*		*
Heterohyrax brucei	Yellow-spotted rock dassie					*
Equus burchelli	Burchell's zebra	*	*			*
Phacochoerus aethiopicus	Warthog	*		*		*
Potamochoerus porcus	Bushpig					*
Hippopotamus amphibius	Hippopotamus					*
Giraffa camelopardalis	Giraffe	*				*
Syncerus caffer	Buffalo		*	*		*
Taurotragus oryx	Eland	*				*
Tragelaphus strepsiceros	Kudu	*		*		*
Tragelaphus scriptus	Bushbuck					*
Hippotragus niger	Sable antelope	*	*	*		*
Kobus ellipsiprymnus	Common waterbuck					*
Redunca arundinum	Reedbuck					*
Connochaetes taurinus	Blue wildebeest					*
Damaliscus lunatus	Tsessebe					*
Aepyceros melampus	Impala			*		*
Oreotragus oreotragus	Klipspringer					*
Raphicerus campestris	Steinbok					*
Raphicerus sharpei	Sharpe's grysbok	*				*
Sylvicapra grimmia	Common duiker					*

Known column: pers. comm. Bongani Dlodlo (Game Scout) & Roger Parry (Manager), Africa Centre for Holistic Resource Management.

3.6.4 Conclusions and Recommendations

A survey of the small mammals is still required for the study area. It has been suggested that rodents be monitored on a permanent grid in the permanent study area using live traps (Cotterill 1995), and that estimates of total species richness be obtained from mammal abundance data collated from such a grid and other techniques.

The high diversity of large mammals, including carnivores, indicates that the ecosystem is relatively intact and functional. Continued conservation of this area and adjacent land will help maintain the long-term integrity of the system.

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APPENDIX 2. **Tree measurements, Panda Masuie Forest, Plot A.**

Plot	subplot	Tree no.	Species	dbh 1 (cm)	dbh 2 (cm)	dbh 3 (cm)	dbh 4 (cm)	basal area @ dbh (m2)	notes
A	1	1	Comb moll	14				0.0196	leaning
A	1	2	Baph mass	6.5				0.0042	@1.2m
A	1	3	Baik plur	19.8				0.0392	
A	1	4	Baik plur	8.7	5.6			0.0107	
A	1	5	Grew mont	5				0.0025	
A	1	6	Baph mass	6.5				0.0042	
A	1	7	Pter ango	53.7				0.2884	
A	1	8	Comb apic	8.7	9.3	8	6	0.0254	also 5.6cm
A	1	9	Julb glob	28.9				0.0835	DEAD
A	1	10	Baik plur	45.5				0.207	
A	1	11	Baik plur	18.8	9.5	18.6		0.079	@1.4m
A	1	12	Comm moss	7.6				0.0058	
A	1	13	Comb apic	5.1				0.0026	
A	1	14	Baph mass	5.1				0.0026	
A	1	15	Baph mass	5.5				0.003	
A	1	16	Comb apic	6	7.6			0.0094	
A	1	17	Comm moss	13.7				0.0188	
A	1	18	Baik plur	53.6				0.2873	
A	1	19	Baik plur	36.8				0.1354	
A	1	20	Baik plur	20.1	14.2			0.0606	
A	1	21	Baik plur	9.3				0.0086	
A	1	22	Baph mass	5.4				0.0029	
A	1	23	Julb glob	16.4				0.0269	@1.2m
A	1	24	Pseudo mapr	8.1				0.0066	
A	1	25	Julb glob	17.2				0.0296	
A	1	26	Dipl cond	8.3				0.0069	
A	1	27	Julb glob	27.9				0.0778	DEAD
A	1	28	Julb glob	10.7				0.0114	
A	1	29	Baik plur	25.4				0.0645	
A	1	30	Baik plur	30.1	33.2			0.2008	
A	1	31	Marg disc	15.4	16.4	12.2	11.8	0.0764	
A	1	32	Baik plur	18.1	33			0.1417	
A	1	33	Baik plur	19				0.0361	
A	1	34	Baik plur	5.6				0.0031	
A	1	35	Julb glob	18.5				0.0342	

