Udzungwa Ecological Monitoring Centre
(Udzungwa Mountains National Park)

Annual Technical Report
Year 4 (January - December 2010)

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Cover photo: view of Mwanihana forest, photo by F. Rovero

Summary

The Udzungwa Ecological Monitoring Centre (UEMC) is a facility of the Udzungwa Mountains National Park (UMNP) established at the end of 2006 with the aim of promoting and facilitating biological research and monitoring in order to increase our understanding of the Udzungwa Mountains, and to utilize this information to develop more effective conservation management and community education plans that will improve the long-term conservation of the UMNP and the adjacent Forest Reserves. This is the fourth year technical report (January - December 2010), and it is aimed at presenting the results of monitoring and training activities, and other programmes conducted, as well as summarize the short and medium-term plans so that it can also serve as a strategic document. A major achievement of 2010 overall has been the inauguration of the new hostel, that consists in two large buildings, a dormitory and a dining hall with kitchen. The hostel is dedicated to enhancing higher education training and training of parks' personnel.

UEMC continued the primate and duiker monitoring programme in Mwanihana forest (UMNP) and the southern Uzungwa Scarp Forest Reserve (USFR), and the results from relative abundance data collected were compared to previous data collected by researchers and UEMC since 1998. The latest set of data makes a significant contribute, as it consists of 14 months of census. This raised the amount of data-set to just over 500 census repetitions in Mwanihana, and 188 in USFR. For the Mwanihana primates, the latest results are very consistent with those from the latest data-set (2009), and confirm that although a phase of slight decline of relative abundance is apparent when all species are pooled, a possible true decline may only be happening for the endemic Udzungwa red colobus. The statistical comparison of all data since 1998 may be confounded by the outstanding values recorded in 1998 and also by the small data-sets collected until 2001. However, when statistical tests are applied only to 2002-2010, the trend found for red colobus seems still to hold. Large temporal variation in primate populations are documented from elsewhere in Africa and may be due to intrinsic, demographic factors, however because of the increasing anthropogenic pressure in the park, these results need to be considered with attention for the possibility that hunting and/or other forms of disturbance may be explaining some of the results.

Results for the southern USFR are confirming the dramatic situation of rapid decline of both primate and duikers highlighted in the previous report. The latest data-set do not highlight further decline, but it does confirm that a very threatening context is occurring. Indeed the results have been compiled with data from other researchers into a published report that was endorsed by the Tanzanian Government (Forestry and Beekeeping Division), supported by the major conservation agencies working in the country, and officially launched in Dar es Salaam in February 2011. Due to the presence of donor representatives, it is hoped that prompt action on the recommendations raised will follow, and indeed USFR is currently in the process of being upgraded to Nature Reserve.

In addition to the primate and duiker long-term monitoring programme, UEMC continued the ranger-based monitoring of large mammals, that occur throughout the park from each of 5 remote ranger posts. Following a baseline data collection in 2009, the responsibility for data collection was partly handed over to the rangers in the beginning of 2010. This led to collecting a second set of data that it is here compared with the previous, to assess consistency. Results are well comparable and overall represent an excellent baseline for promoting this programme further. As part of this programme, and to generally strengthen GIS capacity, UEMC organized a brief GPS and GIS training course that took place in July.

Additional achievements of UEMC in 2010 included:
- continued and strengthened the environmental education programme with 5 primary schools;

- continued accommodation and facilitation of researchers, with the number of researchers hosted that raised to nearly 100;
- training based at the new hostel initiated with a group of 12 student from Pennsylvania State University studying land-use planning in collaboration with Sokoine University of Agriculture and the local Government;
- continued the biodiversity monitoring programme in Mwanihana as part of the TEAM network, with conduction of the second year of monitoring;
- provision of training scholarships to TANAPA and UEMC staff, this including scholarship for two students (Mr. Richard Kishe of TANAPA to attend a Diploma Mweka Wildlife College and Miss Scolastica Mwasenga of UEMC to attend Diploma at Olmotonyi Forestry Institute);
- training support could be granted partially thanks to internal income raised through fees for accommodation, that in 2010 contributed to about 25% of UEMC running costs and that is projected to increase in 2011 with the increase of training courses hosted and/or organized.

Among the short term plans, UEMC intends to organize in 2011 a 2-week summer school that will be dedicated both to international and national students, and to park ecologists from a number of forest parks in the country, to strengthen capacity building on field and GIS tools for assessing biodiversity, as well as working towards the long term goal of standardizing ecological monitoring across protected areas. Towards this end, UEMC is well placed to become a model for biological monitoring and training in the country. Key components of plans for 2011 and the longer-term vision are detailed in the last section of the report.

1. Background and report aim

The Udzungwa Ecological Monitoring Centre (UEMC) is a facility of the Udzungwa Mountains National Park (UMNP) that was inaugurated on the 10th of November 2006. The establishment of the UEMC was promoted and funded by Trento Science Museum in partnership with Tanzania National Parks (TANAPA). The UEMC has been donated to Tanzania National Parks (TANAPA) and it is managed by Trento Science Museum under the conditions stated in a Memorandum of Understanding.

The aim of the UEMC is to promote and facilitate biological research and monitoring in order to increase our understanding of the Udzungwa Mountains, and to utilize this information to develop more effective conservation management and community education plans that will improve the long-term conservation of the UMNP and the adjacent Forest Reserves. Other than providing accommodation and research resources to visiting scientists, the activities originally planned include delivering technical advice to TANAPA (especially UMNP's Ecology Department), implementing monitoring programmes, organizing courses for rangers, scouts, park ecologists and university students, promoting school education programmes for school children, and networking with other biological field stations in the tropics and organizations supporting monitoring centres.

This is the fourth year technical report, and it is aimed at presenting the monitoring data collected and other activities, as well as summarizes the updated short and medium-term plans so that it can also serve as a strategic document. The report is prepared by Trento Science Museum in collaboration with UEMC technical personnel and UMNP/TANAPA's Ecological Monitoring Dept., and it is revised by the Advisory Committee. Previous reports can be found in the UEMC website (UEMC 2008-2010).

