Biodiversity monitoring techniques and standardization across TANAPA forest parks:

report of a training workshop for Park Ecologists

Udzungwa Ecological Monitoring Centre,

Udzungwa Mountains National Park, Tanzania

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This report was prepared by:

Francesco Rovero (MUSE – Museo delle Scienze, Trento, Italy and Udzungwa Ecological Monitoring Centre, Udzungwa Mountains National Park, Tanzania), Wickson Kibasa, Yustina Kiwango, Wilson Frank Maanga, Crispin Mwinuka, Abel Mtui, Gladys Ng'umbi, Joram Ponjoli (TANAPA), and Marco Ciolli (University of Trento, Italy)

All photos are by F. Rovero/MUSE; maps were made by Abel Mtui, TANAPA GIS Unit. The maps for Udzungwa were made by Marco Ciolli and Francesco Rovero.

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E-mail contact: francesco.rovero@muse.it

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1 Background and aims of the workshop

Tropical forests are facing unparalleled rates of deforestation and habitat degradation, with consequent decline and loss of species and populations that is occurring even inside protected areas. Among the most serious challenges for halting this problem is the limited amount of monitoring data available to assess trends, evaluate effectiveness of protected areas, and hence design mitigation strategies. In addition to the paucity of data, there is also a lack of standardized monitoring efforts, even within regions and park systems, so that trends can be compared across sites.

In this global scenario, the situation in Tanzania is no exception. However, the outstanding network of 16 National Parks managed by Tanzania National Parks (TANAPA) has ecological monitoring among its priorities. Yet, efforts towards standardized and effective monitoring remains limited, and this particularly applies to dense forest parks, where harsh terrain and poor visibility make monitoring inherently difficult. As it is often the case, the standardization of data collection, data handling, and interpretation of results are limited and need improvement.

In this context, the Udzungwa Ecological Monitoring Centre (UEMC) is a facility of the Udzungwa Mountains National Park (UMNP) established in 2006 with the aim of facilitating biological monitoring in the Udzungwa Mountains and beyond. One of the long-term objectives of UEMC is to support TANAPA and other biodiversity protection agencies at national level to facilitate standardization of biodiversity monitoring. With the growing experience of UEMC in monitoring and the consolidated partnership between MUSE – Museo delle Scienze and TANAPA, efforts to support standardized ecological monitoring have increased in recent years with a number of training and programmes implemented in UMNP. Among these, the first edition held in 2011 of the international summer school titled 'Tropical rainforest biodiversity: GIS and field tool for assessing, monitoring and mapping' was attended by a number of TANAPA's ecological monitoring staff.

To consolidate these efforts, UEMC organized a 4-day workshop in August 2013 for all forest park ecologists of TANAPA. Objective of the training: using the extensive experience in biodiversity monitoring accumulated in the Udzungwa Mountains National Park (UMNP), the training aimed to provide ecologists with tools for data collection, data analysis and GIS-based mapping of key biodiversity components in forest parks, especially (1) arboreal primates through line-transect census, (2) terrestrial medium-to-large mammals through camera-trapping and (3) large mammals through counts of signs and tracks along defined routes.

The ultimate **GOAL** of the training was to assess in a participatory way the current monitoring programmes in forest parks, review their effectiveness, and propose new and standardized monitoring programmes that can effectively inform the park management on wildlife trends, indicate possible causes of changes, and propose solutions.

The detailed workshop programme is in Appendix 1.

1.1 Focusing monitoring efforts to key biodiversity components: primates and other large mammals

In view of the limited resources (personnel and equipment) that are generally allocated to biodiversity monitoring, and considering that monitoring protocols need to be simple to be sustainable and hence be conducted in the long-term, participants convened that standardized protocols should be few, simple, and have a clear target.

In the forest habitat that covers most of the park targeted by the workshop, a wealth of literature and the experience accumulated in the Udzungwa mountains indicate that arboreal and diurnal primates are excellent model species for monitoring. Because they are large, predominantly arboreal, and live in groups, primates can be easily counted from line-transects. In addition, most species are good indicators of ecosystem health as particularly relates to forest canopy. We particularly refer to the black and white colobus of which at least one representative (*Colobus angolensis* or *Colobus guereza*) occurs in each park. We also refer to the Blue monkey or Syke's monkey (*Cercopithecus mitis* complex) that are also common. Some parks have greater diversity of arboreal monkeys, such as the red colobus in the Uduzngwa mountains (*Procolobus gordonorum*).

Participants during the workshop at the Udzungwa Ecological Monitoring Centre

At the same time, line-transects are suitable to count signs and sightings of medium-to-large terrestrial mammals, both in forest and in the more open habitat occurring in the targeted parks. Mammals that are easily sighted or detected from signs typically include duikers and other forest antelopes (e.g. bushbuck), large carnivores (e.g. leopards) and large herbivores such as buffalos and elephants. Depending on resources available, terrestrial mammals can also be very well monitored by an adequate grid of camera traps, with the advantage that species are identified with certainty from photos and a much larger assemblage of species including the rare, nocturnal and elusive ones. In addition, camera trapping is very suitable to standardization because human error is minimized to placement of camera traps.

With these considerations in mind, the workshop was dedicated to propose a standardized protocol for monitoring primates and other mammals from line transects, and secondarily, to provide the basic training for monitoring mammals through camera trapping.

2 Review of existing ecological monitoring in forest parks and needs for standardization

The workshop begun with a detailed review by each park ecologist of the existing ecological monitoring programmes, their outcomes and challenges. Several parks have specific monitoring programmes, for example monitoring of the impact of tourism on ecosystems as related to waste management (Kilimanjaro, Manyara), or the monitoring of water birds (Manyara, Arusha) and fish (Gombe, Mahale, Rubondo), or the monitoring of poaching and other forms of human disturbance. Several parks also monitor climate parameters in various ways. Here we mainly focus on the monitoring of mammals that as stated above has potential for standardization across all parks.

Below is a map of national parks in Tanzania (source: www.tanzaniaparks.org). The seven forest parks that participated in the workshop form a consistent portion of all National Parks.