Plot	**subplot**	**Tree no.**	**Species**	**dbh 1 (cm)**	**dbh 2 (cm)**	**dbh 3 (cm)**	**dbh 4 (cm)**	**basal area @ dbh (m2)**	**notes**
A	1	36	Baph mass	6.3				0.004	
A	1	37	Marg disc	18.2	9			0.0412	
A	1	38	Marg disc	27.6	15.2	18.8		0.1346	
A	1	39	Pter ango	54.5	53.4			0.5822	
A	1	40	Comm moss	5.7				0.0032	
A	1	41	Baik plur	5.5	5.3			0.0058	
A	1	42	Comm moss	8.4	6.6			0.0114	
A	1	43	Baph mass	9.5	7.2	5.8		0.0176	
A	1	44	Comb apic	5.5				0.003	
A	1	45	Comm moss	6.2				0.0038	DEAD
A	1	46	Comm moss	6.7				0.0045	
A	1	47	Baph mass	5.4				0.0029	DEAD
A	1	48	Grew mont	5.5				0.003	
A	1	49	Baph mass	5.9	6.4			0.0076	
A	1	50	Comb apic	5.7				0.0032	
A	1	51	Comb apic	5.9				0.0035	
A	1	52	Comm moss	5.5				0.003	
A	1	53	Baik plur	5.8				0.0034	
A	1	54	Baik plur	11.3				0.0128	
A	1	55	Comm moss	6.4				0.0041	
A	1	56	Julb glob	26.6				0.0708	
A	1	57	Baph mass	5.6				0.0031	
A	1	58	Baik plur	19.4				0.0376	
A	1	59	Comm moss	5.8				0.0034	
A	1	60	Comb apic	13				0.0169	
A	1	61	Baik plur	5.9	18.2			0.0366	@1.0m
A	1	62	Erythro afri	5.7				0.0032	
A	1	63	Baph mass	5.4				0.0029	
A	1	64	Julb glob	9.2				0.0085	
A	1	65	Baik plur	5.2				0.0027	
A	1	66	Baik plur	6.4				0.0041	
n = 66				**TOTAL B.A. @DBH (m2)**				**3.0617**	

APPENDIX 3. **Tagged trees arranged by species, with total basal area, Panda Masuie Forest, plot A.**

Plot	subplot	Tree no.	Species	dbh 1 (cm)	dbh 2 (cm)	dbh 3 (cm)	dbh 4 (cm)	basal area @dbh (m^2)	Total BA (m^2)
A	1	30	Baik plur	33.2	30.1			0.2914	
A	1	18	Baik plur	53.6				0.2873	
A	1	32	Baik plur	33	18.1			0.2506	
A	1	10	Baik plur	45.5				0.207	
A	1	19	Baik plur	36.8				0.1354	
A	1	11	Baik plur	18.8	18.6	9.5		0.0861	
A	1	29	Baik plur	25.4				0.0645	
A	1	20	Baik plur	20.1	14.2			0.0606	
A	1	3	Baik plur	19.8				0.0392	
A	1	58	Baik plur	19.4				0.0376	
A	1	61	Baik plur	18.2	5.9			0.0366	
A	1	33	Baik plur	19				0.0361	
A	1	54	Baik plur	11.3				0.0128	
A	1	4	Baik plur	8.7	5.6			0.0107	
A	1	21	Baik plur	9.3				0.0086	
A	1	41	Baik plur	5.5	5.3			0.0058	
A	1	66	Baik plur	6.4				0.0041	
A	1	53	Baik plur	5.8				0.0034	
A	1	34	Baik plur	5.6				0.0031	
A	1	65	Baik plur	5.2				0.0027	**1.5837**
A	1	43	Baph mass	9.5	7.2	5.8		0.0176	
A	1	2	Baph mass	6.5				0.0042	
A	1	6	Baph mass	6.5				0.0042	
A	1	36	Baph mass	6.3				0.004	
A	1	49	Baph mass	5.9	6.4			0.0076	
A	1	57	Baph mass	5.6				0.0031	
A	1	15	Baph mass	5.5				0.003	
A	1	47	Baph mass	5.4				0.0029	
A	1	22	Baph mass	5.4				0.0029	
A	1	63	Baph mass	5.4				0.0029	
A	1	14	Baph mass	5.1				0.0026	**0.0551**
A	1	60	Comb apic	13				0.0169	
A	1	8	Comb apic	8.7	9.3	8	6	0.0254	
A	1	16	Comb apic	6	7.6			0.0094	