1.1. Summary of UEMC set-up and personnel

Whilst this is neither a management nor a financial report, the following information are summarized to complete the background to the UEMC functioning. Currently, the UEMC consists of 6 buildings: one includes an office, store and large seminar room and next to it are three researchers' houses, each with two double rooms. In February 2010, the hostel was officially inaugurated, and it consists of a dormitory block (four rooms each with three double-deck beds) and of a dining hall, with kitchen and two stores. This new structure is dedicated to enhancing training capacity. The inauguration was attended by representatives of TANAPA Headquarters (Mr. Inyasi Lejora, Ecological Monitoring Manager), Trento Museum (Dr. Michele Lanzinger, Director), Kilombero District, local villages and schools, in addition to the staff of UMNP and UEMC.

A number of other infrastructural improvements also took place. As the UEMC was experiencing shortage of water during the dry season, the water pipe system was changed and water tank reserve for supplying water to the hostel and UEMC houses was built and completed in the mid of July 2010. Also in order to accommodate the increasing need for storing capacity, a small store (5x5 m) was built in the UEMC plot just next to the main building. This allows releasing pressure on the small store that was used in the main office block to accommodate all the researchers' and UEMC's own equipment and materials.

The staff working at UEMC did not have major changes. In addition to Trento Museum's institutional representative (Dr. Rovero), it includes: UEMC coordinator (Arafat Mtui), a school environmental education officer (Alatupoka Sanga), two field technicians, two gardeners, 1 house-keeper and four watchmen. UEMC recruited Ms Alatupoka Sanga in the mid of 2010 who was trained for three months for replacement of Ms Scolastica Mwasenga. In addition, since 2009

UEMC hosts the TEAM network project that begun in mid-2009, and is run by a staff of 4 people, including a site manager, 2 field technicians and a driver.

UEMC provided scholarships for personnel training. Thus, Ms Scolastica Mwasenga (former UEMC environmental education officer) was supported to join Olmotonyi Forestry Training Institute to pursue certificate in forestry management for two years and joined the college at the beginning of August 2010. Moreover, UEMC supported Mr. Edward Kishe, TANAPA employee with the UMNP Tourism Department, to join Mweka Wildlife College for diploma course programme in wildlife management for two academic years, starting in August 2010.

2. Summary of activities planned and activities implemented

This section provides an overview of activities implemented until the end of 2010 against those that were originally planned, with details for each component - including ecological monitoring data - being presented in following sections. It also compare these with the recommendations provided by the 40 participants that attended an informal discussion on the inauguration day in November 2006 that was aimed at gathering suggestions on ecological monitoring strategies and activity planning.

1. *Provide advisory and technical assistance to the UMNP/Ecology Department on all issues related to ecological monitoring.*

This fundamental activity continued with special focus on improving the ranger-based monitoring of large mammals (see dedicated section below). The report also contains recommendations from the updated analysis of primate and duiker monitoring data.

2. *Implement ecological monitoring protocols in conjunction with the Ecology Department in the UMNP and with the Forestry Division in the Forest Reserves.*

UEMC continued the primate monitoring programme both in Mwanihana (UMNP) and in the southern Uzungwa Scarp Forest Reserve (USFR), thus raising data for both TANAPA and Forestry Division. Due to the alarming situation of biodiversity destruction found in USFR adn highlighted in the previous report (UEMC 2009), a summary report on USFR (see front cover below) was published and launched in February 2011 with the support of Tanzania Forest Conservation Group and as a collaboration between UEMC and other institutions. The launch was attended by important Government and non-governmental representatives, including the donor community, and it has been a major drive towards ensuring long-term protection of the reserve.

Moreover, all data collected by TEAM project in Mwanihana forest within UMNP since 2009 are also readily available.

3. *Facilitate visiting researchers and conservation agencies through providing accommodation, information, research facilities (Internet, computers, etc.).*

In 2010 UEMC hosted 13 long-term researchers plus a number of guest researchers visiting on shorter term basis, adding up to a total number of around 95 researchers accommodated in the houses during the 4 years of activity. UEMC hostel also begun to operate in May 2010 with a group of 11 students and two Professors from Pennsylvania State University (US) who stayed for one month for their study abroad programme. The fees for accommodation in 2010 contributed to 25% of UEMC running costs.