Summary of main and current wildlife monitoring programmes as appraised by the ecologists:

National Park name	Existing wildlife monitoring
Arusha	• Large forest mammals (elephants, buffalos, giraffes): dung counts along a system of transects across the forest plus direct counts of animals seen, done twice per year (wet and dry season); in collaboration with Mweka; transect length from 1-4 km, 20 transects. Done 1999, 2003 and then 2011- more systematically. • Primate monitoring (established after UEMC training in 2011): 3 transects of 1.5,2.5, 3 km. • Water birds counts every month in the lakes. Since 2003.
Manyara	• Large mammals in the ground-water forest: drive counts using forms every month of animals seen along the road/off road, and health checking of animals. • Breeding population of migratory water birds (dates of arrival and departure) every week in the breeding season. Both monitoring conducted since long-time (approx. 20 yrs), but not continuously.
Rubondo	• Elephants, giraffes, chimps, suni, black and white colobus (introduced from mainland). Bushbuck and sitatunga are focal species due to massive population collapse in the past, maybe for a disease. Data collection: forms distributed to ranger posts, when they do patrol they record the presence, number, age/sex, health, location name (no GPS). Forms collected monthly and used for reports. Both conducted for >3 trs.
Gombe	• Chimps monitoring - in collaboration with JGI, current total population of approx. 100 individuals. Long-term (since 1960s). • Olive baboon monitoring, mainly behavior and life history, especially those on lake shore and for disease (STDs) transmission. Long-term. • Chimp monitoring outside the park (Kwitanga forest, 30 chimps)
Mahale	• Chimp monitoring (2 groups) of habituated groups, use of tourist trails. Health conditions monitoring. In collaboration with Japan. FZS has later established a database for chimps and other target animals. • Other primates (e.g. red colobus) using transects along tourist trails. Frequency can be daily because guides going with tourists also collect data. Long-term (since the 70s). • Transects for ranger to count mammals were established from 2 ranger posts, for weekly counts. Since 2007.
Kilimanjaro	• Elephant: in Kilimanjaro/Amboseli using 8 km transect on E side of park and collection of Human Wildlife Conflict data in west Kilimanjaro since 2007, plus duikers and other large mammals counted using forms by rangers. • KILI project (German funded) monitors various biodiversity components in plots.
Udzungwa	• Diurnal primates: monitoring in Mwanihana (UMNP) and Uzungwa Scarp Foorest Reserve using 3-4 transects or 4 km. Since 2002 (2004 in USFR). • Terrestrial mammals, climate and vegetation through TEAM monitoring (since 2009). • Sanje mangabey habituated group (since early 2000s). • Large mammals from remote ranger posts (since 2009, discontinuous).

A number of challenges and recommendations emerged as being common to the majority, if not all, of the parks, as follows:

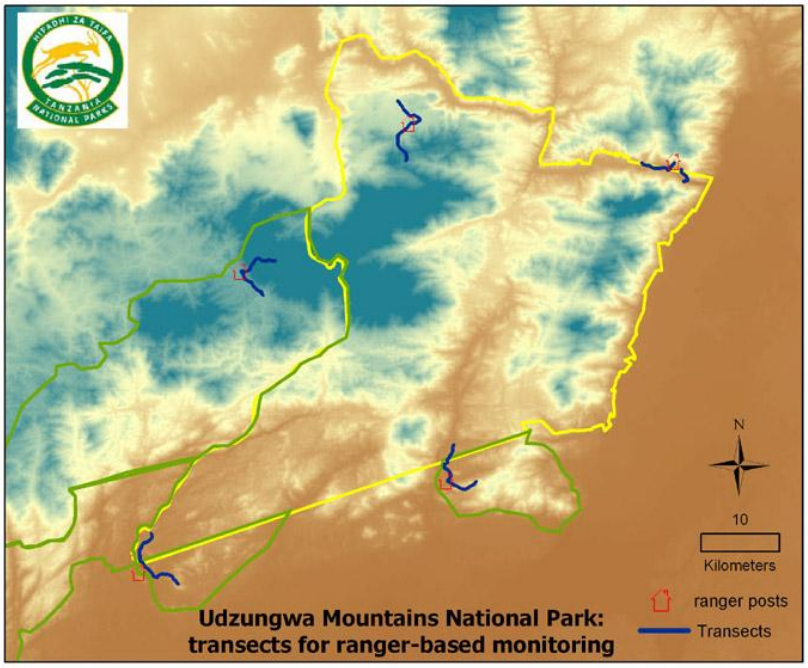
- General lack of resources (personnel) to ecological monitoring for data collection and analysis.
- Lack of capacity building for analyzing data.
- Some parks have information and data from anti-poaching that ecologists can analyze and use, but due to time constraints and/or training data are not always systematically collected.
- Hence participants agree on the need for a standard way to enter the anti-poaching data. There are forms but is missing the handling of data and integration of departments.
- Monitoring protocols changed over the years, so there is a need for updated training and standardized methods.
- The reporting frequency of existing programmes need improvement…
- There is a general lack of use of long-term data for assessing trends, at least as far as the ecologists are aware.

Despite these limits, there is a consistent base of ecological monitoring work and capacities that if adequately organized can result in successful and sustained monitoring efforts similar to what done in individual parks such as Udzungwa.

Participants observed that an Ecological Monitoring Manual has been under preparation by TANAPA for some time ('TANAPA Manual on Monitoring Ecological Change, version 1, 2008'). This draft Manual includes a wide range of monitoring tools than those adopted in this workshop. However, a review of the relevant protocols (those for monitoring wildlife) included in the manual gave the impression that the methods proposed are scientifically very solid but of difficult application under current scenario. For example, the key method proposed for censusing animal populations is the distance sampling, with data analyzed using the dedicated software 'Distance' developed by Steve Buckland and colleagues. While this method is indeed the canonical approach to estimating density and abundance, it requires advanced routines of data collection, large sample size, and considerable statistical knowledge for analyzing data properly. Participants observed that these methods can be considered for periodic census of key species rather than for continuous and locally-based monitoring of changes in relative abundance (as proposed here), and will need to be implemented with external assistance under the current capacity of the Department.

3 Proposal for standardized monitoring methods for primates and other large mammals

We recommend the establishment of a transect-based monitoring programme in each forest park consisting of a network of **minimum 4 transects**, of minimum length 4 km each, primarily aimed at monitoring primates but also other large mammals (including dungs and tracks). A system of 4 transects is for example used in Mwanihana forest, which is approximately 150 km^2 in the eastern Udzungwa (see maps in following pages). While transects for primates will necessarily target densely forested areas of the park, such as Mwanihana forest in Udzungwa, a more widespread grid of transects can be designed to monitor with the same protocol large mammals in more open/drier habitats of the parks. In this case in addition to sightings, signs such as dungs and tracks of the most easily identified species will also be recorded. An example for Udzungwa is shown here. A similar scheme is also under implementation in Arusha National Park (see Appendix 4).