Plot	**subplot**	**Tree no.**	**Species**	**dbh 1 (cm)**	**dbh 2 (cm)**	**dbh 3 (cm)**	**dbh 4 (cm)**	**basal area @dbh (m^2)**	**Total BA (m^2)**
A	1	51	Comb apic	5.9				0.0035	
A	1	50	Comb apic	5.7				0.0032	
A	1	44	Comb apic	5.5				0.003	
A	1	13	Comb apic	5.1				0.0026	**0.0641**
A	1	1	Comb moll	14				0.0196	**0.0196**
A	1	17	Comm moss	13.7				0.0188	
A	1	42	Comm moss	8.4	6.6			0.0114	
A	1	12	Comm moss	7.6				0.0058	
A	1	46	Comm moss	6.7				0.0045	
A	1	55	Comm moss	6.4				0.0041	
A	1	45	Comm moss	6.2				0.0038	
A	1	59	Comm moss	5.8				0.0034	
A	1	40	Comm moss	5.7				0.0032	
A	1	52	Comm moss	5.5				0.003	**0.058**
A	1	26	Dipl cond	8.3				0.0069	**0.007**
A	1	62	Erythro afri	5.7				0.0032	**0.003**
A	1	48	Grew mont	5.5				0.003	
A	1	5	Grew mont	5				0.0025	**0.006**
A	1	9	Julb glob	28.9				0.0835	
A	1	27	Julb glob	27.9				0.0778	
A	1	56	Julb glob	26.6				0.0708	
A	1	35	Julb glob	18.5				0.0342	
A	1	25	Julb glob	17.2				0.0296	
A	1	23	Julb glob	16.4				0.0269	
A	1	28	Julb glob	10.7				0.0114	
A	1	64	Julb glob	9.2				0.0085	**0.3427**
A	1	38	Marg disc	27.6	15.2	18.8		0.1346	
A	1	37	Marg disc	18.2	9			0.0412	
A	1	31	Marg disc	15.4	16.4	12.2	11.8	0.0764	**0.2523**
A	1	24	Pseudo mapr	8.1				0.0066	**0.007**
A	1	39	Pter ango	54.5	53.4			0.5822	
A	1	7	Pter ango	53.7				0.2884	**0.8706**