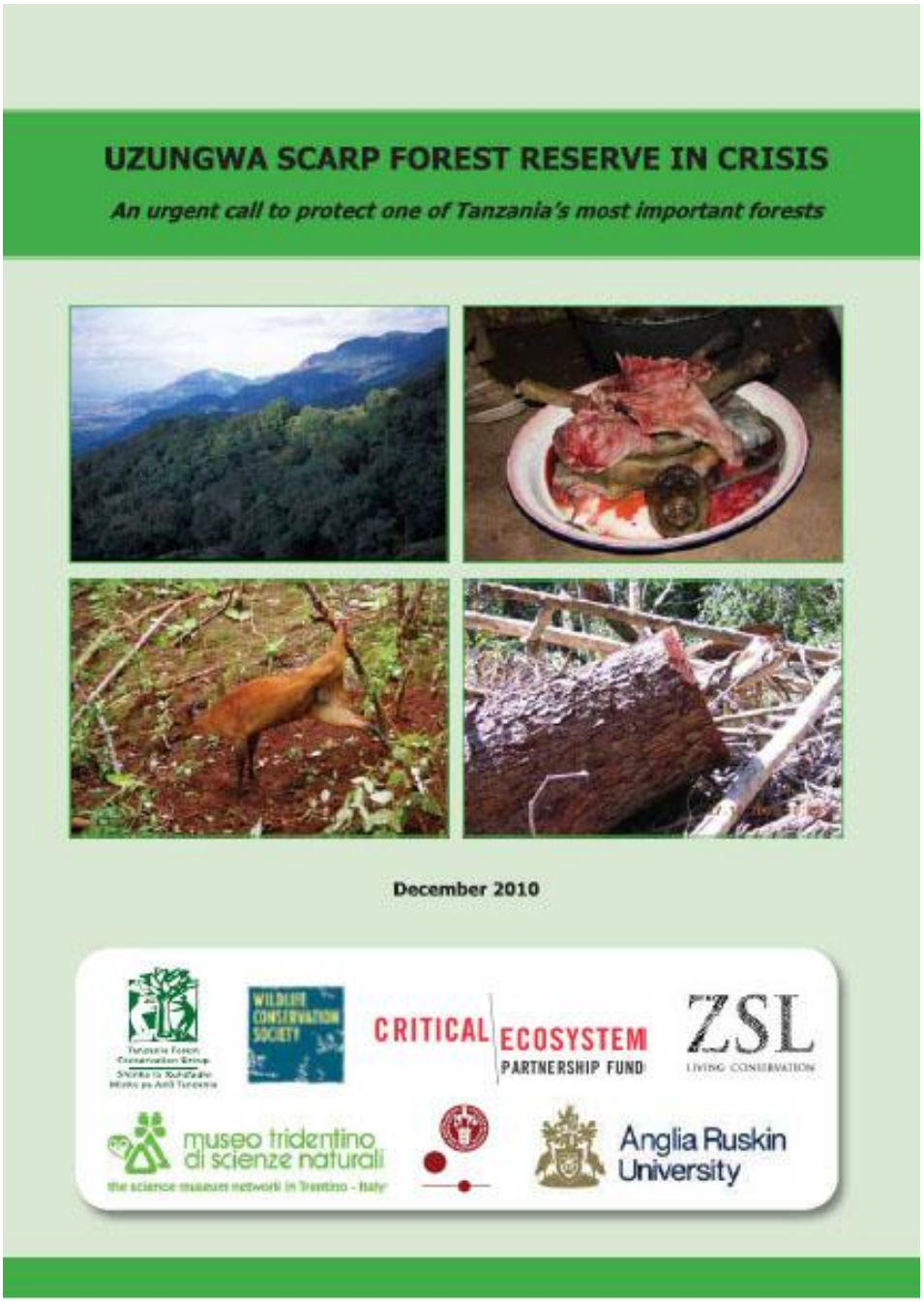


Figure 1. The front cover of the report on Uzungwa Scarp Forest Reserve launched on February 4th, 2010, in Dar es Salaam

4. *Organize training courses in ecological monitoring to rangers, park ecologists and students.*

The ranger-based monitoring programme is on-going (details below), and involved additional training on use of GPS and GIS capacity done in conjunction with the establishment of the GIS database. The new hostel will allow to strengthen this component. Indeed in July 2011 a summer school on field and GIS tools to assess and map forest biodiversity will be held at UEMC and will be dedicated to both international undergraduate students and TANAPA ecologists, plus a number of Tanzanian students (http://www.mtsn.tn.it/INGLESE/ing_sezioni/sum-sch11.asp).

5. *Organize education activities for school children.*

This programme continued and consolidated in 2010 with the 5 primary schools that were already involved since 2007. Activities ranged from lessons in class and visits to the park (and also to Mikumi National Park) to special events such as cinema nights and the celebration of the World Environmental Day (June 5th) that was held at Mang'ula village. In collaboration with the park's Community Conservation programme, plans have been developed in 2010 to strengthen this component, and beginning in 2011 teachers' training activities will begun.

6. *Establish a GIS database on Udzungwa biodiversity.*

The GIS database was established in July 2009 (see UEMC 2010). In July 2010, refinement of the database and further GIS training was organized by UEMC with support of Nick McWilliams from Anglia Ruskin University (UK). Training lasted 1 week and was aimed at improving park's staff capacity to handle spatial information (from patrols and monitoring activities) into GIS software.

Training on GIS given by Nick McWilliams of Anglia Ruskin University
to park's staff in July 2010.

7. *Promote external collaborations and networking with other monitoring programmes, ecological centres and field stations in the tropics.*

The continuation and consolidation of TEAM project (Tropical Ecology, Assessment and Monitoring), with its expanding network of field sites and field stations (www.teamnetwork.org) represents the major contribution towards this goal. Although based at UEMC, this project is run independently from UEMC routine activities. However, given the great relevance to UEMC activities and biodiversity assessment in UMNP, the report will update a summary of data collected during the second year of monitoring.

3. Recommendations from the inaugural stakeholders' workshop: follow-up in years 1- 4

1. Existing primate monitoring protocols in UMNP; the importance of continuing existing practice was emphasized.

2. Ranger-based monitoring protocols and training needed; highly recommended component that can be linked to village monitoring teams, there is a need to disseminate a standardized monitoring protocol to all stakeholders.

Both recommendations have been consolidated. Standardization of monitoring protocols extended to other forest National Parks is one of the goal of the summer school held in July 2011.

3. How to implement monitoring in Forest Reserves; it was noted that there is very limited personnel and resources by the Forestry Division to implement monitoring, however, training is fundamental and community scouts should be involved.

UEMC continued with monitoring primates and ungulates in USFR, and the updated results presented here, indicating dramatic declines in population abundance show the importance of this effort.

4. Impact of firewood collection on biodiversity (and more generally, habitat disturbance monitoring), how to continue previous work and start long-term monitoring programme; the need for WWF and Park Ecologist involvement was recommended to repeat the protocols initiated.

UEMC repeated in mid-2008 the 2005 study on the impact of firewood collection, with support from WWF. TANAPA has decided to stop firewood collection as of July 2011. While the banning will be beneficial to the ecosystem, improved environmental education, public awareness raising and support to the provision of alternatives sources of energy to the communities will be critical to ensure long-term sustainability of this management decision.

5. Sanje Mangabey long-term monitoring; the UMNP's Ecology Department has been conducting a habituation program with one group since 2002 and this is on-going.