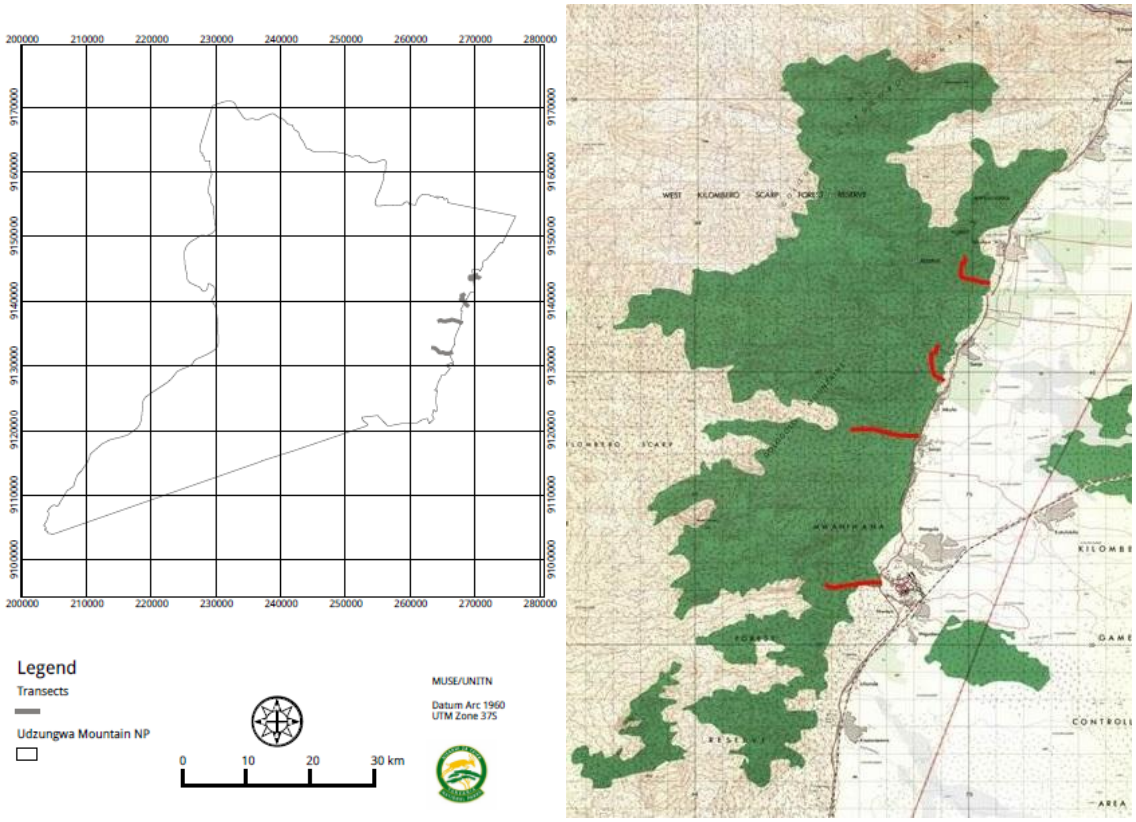
Map of transects (each 4-6 km in length) done in UMNP for monitoring large mammals from remote ranger posts, while in the eastern forest block (Mwanihana) primates and other forest mammmals are monitored through 4 additional transects (map below).

The placement of transects in each park was done very accurately, compromising between accessibility (e.g. presence of roads), possibility to maintain the trails in dense vegetation and adequate coverage and spread in the target forest area. The typical choice for placing a transect is, for example, a tourist trail with relatively low frequency of visitors (especially in early morning when trails will be used for monitoring) or a park service trail/road used by rangers. This ensures that transects will be regularly maintained. With these basis, we used the knowledge of the respective park ecologists to place and map the potential transects.

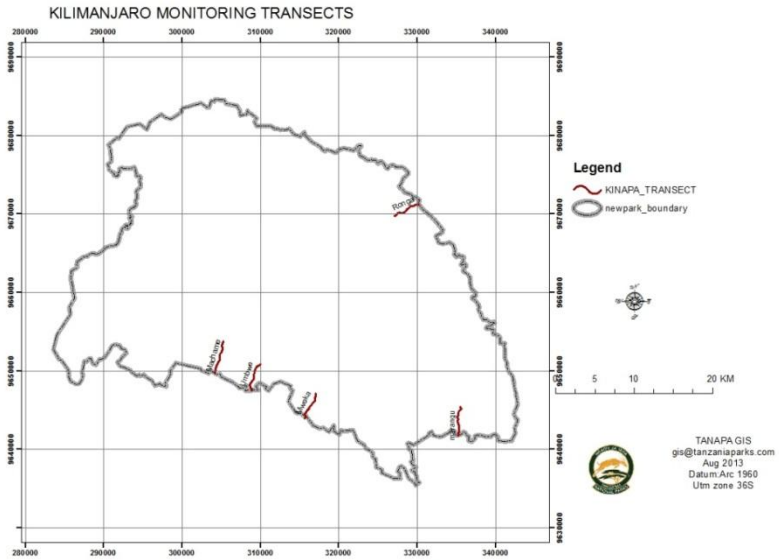
The transect layout was designed jointly with help from Abel Mtui (TANAPA GIS Unit) and Dr. Marco Ciolli (University of Trento), and awaits field validation, re-tracking of transects using GPS to validate maps, ground measure the distance (using tape measure) and marking the transects at 50-m intervals using aluminium TAGS. To ensure that all the ecologists can access the information, the data of each park were saved in a project in Arc Info geodabase format that is compatible with open-source Quantum GIS. Maps below presents the transects layout for all parks.

The map for Mahale was not drafted in absence of the relevant park ecologist, it is however planned for its inclusion in near future.