APPENDIX 4. **Tree positions, Panda Masuie Forest, plot A.**

Tree No.	Species	Subplot	Peg no.	Dist B (m)	Peg no.	Dist A (m)
1	Comb moll	0.0417	1	8.8	2	24.2
2	Baph mass	0.0417	1	7.2	2	22.56
3	Baik plur	0.0417	1	7	2	22.25
4	Baik plur	0.0417	1	7.15	2	22.4
5	Grew mont	0.0417	1	11.16	2	18.81
6	Baph mass	0.0417	1	16.06	2	14.78
7	Pter ango	0.0417	1	18.6	2	11.6
8	Comb apic	0.0417	1	25.77	2	3.5
18	Baik plur	0.0417	1	27.76	2	16.4
19	Baik plur	0.0417	1	27.8	2	17.2
20	Baik plur	0.0417	1	26.8	2	16.6
21	Baik plur	0.0417	1	17.79	2	26.67
22	Baph mass	0.0417	1	14.52	2	25.6
28	Julb glob	0.0417	1	27.4	2	26.5
29	Baik plur	0.0417	1	30.16	2	27.28
30	Baik plur	0.0417	1	29.65	2	26.43
31	Marg disc	0.0417	1	30.47	2	24.26
32	Baik plur	0.0417	1	29.25	2	21.5
33	Baik plur	0.0417	1	30.6	2	20.25
34	Baik plur	0.0417	1	30.9	2	20.13
9	Julb glob	1b	3	26.06	2	7.9
10	Baik plur	1b	3	9.48	2	24.8
11	Baik plur	1b	3	18.85	2	30.4
12	Comm moss	1b	3	20.35	2	25.8
13	Comb apic	1b	3	25.32	2	32.55
14	Baph mass	1b	3	21.47	2	19.9
15	Baph mass	1b	3	26.1	2	17.95
16	Comb apic	1b	3	19.9	2	14.1
17	Comm moss	1b	3	22.37	2	11
35	Julb glob	1b	3	29.1	2	27.8
36	Baph mass	1b	3	29.17	2	29.29
37	Marg disc	1b	3	25.4	2	29.68
38	Marg disc	1b	3	21.1	2	32.85
23	Julb glob	1c	4	1.5	5	24.15
24	Pseudo mapr	1c	4	3.42	5	23.25

Tree No.	Species	Subplot	Peg no.	Dist B (m)	Peg no.	Dist A (m)
25	Julb glob	1c	4	3.38	5	22.4
26	Dipl cond	1c	4	3.42	5	22.2
27	Julb glob	1c	4	11.61	5	14.9
44	Comb apic	1c	4	25.99	5	9.73
45	Comm moss	1c	4	21.65	5	7.25
46	Comm moss	1c	4	21.21	5	7.04
47	Baph mass	1c	4	23.4	5	12.86
48	Grew mont	1c	4	15	5	20.56
49	Baph mass	1c	4	16.83	5	22.4
50	Comb apic	1c	4	15.51	5	24.45
51	Comb apic	1c	4	21.17	5	26.45
52	Comm moss	1c	4	21.7	5	24.55
53	Baik plur	1c	4	27.68	5	28.9
54	Baik plur	1c	4	27.27	5	28.4
55	Comm moss	1c	4	25.53	5	25.5
56	Julb glob	1c	4	24.3	5	26.6
57	Baph mass	1c	4	27.83	5	26
58	Baik plur	1c	4	30	5	26.5
59	Comm moss	1c	4	30.4	5	21.4
60	Comb apic	1c	4	30.16	5	21.15
61	Baik plur	1c	4	32.1	5	22.3
62	Erythro afri	1c	4	26.5	5	15.75
39	Pter ango	1d	6	14.4	5	24
40	Comm moss	1d	6	16.96	5	20.95
41	Baik plur	1d	6	17.2	5	20.6
42	Comm moss	1d	6	18.5	5	12.1
43	Baph mass	1d	6	21.6	5	10.19
63	Baph mass	1d	6	27.25	5	19.05
64	Julb glob	1d	6	20.2	5	19.01
65	Baik plur	1d	6	20.76	5	28.39
66	Baik plur	1d	6	19.65	5	26.95

APPENDIX 5. **Plant checklist and cover-abundance values, Panda Masuie Forest, plot A.**