The study initiated in mid-2008 on demography monitoring of Sanje Mangabey was conducted until mid-2009 with 4 repeated counts of a number of non-habituated groups. The results were presented in the previous report (UEMC 2009). The difficulties of following non-habituated groups and obtaining reliable and periodic counts made this programme of limited cost-effectiveness, especially in view of its long-term sustainability. Therefore it was discontinued. However, two groups of mangabeys are currently habituated and regularly followed by long-term researchers and park ecologists, therefore data on counts are collected much more routinely and can be used as baseline information.

6. Standardizing protocols according to Hotspot-wide monitoring initiative; the importance of TANAPA implementing a centralised data-base of monitoring data was recognized.

This links to the objective 2 (above) and the need for networking with similar parks in the country. Plans to standardize monitoring across forest parks will move forward with the training in 2011.

4. Ecological monitoring results: primate and forest antelope monitoring

4.1. Primate monitoring in Mwanihana forest

UEMC adopted the Primate Monitoring Programme established in 1997 in Mwanihana forest, and transects details are reported below (Table 1, see also Rovero et al. 2006). 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 (m a.s.l.)	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 below (Table 2). The series presented in previous report is updated with the consistent data-set (n=112 census walks) collected by Arafat Mtui (data-set 9). This ensures consistency with data collected earlier by Mtui during 2003-2004 and 2008-2009.

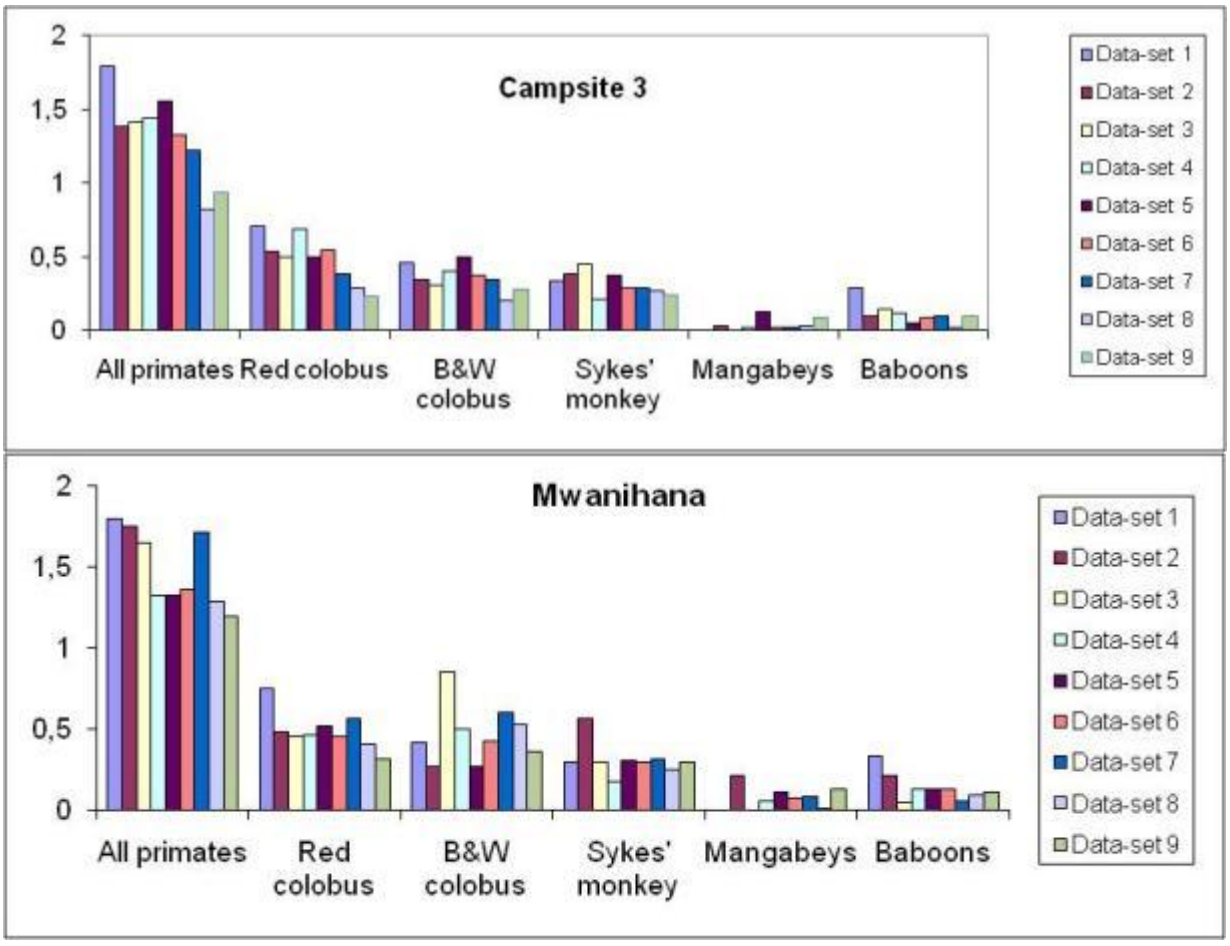
The current data-set for Mwanihana consists overall of 505 transect repetitions, equivalent to 1977.1 km walked. This is the largest and longer-term monitoring data-set available for the area.

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
1	UBP	August - October 1998	6	6	8	6
2	CAS	October 1999 - February 2000	15	15	14	11
3	ARM	May - September 2001	5	5	6	-
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
	All observers		142	142	143	78

The results of primate group sightings are summarized as the mean encounter rate with primate groups (groups seen per km of transect walked) and are reported in the following graphs (Figure 2) for all data-sets since 1998 and for each transect.