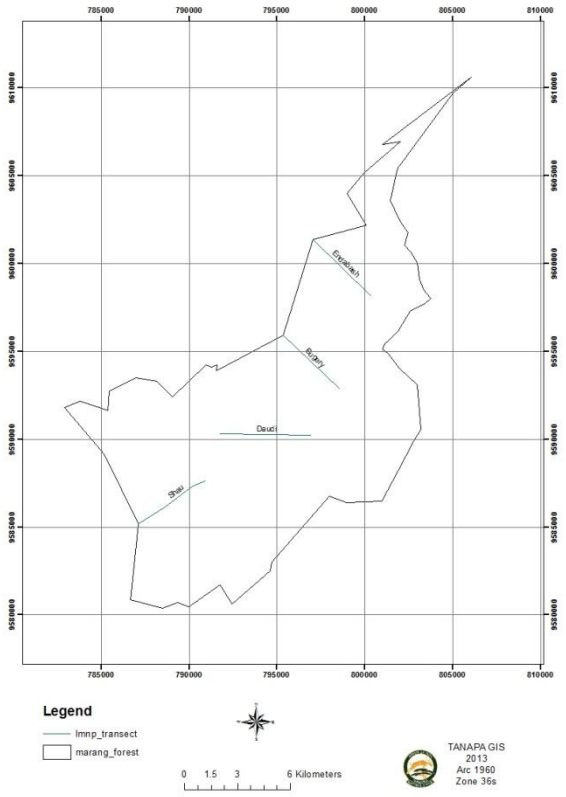
Udzungwa (map of the park – left and Mwanihana forest only – right, which is where primate transects are located)**:**



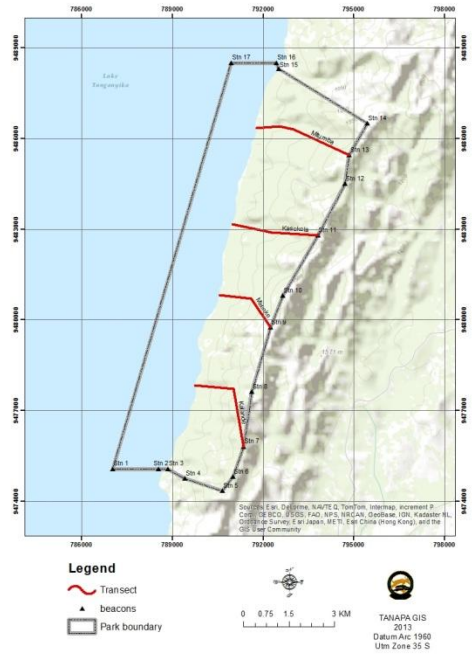
Kilimanjaro:



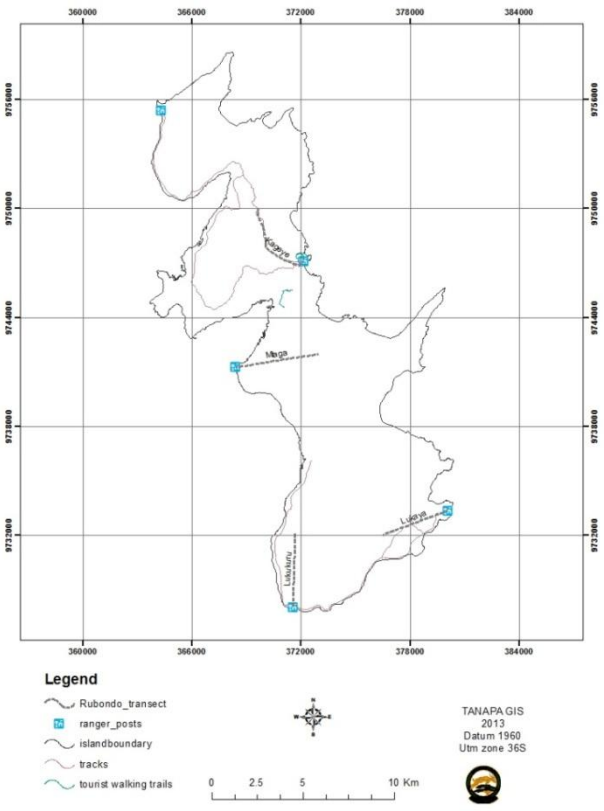
Lake Manyara:



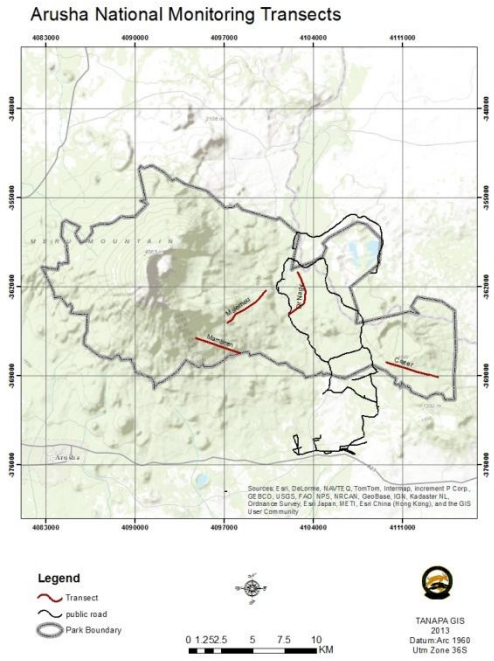
Gombe stream:



Rubondo Island:



Arusha:



The monitoring programme should initially last 5 years, with at least 15-20 transect repetitions being done per year or period. For 'period' we mean the dry season: when it is easier for logistic reasons to concentrate the census in the dry months, the 15-20 repetitions can be done in those months. Hence, the frequency of replicates will depend on the schedule: 2 walks per month every month (=24 per year) will be the standard, but if easier 4 walks per month in dry season (6 months June – November and hence 24 walks).

We recommend ecologists be able to train **field technicians** to walk transects along with themselves, since the use of rangers for systematic and scientifically-sound monitoring can be very difficult, as experience has shown. Transects will be walked using the **data collection form** (see Appendix 2) adopted and approved by the participants.

Data collection will involve walking transects slowly (approximate speed of 1 km per hour) and starting them always between 7 and 8 a.m., for consistency. Upon sighting primates, observers will record their position along the transect, the species, the number of individuals (if possible) and complementing information such as position of the primate group on the tree, behavior, and association with other species. In addition, when a laser range finder and compass are available, ecologists should also record the *horizontal* distance to the first animal seen (in practice the distance is measured to the nearest tree trunk) and the angle between the transect direction and the animal. In this way, data can later allow to apply distance sampling analysis, or simply to verify the range of distances recorded and remove outliers or determine a cut-off transect width for the effective area sampled.