L/form	Species	Plot 1a	Plot 1b	Plot 1c	Plot 1d	Other
W	Allophylus africanus *P.Beauv.*	1				
H	Aristolochia heppii *Merxm.*		1			X
H	Asparagus africanus *Lam.*		0		1	X
W	Baikiaea plurijuga *Harms*	1	0	1	0	X
W	Baphia massaiensis *Taub.*	1	1	1	0	X
H	Basananthe hanningtoniana *(Mast.) W.J.de Wilde*		1			X
W	Bauhinia petersiana *Bolle* subsp. macrantha *(Oliv.) Brummitt & J.H.Ross*	1	0	1	0	X
H	Berlinianche aethiopica *(Welw.) Vattimo-Gil*					X
H	Bidens pilosa *L.*	3				X
H	Blepharis sp. cf. maderaspatensis *(L.) Roth*	0				X
G	Brachiaria nigropedata *(Ficalho & Hiern) Stapf*					X
W	Brachystegia boehmii *Taub.*	0			0	X
H	Cardiospermum halicacabum *L.* var. microcarpum *(Kunth) Blume*		0			X
W	Catunaregam spinosa *(Thunb.) Tirveng.* subsp. spinosa					X
H	Chamaecrista absus *(L.) Irwin & Barneby*	0	0	1		X
H	Citrullus lanatus *(Thunb.) Matsum.& Nakai*	0				X
H	Cleome monophylla *L.*	2	2		0	X
H	Clerodendrum ternatum *Schinz*	2				X
W	Combretum apiculatum *Sond.*	1	1	3	1	X
W	Combretum molle *G.Don*	1				
W	Combretum zeyheri *Sond.*	0		0		X
H	Commelina africana *L.*	1	3	0		X
H	Commelina zambesica *C.B.Clarke*		0	0		X
W	Commiphora mossambicensis *(Oliv.) Engl.*	1	0	0	1	X
H	Corchorus tridens *L.*	2				X
H	Crinum crassicaule *Baker*		0		0	X
H	Cyperus margaritaceus *Vahl*	2	0			X
H	Cyphostemma cirrhosum *(Thunb.) Wild & R.B.Drumm.*	1	1	0		X
G	Digitaria eriantha *Steud.*					X
W	Diplorhynchus condylocarpon *(Müll.Arg.) Pichon*	1	1	0	0	X
G	Eragrostis glandulosipedata *De Winter*					X
W	Erythrophleum africanum *(Welw.) Harms*			0	0	X

L/form	Species	Plot 1a	Plot 1b	Plot 1c	Plot 1d	Other
W	Euphorbia matabelensis *Pax*	2	0	1	0	X
W	Friesodielsia obovata *(Benth.) Verdc.*	2		1		X
H	Gisekia pharnaceoides *L.* var. pharnaceoides	0	1			X
W	Grewia monticola *Sond.*	1	1	1	1	X
W	Guibourtia coleosperma *(Benth.) J.Léonard*	1			1	X
H	Hemizygia bracteosa *(Benth.) Briq.*	1				X
H	Indigofera astragalina *DC.*	1		3	1	X
H	Indigofera vicioides *Jaub.& Spach* var. vicioides	2				X
H	Jasminum fluminense *Vell.*	0				X
W	Julbernardia globiflora *(Benth.) Troupin*	0	0	4		X
H	Justicia kirkiana *T.Anderson*					X
W	Kirkia acuminata *Oliv.*					X
W	Lannea discolor *(Sond.) Engl.*				1	
G	Leptocarydion vulpiastrum *(De Not.) Stapf*					X
H	Limeum fenestratum *(Fenzl) Heimerl* var. fenestratum	0	1			X
H	Macrotyloma daltonii *(Webb) Verdc.*					X
W	Margaritaria discoidea *(Baill.) G.L.Webster* var. nitida *(Pax) Radcl.-Sm.*	1	1		0	X
H	Mariscus dubius *(Rottb.) C.E.C.Fisch.*	1	0	1	0	X
H	Mariscus fulgens *(C.B.Clarke) Vorster*	2				X
H	Melhania acuminata *Mast.*	0				X
W	Ochna pulchra *Hook.* subsp. pulchra	0	0	1		X
H	Oxygonum delagoense *Kuntze*	2	1		1	X
G	Panicum maximum *Jacq.*	5	5	4	5	X
H	Phyllanthus pentandrus *Schumach.& Thonn.*	1	1	1	6	X
W	Pseudolachnostylis maprouneifolia *Pax*			5	0	X
W	Pterocarpus angolensis *DC.*	8			0	
W	Rotheca myricoides *(Hochst.) D.A.Steane & Mabb.* subsp. myricoides					X
G	Schmidtia pappophoroides *Steud.*	1	7	3		X
H	Solanum incanum *L.*	1		2		X
H	Spermacoce senensis *(Klotzsch) Hiern*	2				X
G	Stipagrostis uniplumis *(Licht.) De Winter*					X
H	Streptopetalum serratum *Hochst.*	0				X
W	Strychnos madagascariensis *Poir.*					X
W	Strychnos spinosa *Lam.*					X
H	Tephrosia purpurea *(L.) Pers.*					X