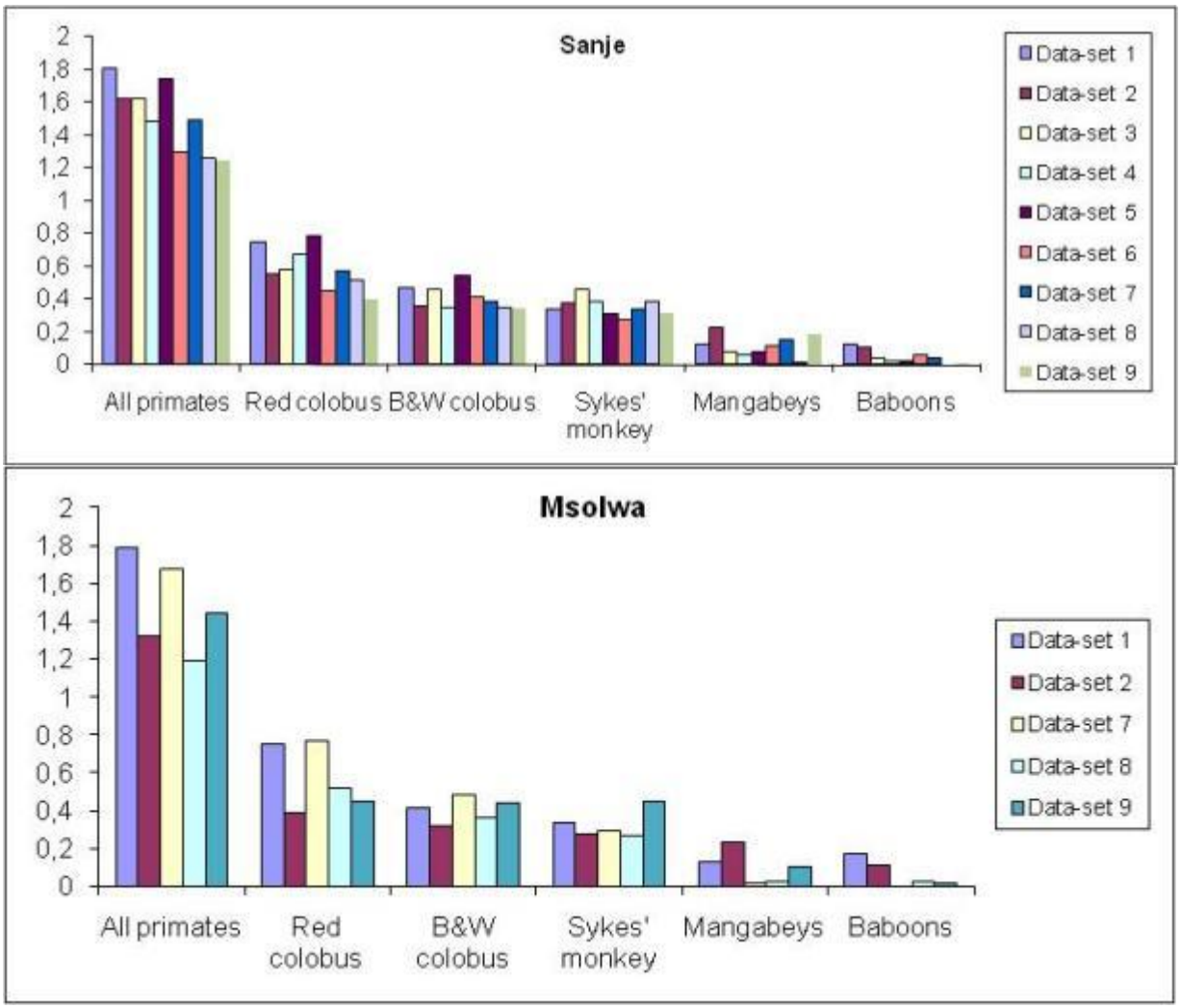


Figure 2. Results of primate monitoring expressed as the mean number of primate groups seen per km of transects for all four transects from 1998 until January 2011 (the last 4 sets of data being collected by UEMC). Data for the fourth transects (Msolwa) were collected beginning in April 2007.

The differences in abundance among species and transects (related to the different proportions of forest habitat represented) have been discussed elsewhere (Rovero et al. 2006). Of focal attention here are the temporal variations within species and transects.

The inclusion of the latest data-set collected in 2010 is critical and indicates some clear differences, in particular: at campsite 3, the pattern emerged in the previous report of declining primates especially due to the two colobus appear to be confirmed only for the red colobus. Similar consideration apply to Mwanihana transect, i.e. there appear to be a decline in both colobus monkeys. Overall, these statistically confirmed changes - reflected in the profiles for all transects pooled (detailed below) - confirm that a soft, but steady decline in the relative abundance of red colobus may be truly happening.

To simplify the analysis (and following Rovero and Mtui 2006), data from the four transects (including Msolwa) were lumped across transects and statistical tests (one-way Analysis of Variance followed by Bonferroni post-hoc comparisons run using SPSS package) were run on this lumped distribution (Figure 3). This lumping is justified by the fact that all three transects

traverse a similar range in variation of gross habitat types, from deciduous/semi-deciduous to semi-evergreen and evergreen forest, and comparable altitudes, all starting at the base of the forest (300 m asl) and reaching altitudes between 600 and 1000 m.