Data will later be entered in a simple excel data sheet, and ecologists will be summarizing results every 6 months to 1 year, and produce summary charts of mean encounter rate + SD (standard deviation), i.e. the number of primate groups seen per km of transects walked, as well as the and mean encounter rate of dungs/tracks of other mammal sighted (see Appendix 2). These summaries will be done for each transect and for all transects pooled. Upon repeating the monitoring year after year, the results can be compared by plotting them in charts where subsequent years are represented by different chart bars. Results can be compared across years through relatively simple statistical tests (Analysis of Variance) to determine whether relative abundance changed or not with time.

An example of data from Udzungwa analyzed in this way is presented in Appendix 3.

The initial data collected in Arusha National Park is also presented in Appendix 4.

4 Camera trapping

In the course of the workshop, ecologists were exposed to both field training on setting camera traps and the analysis of data and main applications to wildlife studies. In general, camera trapping has a vast potential for standardizing monitoring, however its robust application can be costly because it needs a relative large number of cameras (minimum 20), and it also require skilled attention to data retrieval and analysis. Hence, camera trapping was not proposed as the main mammal monitoring tool, but still considered of high importance by park ecologists including for its utility to make faunal inventories in areas little surveyed in the past.

Indeed, in addition to Udzungwa, where the long-term TEAM project implements monitoring through camera traps set in Mwanihana forest, a number of park ecologists have used or plan to use camera traps. The use of camera trapping for inventories (checklists) can be relatively easy, as it does not require a large number of cameras or particular limits in sampling effort. Cameras can be set opportunistically to maximize chances of captures. All details can be found in the review at this link: http://www.italian-journal-of-mammalogy.it/article/view/8789.

For monitoring purposes however, its application needs to be standardized and a fixed grid of cameras is placed and sampled every year for at least 30 days. TEAM monitoring, for example, consists of 60 camera traps set at a density of1 camera per 2 km^2, set for 30 days in the dry season. Cameras are set in consecutive arrays of 20 units, so that the overall exercise lasts around 4 months. All details can be found in the TEAM website (see Appendix 2).

5 Actions ahead and recommendations

Following the mapping layout, park ecologists assigned themselves the task of implementing the transects in each park by marking them using aluminium tags attached to trees along trails every 50 m for the whole length of the transect (usually 4 km). Ecologists should also map the transects using GPSs so that TANAPA GIS Unit can then store data on the realized transects.

Once transects are prepared, each park should propose the schedule for implementation and start collecting data. This will need adequate training of the field team by the ecologists following the field training that was conducted during the workshop. Training needs to ensure that transect walk

pace, sighting and identification of animals, data recording on the notebook and then transfer of data into the forms and into excel are essential steps properly done.

Participants raised the following recommendations:

- future training be further focused on data analysis, interpretation of results, and simple statistical approaches to compare results of data-sets across years, GIS tools;
- consider to held a follow-up workshop possibly in 2015 to present the results from all parks and evaluate the progresses;
- organize exchange visits and training workshops such as this, both in Tanzania and internationally;
- most parks will need the right equipment to implement monitoring, especially range finders, in addition to good quality binoculars and compasses;
- participants do not recommend the systematic use of rangers for this exercise, however they observe that rangers are an option in some park (at least for security and highly depending on their skills and commitment), but all agree that trained and dedicated field assistants or causal laborer already in place are recommended, or the use of students doing internships (with the important consideration that field personnel should not change frequently).

The **way ahead** for the monitoring programme is proposed as follows:

Period	Task
February – April 2014	All forest parks have realized the transects in each park and these are mapped with support from TANAPA GIS Unit
February – June 2014	All park begin trail data collection, following the agreed protocol, as implemented by trained personnel
July-December 2014	First standardized, 6-month data collection period begun. Data are analyzed in Excel as for this report and compiled at TANAPA Headquarters.
First semester 2015	Data collection continue with feed-back recommendations from the scrutiny of data collected in 2014.
Second semester 2015	Pending funding, a second workshop is organized to review progress and conduct further training. (MUSE-Trento facilitation).

Appendices.

1. Workshop programme

Monday 19th	AM (8.30-12.30): Welcome note by the Chief Park Warden, UMNP and presentation of participants. Programme presentation and general introduction to biodiversity monitoring in forest parks (Rovero). Participatory assessment of on-going monitoring in forest parks, challenges and needs (All participants). PM (14.30): Key monitoring programmes conducted in the UMNP (Rovero and Ponjoli). Line-transects for primates: theory, data collection, and transect layout design (Rovero).
Tuesday 20th	Full day in Mwanihana forest: field practical on line transects, counts of tracks and signs and camera trapping.
Wednesday 21st	AM: practical exercises with laptops: data analysis with Udzungwa data-set (primates census and/or large mammal counts), including GIS visualization of results (Rovero, Mtui, Ciolli). PM: camera trapping: theory and data analysis exercises (Rovero).
Thursday 22nd	AM: designing monitoring protocol at each park where this is needed using GIS (Mtui and Ciolli with all participants). PM: brainstorming on standardizing methods, actions ahead, course closure and evaluation (All participants).

2. List of sources for protocols and forms for data collection

Publications and reports of UEMC monitoring can be downloaded here http://www.udzungwacentre.org/resources.asp

The detailed camera trapping protocol for monitoring terrestrial vertebrates adopted by TEAM network can be downloaded at http://www.teamnetwork.org/files/protocols/terrestrial-vertebrate/TEAMTerrestrialVertebrate-PT-EN-3.1.pdf

A review on the technical details of camera trapping can be downloaded here http://www.italian-journal-of-mammalogy.it/article/view/8789

Form for primate line-transect data collection.