L/form	Species	Plot 1a	Plot 1b	Plot 1c	Plot 1d	Other
W	Terminalia sericea *DC.*			5		X
H	Tribulus terrestris *L.*	1				X
H	Triumfetta rhomboidea *Jacq.*	1		0	0	X
H	Turbina holubii *(Baker) A.Meeuse*					X
G	Urochloa sp.					X
W	Vangueria infausta *Burch.*	2		1	0	X
H	Vigna unguiculata *(L.) Walp.* subsp. dekindtiana *(Harms) Verdc.*	1			0	X
W	Vitex mombassae *Vatke*		0			X
W	Ximenia caffra *Sond.*					X

Notes: Species recorded outside subplot 1 are indicated by X in 'other' column.
W = Woody, H = herb, G = grass

APPENDIX 6. **Preliminary list of insects collected from Plot A, Panda Masuie Forest.**

COLEOPTERA
Family: Carabidae (ground beetles)
Scarites praevius Per
Anthia massilicata Guer

Family: Tenebrionidae
Psammodes muelleri, Per
Phanerotoma scrobicle Gerst

Family: Scarabaeidae (dung and fruit beetles)
Pachlomerus femoralis Kirby
Garreta nitens Ol.
Khleper sp.
Gymnopleurus humanus Mcl.
Pachnodellas sinuata Fab (Cetoniini)
Dicranorrhina derbyana Westw(Cetoniini)

Family: Cerambycidae
Phantasis mystica, Dist

Family: Elateridae (click beetles)
Oxynopterus vilidicornis Boh

Family: Histeridae
Macrolister latipes Beauy

Family: Lycidae
Lycus trabeatus Guer.
Lycus sp.

ORTHOPTERA (grasshoppers and crickets)
Family: Acrididae
Acrophymus rossi Uvarov.
Acrida turrita Kra.
Cantantops fasciatus Karny
Humbe tenuicornis Sch.
Gastrimagus africanus Sauss
Oedaleus citrinus Sauss
Oedaleus senegalensis Krass.
Acrida acuminata Dirsh
Rachitopis sp.
Acrotylus sp.
Cantatops melanosticta Sch.

Family: Sternopelmatidae
Maxentius pinguis Wlk.

Family: Gryllidae

Clearidas nigriceps Stal.

HYMENOPTERA (100 specimens)
Family: Ichneumonidae
Chalcidoidea
Formicidae

DIPTERA (384 specimens)
Families Tipulidae
Cecidomyiidae
Psychodidae
Simullidae
Sciaridae
Phoridae
Lonchaeidae
Sepsidae
Lauxanniidae
Chloropidae
Sphaeroceridae
Drosophilidae
Muscidae
Tachnidae

APPENDIX 7. **List and abbreviations of the Lepidoptera species collected during training course at Panda Masuie Forest, January 2004**.