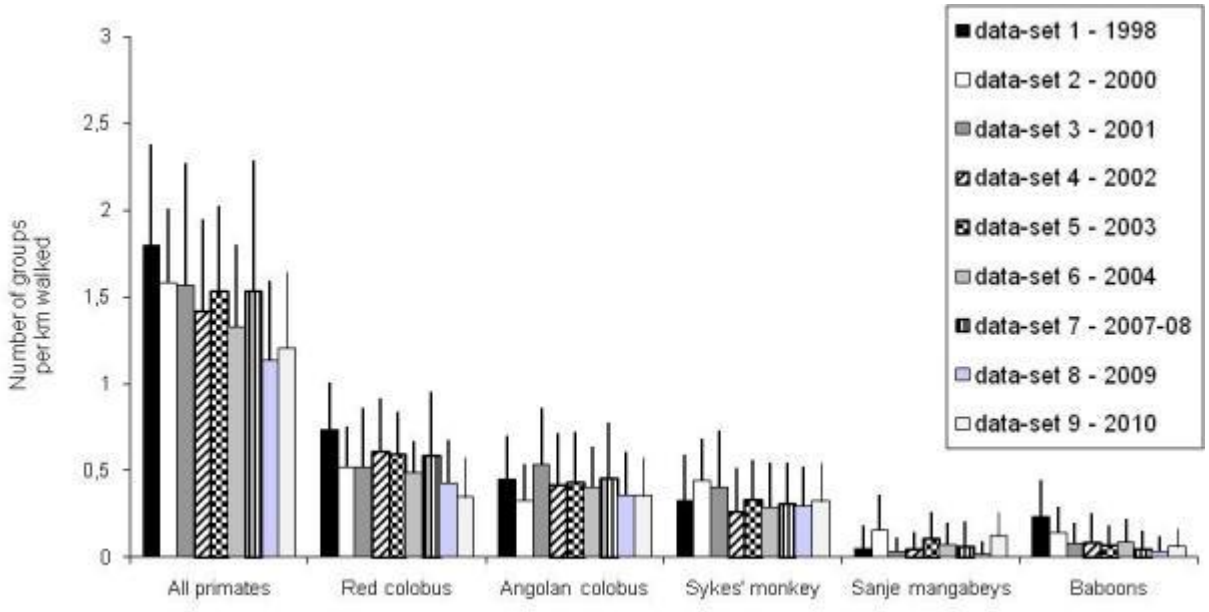


Figure 3. Results (mean number of primate groups seen per km and standard deviation) of primate census pooled for 4 transects from data collected from 1998 until January 2011 (the last 3 sets of data being collected by UEMC)

Differences among observers in primate's encounter rate were significant for all specie (Table 3). Bonferroni's post-hoc multiple comparisons help assessing if these differences reveal meaningful, temporal trends or not. In comparison to the analysis of previous years, the inclusion of the latest set of data determines a greater number of statistical differences between pairs of observers. These Statistical results are summarized in Table 3.

Table 3. Results of ANOVA and post-hoc comparisons on primate census results obtained by different observers

Species	F (df = 8,491)	P (differences between observers)	Post-hoc comparisons significant at P<0.05
All primates	7.469	<0.01	Data-set 1 vs 6,8,9; set 2 vs 9; set 5 vs 8,9; set 7 vs 8,9; set 8 vs 9
Red colobus	9.832	<0.01	Data-set 1 vs 6,8,9; set 2 vs 9; set 4 vs 8,9; set 5 vs 8,9; set 6 vs 9; set 7 vs 8,9
Angolan colobus	2.276	<0.05	None significant
Sykes' monkey	2.333	<0.05	Data-set 2 vs 4, 6,8
Mangabeys	6.798	<0.01	Data-set 2 vs 3,4,6,7,8; set 8 vs 9
Baboons	8.137	<0.01	Data-set 1 vs all; set 2 vs 7,8,9; Ob 2 vs 7,8

Careful consideration of the results shows that the drop observed in 2009 is in fact maintained only for the red colobus (see statistical differences between earlier and latest data-sets), while for all primates the results actually indicate a slight increase. No significant differences were observed for the Angolan colobus; the trend for Sykes' and baboon is similar to that reported in 2009, i.e. differences are due to unusually high results from the data-set 2. This also applies to Sanje mangabeys, with the addition that results from the latest data-set are significantly higher than the previous, and this slight increase is also shown in the baboon. As noted in earlier reports, results should always be taken with caution because slight changes in animal detection by the observers may result in variation that do not reflect true temporal trends.

The possible explanations for the results of declining red colobus may lie on anecdotic instances of poaching with armed guns have been collected in latest years by various researchers and by rangers working or patrolling in the area. Campsite 3 is also crossing the area of forest used by the large settlement of Mwaya; there are also rumours that hunters from Kiberege village (10 km south along the park edge) can easily access the highest part of the forest for setting snares and hunt with guns. Such disturbance may have increased colobus' shyness and/or force them to move to other parts of the forest, thus resulting less detected from the transect.

The previous report (UEMC 2010) provided suggestion for the apparent variation in mangabeys and baboons. It is good news that the possible decline trend of baboons, compatible with a situation of increasing conflicts with park-adjacent villagers, is actually not maintained with the updated data-set. These 2 predominantly terrestrial species are of difficult detection from line transects and are therefore the species for which result interpretations is particularly complex. However, the inclusion in the statistical analysis of data from Msolwa transect seems to confirm the decline supposed earlier that baboons faced in this area. Msolwa is the northern-most portion of Mwanihana forest, possibly the least patrolled, and the area where illegal encroachment by Wahehe hunters living in the area has been reported, including during the extensive surveys of the forest done fot the TEAM project during the last quarter of 2010 (see also previous report).

Finally, for the careful interpretation of the results it is also useful to run the statistical analysis on data-sets 4-9 only (i.e. from 2002), both because of too contrasting results for some of the earlier data-sets (especially data-set 1 and 2) and because the sample size was small and/or involved different observers. Data-sets 4-9 are instead very consistent and inter-observer differences have been checked for consistency. With such analysis, while the direction of overall differences do not change much, inter-observer post-hoc comparisons show that the differences for red colobus of data-sets 7 with 8-9, 6 with 9, and 4 with 8-9 are mantained. On the contrary, most of the significant comparisons in Table above are not mantained, with the exception of a signficant drop between data-set 7 and 8-9 for all primates.

4.2. Primate monitoring in Uzungwa Scarp Forest Reserve

The same line-transect technique used for censusing primates in Mwanihana was also used in the Uzungwa Scarp Forest Reserve (USFR) beginning in 2004 by F.R.; 23 repetitions in each of three transects were obtained during 2004-2005 by F.R. and others (mainly Arafat Mtui). UEMC continued this protocol: 10-14 repetitions were obtained during 2007-2008, 7-9 repetitions in 2009, and 13 repetitions in 2010 (Table 4). This totaled 188 repetitions, equivalent to 670.7 km walked.