Line Transect data collection form, Uduzungwa Mountains DD/MM/YY _____

Observer1 _____ Observer 2 _____ Forest _____

Start time _____ End time _____ Transect _____ Lenght _____

Weather _____ Notes _____

				First Individual Seen			Gp center				
Obs. Time	Position (m)	Species	S/H	AOD	Angle	PD	PD	N. Ind	Age/Sex Class	Height *	Notes (associations, tree, feeding, response to observer)

* 1-Canopy, 2-mid canopy, 3-Ground

Example of Excel data-sheet for entering primate transect data:

# of transect	Transect name	Day	month	year	time	position on transect	species	num of individuals	seen(s)/ heard(h)	Association with other species	weather	Observer	Transect time
1	Camsite3	24	12	2008	9:20am	125m	Baboon	1	s	no	sunny	ASM + SS	09:18 - 10:49
1	Camsite3	24	12	2008	10:22am	640m	Sykes	1	h	no	sunny	ASM + SS	09:18 - 10:49
1	Camsite3	24	12	2008	10:37am	850m	Sykes	2	s	B/W colobus+RC monkey	sunny	ASM + SS	07:28 - 10:49am
1	Camsite3	24	12	2008	10:37am	850m	Red colobus	11	s	BW colobuscolobuscolobus+Syk	sunny	ASM + SS	09:18 - 10:49
1	Camsite3	24	12	2008	10:37am	850m	BW colobus	4	s	RC monkey+Sykes	sunny	ASM + SS	09:18 - 10:49
2	Camsite3	23	1	2009	7:19am	70m	BW colobus	1	h	no	sunny	SS + RM	07:13 - 10:45
2	Camsite3	23	1	2009	7:28am	200m	BW colobus	1	s	no	sunny	SS + RM	07:13 - 10:45
2	Camsite3	23	1	2009	9:05am	1745m	Red colobus	3	s	no	sunny	SS + RM	07:13 - 10:45am
2	Camsite3	23	1	2009	8:38am	1310m	Sykes	3	s	no	sunny	SS + RM	07:13 - 10:45
2	Camsite3	23	1	2009	8:18am	1000m	Sykes	4	s	no	sunny	SS + RM	07:13 - 10:45am
3	Camsite3	15	1	2009	7:41am	470m	Red colobus	13	s	no	sunny	Mk+SIN	07:15-11:00am
3	Camsite3	15	1	2009	10:40am	3500m	Red duiker	1	s	R. durker	sunny	SS + MK	07:15-11:00
3	Camsite3	15	1	2009	9:31am	2020m	Red colobus	12	s	R.C+BW	sunny	Mk+SIN	07:15-11:00am
3	Camsite3	15	1	2009	9:31am	2020m	BW colobus	5	s	R.C+BW	sunny	SS + MK	07:15-11:00
3	Camsite3	15	1	2009	9:20am	1935m	Red colobus	1	h	no	sunny	SS + MK	07:15-11:00
3	Camsite3	15	1	2009	9:02am	1850m	BW colobus	3	s	no	sunny	SS + MK	07:15-11:00
3	Camsite3	15	1	2009	8:42am	1650m	Sykes	1	h	no	sunny	Mk+SIN	07:15-11:00am
3	Camsite3	15	1	2009	7:23am	130m	Baboon	1	h	no	sunny	SS + MK	07:15-11:00
4	Camsite3	5	2	2009	07:49am	380m	Red colobus	1	h	n.	Clouds	SS + RM	07:24 - 11:34am

Example of calculation in Excel of mean+SD encounter rates of primate groups:

1. Number of groups seen per transect									
replicate	month	red colobus	angolan colobus	sykes	baboon	mangabeys	All primates	length	
1	Dec,08	1	1	1	1	0	4	4,0	
2	Jan,09	1	1	2	0	0	4	4,0	
3		2	2	0	0	0	4	4,0	
4	Feb,09	1	1	2	0	0	4	4,0	
5		2	0	0	0	0	2	4,0	
6	Marc,09	2	0	1	0	0	3	4,0	
7		1	0	0	0	1	2	4,0	
8	Apr,09	1	2	0	0	1	4	4,0	
9		1	1	2	0	0	4	4,0	
2. Calculation of encounter rate = groups / length									
1	Dec,08	0,25	0,25	0,25	0,25	0	1		
2	Jan,09	0,25	0,25	0,5	0	0	1		
3		0,5	0,5	0	0	0	1		
4	Feb,09	0,25	0,25	0,5	0	0	1		
5		0,5	0	0	0	0	0,5		
6	Marc,09	0,5	0	0,25	0	0	0,75		
7		0,25	0	0	0	0,25	0,5		
8	Apr,09	0,25	0,5	0	0	0,25	1		
9		0,25	0,25	0,5	0	0	1		
3.Calculation of mean and standard deviation (these values are then showed on charts as in Appendix 3)									
		red colobus	angolan colobus	sykes	baboon	mangabeys	All primates		
Mean		**0,33**	**0,22**	**0,22**	**0,03**	**0,06**	**0,86**		
SD		**0,13**	**0,20**	**0,23**	**0,08**	**0,11**	**0,22**		

3. Udzungwa multi-year data analysis example (extract from 2013 UEMC technical report; data are not for public use)

Primate monitoring in Mwanihana forest

The Primate Monitoring Program established in 1997 in Mwanihana forest, uses transects established along tourist trails maintained by the park. Details of transect length and habitat types are reported below (Table 1). Transects are repeated every two weeks by one observer that walks slowly (1 km per hour) and records all sightings of primate groups, together with its position, distance to each group, number of individuals (when possible) and observer's position along the transect.

Table 1. Characteristics of four transects used for primate censuses in Mwanihana Forest, Udzungwa Mountains National Park, Tanzania

Transect	Length of transect (km)	Altitude	Gross forest type and portion along the line (km)
T1 (Camp Site 3)	4.0	350 - 800	Deciduous (0.8 km), semi-deciduous (0.6 km), open area (0.4 km), evergreen (2.2 km).
T2 (Mwanihana Trail)	4.0	320 - 590	Deciduous (1.4 km), semi-deciduous (0.4 km), evergreen (2.2 km).
T3 (Sanje Falls)	3.7	330 - 700	Mixed deciduous and semi-deciduous (0.8 km), evergreen (2.9 km).
T4 (Msolwa)	4.0	330 - 600	Mixed deciduous and semi-deciduous (1 km), evergreen (3 km).