Species	**Abbreviation**
Acraea anemosa	A. ane
Acraea lygus	A. lyg
Acraea natalica	A. nat
Acraea neobule	A. neo
Azanus moriqua	A. mor
Belenois aurota	B. aur
Belenois creona	B. cre
Belenois gidica	B. gid
Borbo fatuellus	B. fat
Byblia anvatara	B. anv
Catopsilia florella	C. flo
Charaxes saturnus	C. sat
Charaxes varanes	C. var
Colotis antevippe	C. ant
Colotis evagore	C. eva
Colotis evenina	C. eve
Colotis pallene	C. pal
Cupidopsis jobates	C. job
Eurema brigitta	E. bri
Eurema hecabe	E. hec
Graphium angolanus	G. ang
Graphium leonidas	G. leo
Hamanumida daedalus	H. dae
Hypolimnas misippus	H. mis
Kedestes callicles	K. cal
Lampides boeticus	L. boe
Leptotes sp.	Lept
Mylothris agathina	M. aga
Papilio demodocus	P. dem
Pelopidas sp.	Pelop
Phalanta phalantha	P. pha
Pinacopteryx eriphia	P. eri

Precis hierta	P. hie
Precis oenone	P. oen
Pseudonacaduba sichela	P. sic

APPENDIX 8. **Bird checklist for Panda Masuie Forest (QDS 1825 B2) (12-16 Jan 2004)**.

Scientific name	**Species**	**Habitat**		**True woodland species**
Egretta garzetta	Little Egret	BD		
Ciconia abdimii	Abdim's Stork	BD		
Ciconia episcopus	Woolly-necked Stork	B		
Dendrocygna viduata	White-faced Duck	BD		
Alopochen aegyptiacus	Egyptian Goose	BD		
Anas hottentota	Hottentot Teal	BD		
Anas erythrorhyncha	Red-billed Teal	BD		
Gyps africanus	White-backed Vulture	B		
Necrosyrtes monachus	Hooded Vulture	B		
Trigonoceps occipitalis	White-headed Vulture	B		
Torgos tracheliotos	Lappet-faced Vulture	B		
Milvus migrans parasitus	Yellow-billed Kite		S	
Terathopius ecaudatus	Bateleur	B		
Aquila wahlbergi	Wahlberg's Eagle		S	W
Aquila rapax	Tawny Eagle	B		
Buteo buteo vulpinus	Steppe Buzzard	B		OW
Kaupifalco monogrammicus	Lizard Buzzard		S	W
Accipiter badius	Little Banded Goshawk		S	W
Accipiter ovampensis	Ovambo Sarrowhawk	B		W
Polyboroides typus	Gymnogene		S	W
Falco amurensis	Eastern Red-footed Kestrel	B		
Francolinus swainsonii	Swainson's Francolin		S	
Numida meleagris	Helmeted Guineafowl		S	
Eupodotis ruficrista	Red-crested Korhaan		S	OW
Charadrius tricollaris	Three-banded Plover	BD		
Tringa nebularia	Greenshank	BD		
Tringa hypoleucos	Common Sandpiper	BD		
Vanellus armatus	Blacksmith Plover	BD		
Burhinus vermiculatus	Water Dikkop	BD		
Pterocles bicinctus	Double-banded Sandgrouse	B		
Streptopelia capicola	Cape Turtle Dove		S	OW
Oena capensis	Namaqua Dove	B		
Turtur chalcospilos	Green-spotted Dove		S	W
Poicephalus meyeri	Meyer's Parrot	B		W
Corythaixoides concolor	Grey Lourie	B		W
Chrysococcyx klaas	Klaas Cuckoo		S	OW
Clamator levaillantii	Striped Cuckoo		S	W