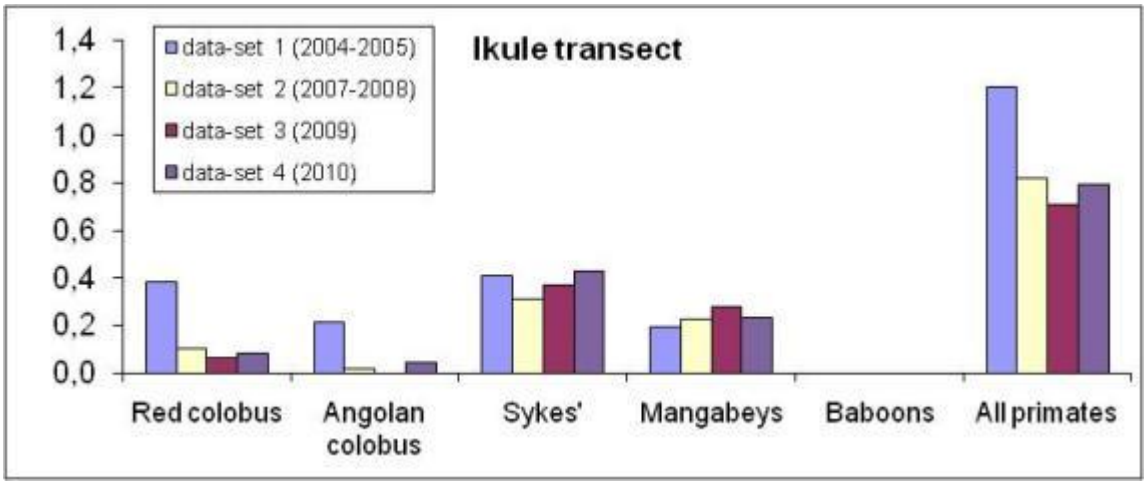
Monitoring was generally constrained by the remote location of USFR against the available budget and manpower. Moreover, census in the JKT transect, which is inside an area of the Forest Reserve managed by military station, had to be discontinued in 2009 due to problems and delays to obtain permits, and therefore a new transect (called TAZARA) was initiated. The high-

elevation, Kitolomero transect was also discontinued from 2007 because it needed camping and too much costs.

Table 4. Number of primate censuses conducted by each observer and data-set in Uzungwa Scarp Forest Reserve, southern Udzungwa Mountains

N°	Observer	Period	Transect					
			Ikule	Mkaraji	JKT	Kitol	Tazara	All
1	FR+ASM	July 2004 - June 2005	23	21	22	20	na	86
2	AMANI	January 2007 - June 2008	14	14	10	na	na	38
3	ASM	January-September 2009	9	9	na	na	7	25
4	ASM	October 2009 – January 2011	13	13	na	na	13	39
All			59	57	32	20	20	188

Results for each transect, and for all transects combined are presented in the following charts (Figure 4-5). For all transects, the alarming declining trend that emerged with the previous 3 data-sets especially for the two colobus monkeys is confirmed (statistical results in Table 5) although it did not worsen further. In fact, Angolan colobus, never sighted in the previous period, "re-appeared" again, but only in the Ikule transect which is the one crossing the largest amount of cross-canopy, interior forest. Overall data confirm that heavy poaching and habitat disturbance is threatening the colobus to alarming states. Given the seriousness of these results, a special report that combines data with other researchers was launched in February 2011 (Rovero et al. 2010), as mentioned above.



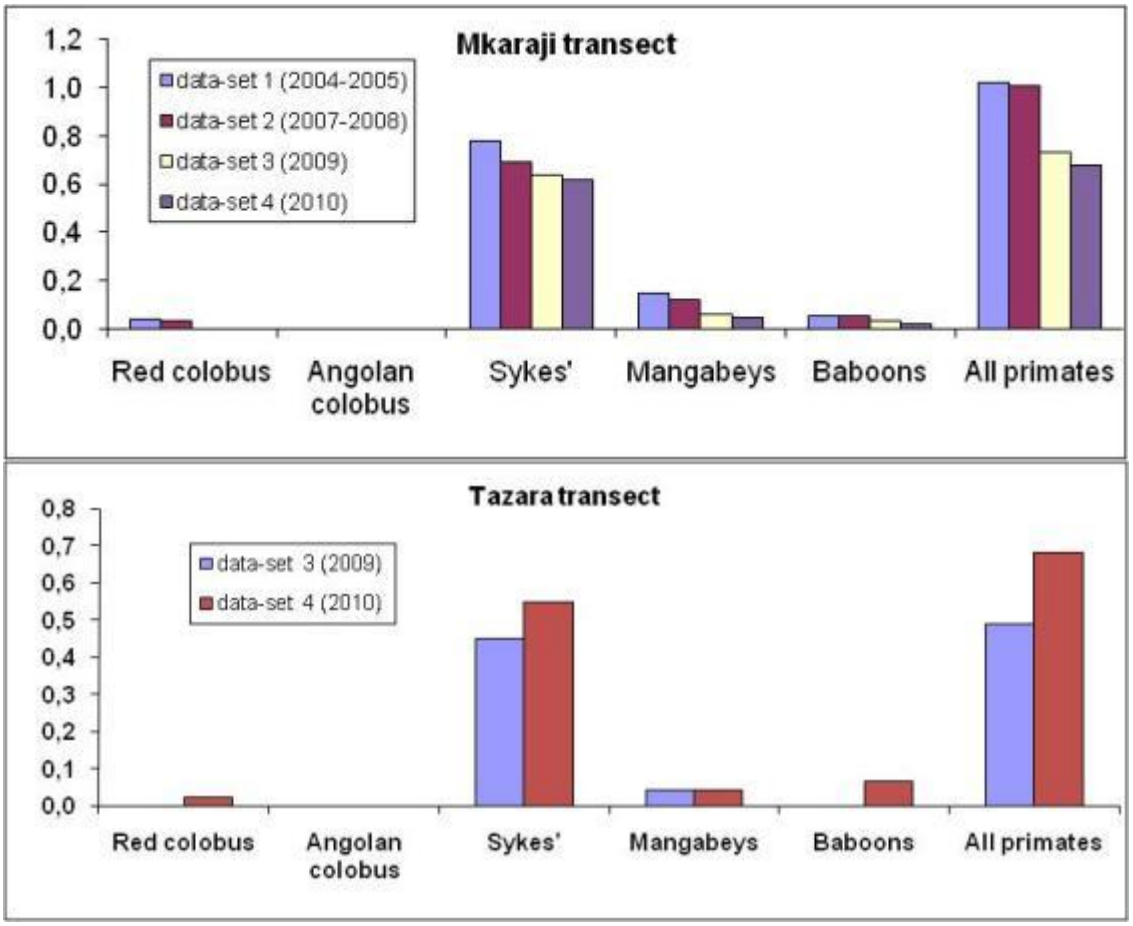


Figure 4. Primate census results obtained in USFR during 2004-2010: results for each of three transects currently repeated