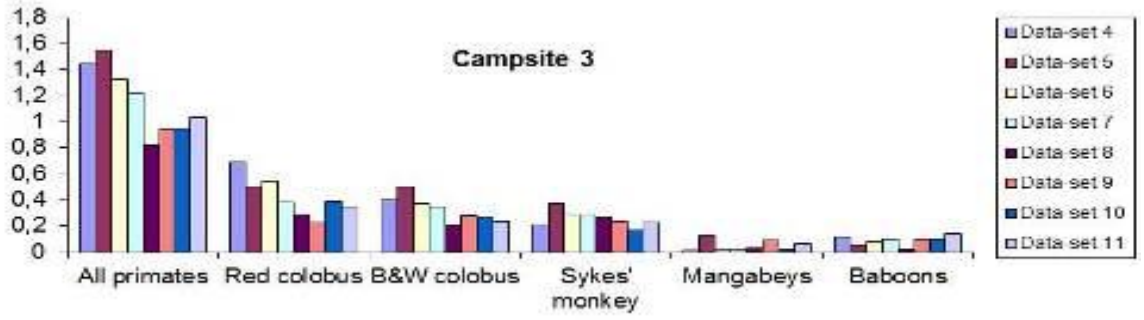
The updated list of data-sets collected by various observers over the years is presented in Table 2. As elaborated in previous reports however, data collected during 1998-2001 were deemed unreliable mainly because inter-observer consistency in data collection was not ensured. Therefore, from the present report it was decided not to include these data (which remains available on request), and hence present data from 2002-2012. Inter-observer consistency in data collection has been regularly checked for this data-set, and it was also ensured by minimizing the number of data-collectors.

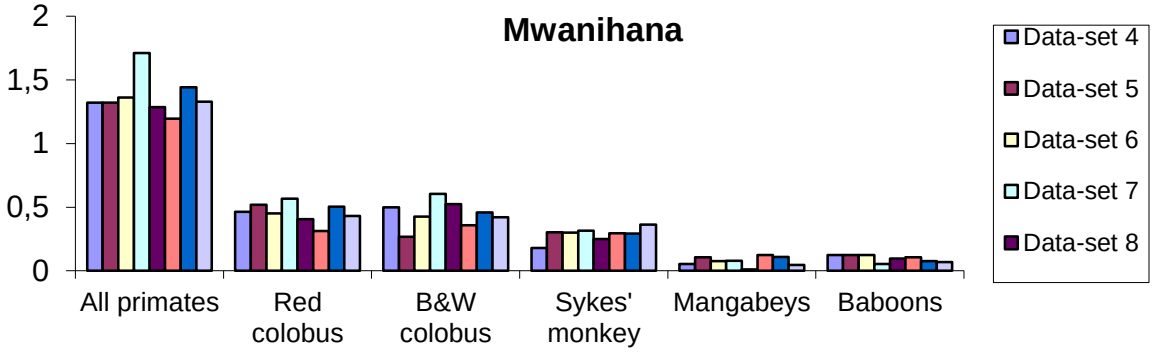
Table 2. Number of primate censuses conducted by each observer and data-set in Mwanihana Forest, Udzungwa Mountains National Park, Tanzania

N°	Observer	Period	Transect			
			C3	MW	SJ	MSO
4	FR	July 2002 - January 2003	13	14	14	-
5	ASM1	February-August 2003	14	14	13	-

6	ASM2	February-December 2004	20	20	19	-
7	AK (UEMC)	April 2007-August 2008	20	19	20	13
8	ASM3 (UEMC)	December 2008-October 2009	21	21	21	20
9	ASM4 (UEMC)	November 2009-January 2011	28	28	28	28
10	ASM+MK (UEMC)	February 2011-January 2012	23	23	23	23
11	MK (UEMC)	February 2012 - December 2012	22	22	22	22
	All observers		161	161	160	106

The updated data-set 2002-2012 for Mwanihana consists overall of 588 transect repetitions, for over 2300 km walked. This remains the largest and longer-term monitoring data-set available for the area (Table 2). To assess raw trends in relative abundance with time, the charts below present, for each transect (Fig. 2) , and then for all transect combined (Fig. 3), the results quantified as mean primate group's encounter rate, computed per each period of data collection (broadly corresponding to years).





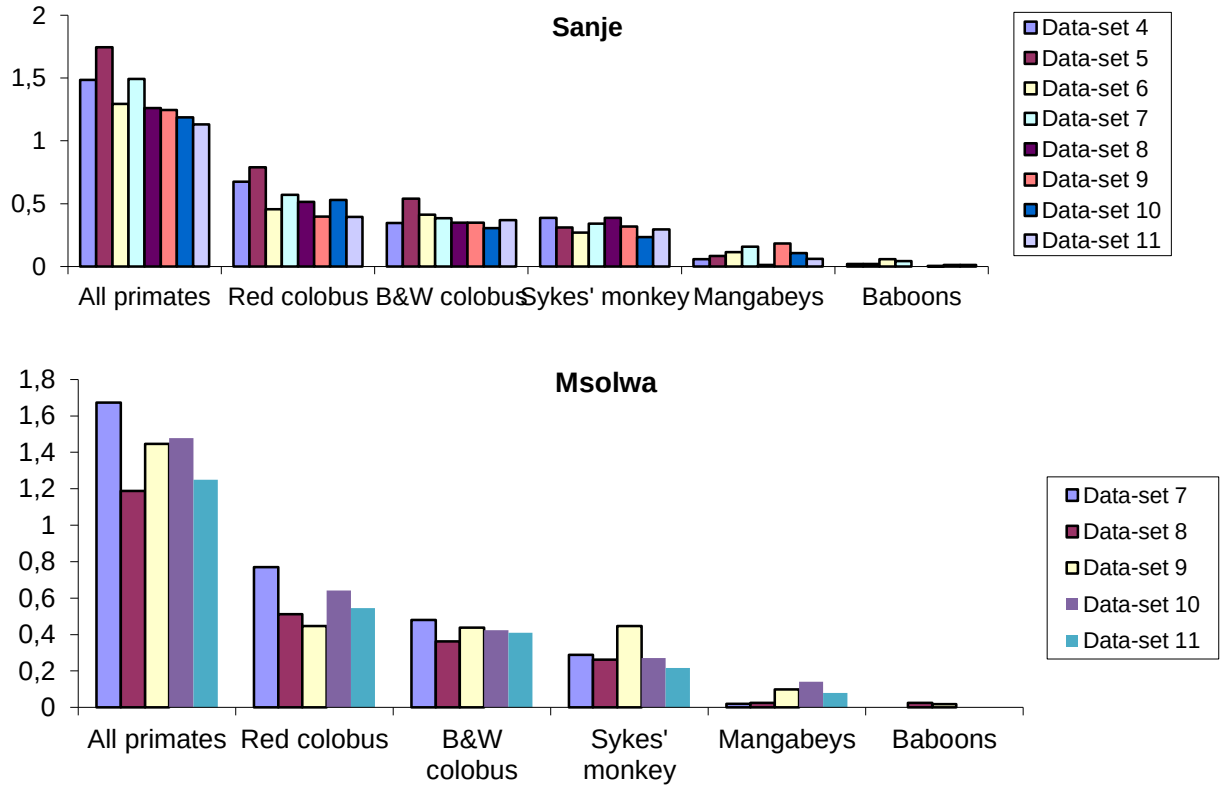


Fig. 1. Results of primates' encounter rate by observer for the 4 transects in Mwanihana forest.