Scientific name	Species	Habitat		True woodland species
Clamator jacobinus	Jacobin Cuckoo		S	W
Cuculus solitarius	Red-chested Cuckoo		S	W
Otus leucotis	White-faced Owl		S	W
Caprimulgus rufigena	Rufous-cheeked Nightjar		S	W
Macrodipteryx vexillaria	Pennant-winged Nightjar		S	W
Cypsiurus parvus	Palm Swift	B		OW
Colius indicus	Red-faced Mousebird	B		
Merops pusillus	Little Bee-eater	B		
Merops apiaster	European Bee-eater		S	
Halcyon chelicuti	Striped Kingfisher		S	W
Eurystomus glaucurus	Broad-billed Roller	B		W
Coracias caudata	Lilac-breasted Roller	B		OW
Coracias garrulus	European Roller	B		
Phoeniculus purpureus	Red-billed Woodhoopoe	B		W
Phoeniculus cyanomelas	Scimitar-billed Hoopoe	B		W
Upupa epops	African Hoopoe		S	OW
Tockus flavirostris	Yellow-billed Hornbill	B		OW
Tockus erythrorhynchus	Red-billed Hornbill	B		OW
Tockus nasutus	Grey Hornbill		S	W
Campethera abingoni	Golden-tailed Woodpecker		S	W
Thripias namaquus	Bearded Woodpecker		S	W
Prodotiscus zambesiae	Slender-billed Honeyguide		S	W
Mirafra rufocinnamomea	Flappet Lark		S	
Eremopterix leucotis	Chestnut-backed Finchlark	B		
Hirundo rustica	European Swallow		S	
Dicrurus adsimilis	Fork-tailed Drongo		S	W
Melaenornis pammelaina	Black Flycatcher		S	W
Campephaga flava	Black Cuckooshrike		S	W
Oriolus larvatus	Black-headed Oriole		S	W
Oriolus auratus	African Golden Oriole		S	W
Chlorocichla flaviventris	Yellow-bellied Bulbul		S	OW
Parus niger	Southern Black Tit		S	W
Turdus libonyana	Kurrichane Thrush		S	W
Erythropygia leucophrys	White-browed Scrub Robin		S	OW
Phylloscopus trochilus	Willow Warbler		S	W
Sylvia communis	Whitethroat		S	OW
Camaroptera stierlingi	Stierling's Barred Warbler		S	W
Camaroptera brachyura	Bleating Bush Warbler	B		thickets
Cisticola juncidis	Fan-tailed Cisticola	B		

Scientific name	**Species**	**Habitat**		**True woodland species**
Cisticola chiniana	Rattling Cisticola	B		OW
Prinia subflava	Tawny-flanked Prinia		S	thickets
Muscicapa striata	Spotted Flycatcher		S	W
Batis molitor	Chinspot Batis		S	W
Terpsiphone viridis	Paradise Flycatcher		S	W
Anthus caffer	Bushveld Pipit		S	
Lanius collurio	Red-backed Shrike	B		
Nilaus afer	Brubru		S	W
Tchagra australis	Three-streaked Tchagra	B		OW
Tchagra senegala	Black-crowned Tchagra	B		W
Prionops retzii	Red-billed Helmet Shrike		S	W
Onychognathus morio	Red-winged Starling	B		
Cinnyricinclus leucogaster	Plum-coloured Starling		S	W
Nectarinia senegalensis	Scarlet-chested Sunbird		S	W
Petronia superciliaris	Yellow-throated Sparrow		S	W
Passer griseus	Grey-headed Sparrow		S	W
Plocepasser mahali	White-browed Sparrow-weaver	B		
Euplectes albonotatus	White-winged Widow		S	
Uraeginthus angolensis	Blue Waxbill		S	
Vidua macroura	Pin-tailed Whydah	B		
Vidua paradisea	Paradise Whydah	B		
Vidua regia	Shaft-tailed Whydah	B		
Serinus mozambicus	Yellow-eyed Canary		S	OW
Serinus mennelli	Black-eared Canary		S	W
Emberiza tahapisi	Rock Bunting	B		OW
Emberiza flaviventris	Golden-breasted Bunting		S	W
	(102 species)	**48**	**54**	**61**

Key: BD - basalt (dam), B - basalt (mixed), S - Kalahari sand, W - woodland, OW - open woodland.