Transect-specific results do not reveal striking trends of changes in abundance, as observed from earlier comparisons. Mwanihana appears the transect with more constant results, Msolwa has some variations which may be due the fact that this transects has a more limited data-set. Results for Campsite 3 reveals no further evidence of the apparent decrease observed in previous years and that was mainly emerging for red colobus. Similar observations apply to results for Sanje transect. Indeed for these two transects, the reduced and more consistent data set used (that excludes data from before 2002), does maintain an apparent decrease trend for all primates, however none of the results for the 3 forest arboreal monkeys appear to contribute to this overall trend in any particular strength.

Statistical analysis - ANOVA and post-hoc comparisons (Table 3) – was performed on the pooled data-set. Robust and complete statistical analysis for the whole data-set is in progress for a scientific paper. ANOVA results indicate that for all primates and for the red colobus the inter-observer differences are significant, while for Angolan colobus and Sykes' monkeys they are not. Post-hoc comparisons for the former two species for which differences are significant, however, do not reveal the occurrence of any significant increase or decline with time.

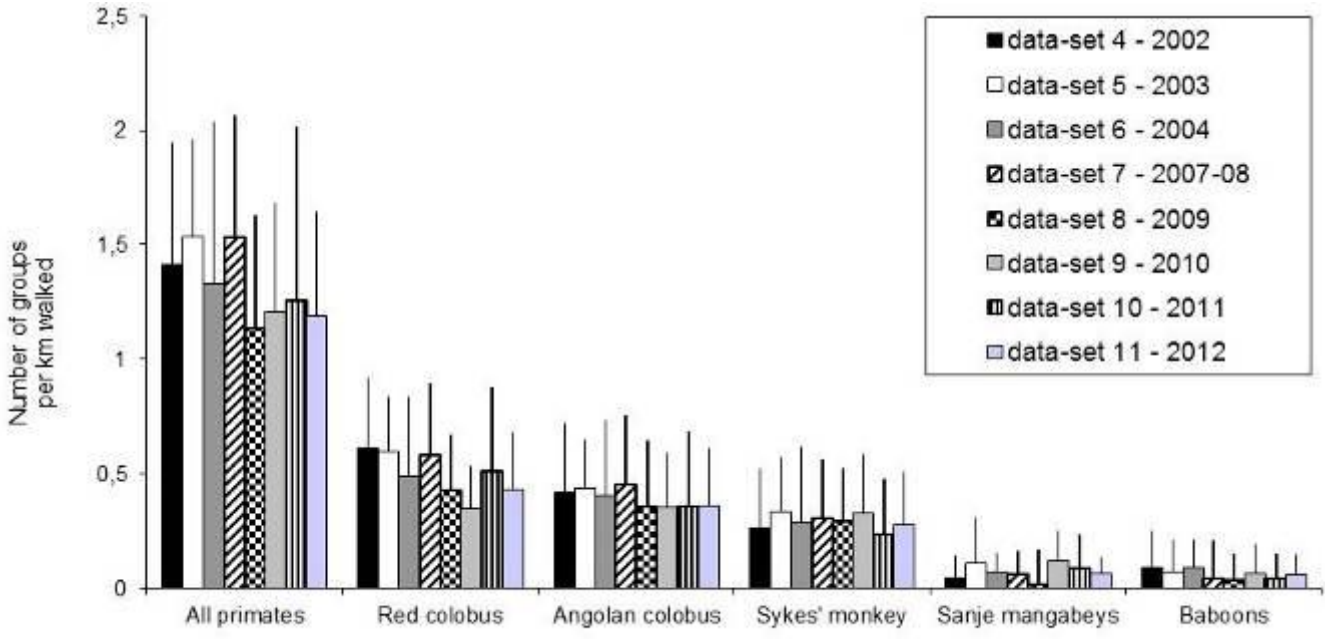


Fig. 2. Results of primates' encounter rate by observer for all transects pooled in Mwanihana forest.

Table 3. Results of ANOVA tests on primates' encounter rate by observer, with significant outcomes of post-hoc comparisons

	F statistic	P	Turkey's post-hoc comparisons
All primates	5.998	<0.001	Obs 5 vs 8,11 Obs 7 vs 8,9,10,11
Red colobus	9.140	<0.001	Obs 4 vs 8,9 Obs 5 vs 8,9,11 Obs 7 vs 8,9,11 Obs 9 vs 10
Angolan colobus	1.709	=0.104	None significant
Sykes' monkey	1.313	=0.241	None significant

3.4. Interpretation of monitoring results

For primates, the increased data-set generally corroborates the conclusions in earlier reports, i.e. that populations appear to be relatively stable over time in Mwanihana forest, UMNP, while the declining trend in USFR persists and continues to be alarming. Hence, while the variation in relative abundance that emerged for Mwanihana should be considered natural and/or due to minor inter-observer differences, those emerged in USFR indicate a real declining trend. A detailed paper on these differences and the likely determinants has been published in 2012 (Rovero et al. 2012, *Biological Conservation* 146: 89-96), and used data from 2004-2009. The paper shows the relative effect of habitat degradation and hunting in determining the trends observed, with hunting mainly explaining the decline in population abundance of the colobines in USFR.

The key recommendations from these results are therefore similar to those previously stated, and particularly:

1. it is critical to continue and monitor with methodological consistency to previous efforts the primates of both forests;
2. conservation of these important primate populations depends on the good protection effort allocated to the forests where they occur. For USFR in particular, it is hoped that the proposed upgrading to Nature Reserve can be quickly done and can be associated to effective ground protection.

4. Preliminary results of the monitoring programme in Arusha National Park (data provided by Gladys Ng'umbi, TANAPA)

Data were collected in the first half of 2013 as follows:

Transect name (length)	Number of replicates (period)
Mbega trail (3.6 km) Momela Fig tree (3.5) Mambreni (2.5)	N=6 rep (Feb-July 2013) N=4 rep (Feb-May 2013) N=3 rep (Feb-April 2013)

Preliminary summary of encounter rate by transects for primates and the red duiker are in the chart below.