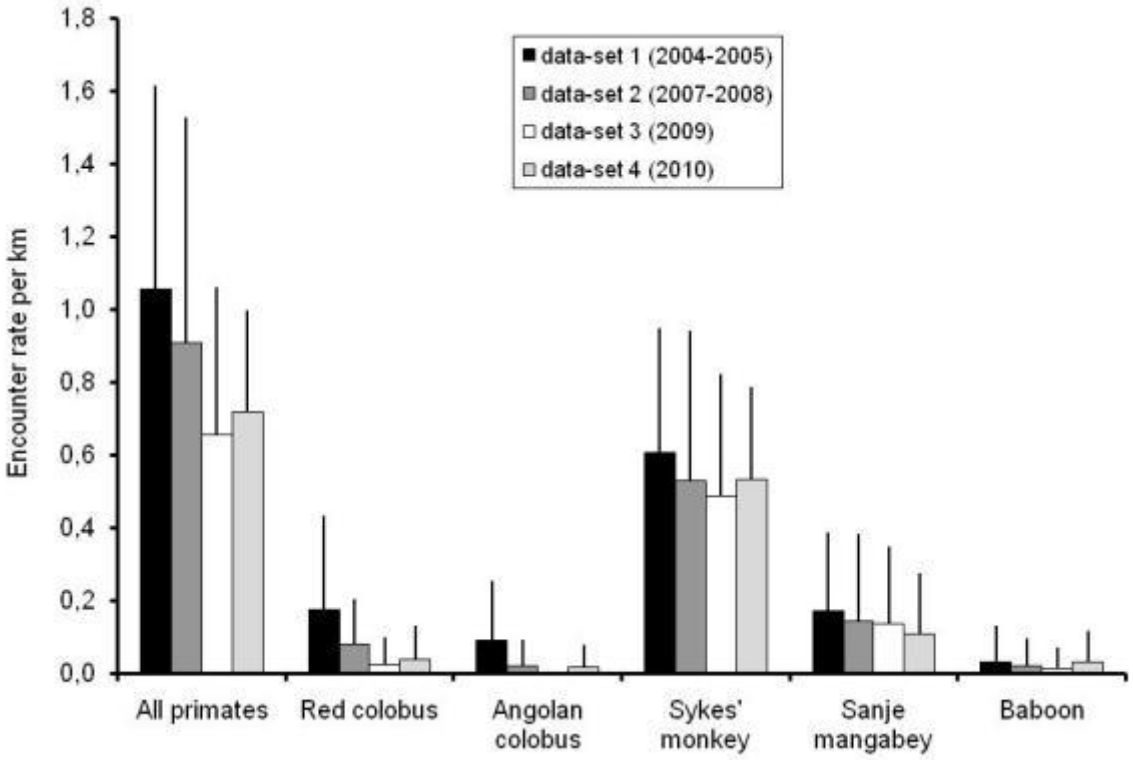


Figure 5. Primate census results in USFR: pooled transects

Table 5. Results of ANOVA on primate census results (all transects pooled) obtained in USFR

Species	F (df = 3,169)	P (differences between observers)	Post-hoc comparisons significant at P<0.05
All primates	5.640	**<0.01**	Data-set 1 vs 3,4
Red colobus	6.778	**<0.01**	Data-set 1 vs 2,3 (P=0.053 1 vs 2)
Angolan colobus	6.602	**<0.01**	Data-set 1 vs all
Sykes' monkey	0.948	=0.419	None significant
Mangabeys	0.730	=0.535	None significant
Baboons	0.346	=0.792	None significant

4.3. Harvey's duiker monitoring in Mwanihana forest

Along with primate census, all sightings of duikers were also scored beginning from transects conducted in 2002 (data-set 4). The Harvey's (red) duiker *Cephalophus harveyi* is the only forest antelope species that is sighted in the day and frequently enough to be monitored through line-transects. Other species such as suni, blue duiker, and Abbott's duiker are either very rare or crepuscular/nocturnal, and we found that others techniques are best suited for their monitoring, such dung counts and camera-trapping. Whilst these techniques are either more challenging methodologically or more costly, data on the Harvey's duiker alone seems very useful for monitoring and management purposes since this is the most common antelope and it is targeted by hunters through snaring even inside the National Park; thus, besides being an indicator of human disturbance it represents an indicator of forest floor ecosystem health, being also likely affected by firewood collection.

Table 6. ANOVA results of inter-observer differences in Harvey's duiker census results

Species	F (df = 4,97)	P (differences between observers)	Post-hoc comparisons significant at P<0.05*
Campsite 3	3.203	**<0.05**	
Mwanihana	0.856	=0.49	
Sanje	0.921	=0.45	
Msolwa	0.044	=0.83	
All transects	2.449	**<0.05**	Data-set 1 vs 4

*Done only for pooled transect data-set

Updated results from the report of year 1 are shown in Figure 5 for data-set 1 (F. Rovero: 2002-2003), 2 (A. Mtui: 2004), 3 (A. Kitegile and A. Mtui - UEMC: 2007-2008), 4 (A. Mtui: 2009) and 5 (A. Mtui: 2010) for a total of 352 repetitions pooling all transects. Statistical tests reported in Table 6 confirm the trend highlighted in the previous report, i.e. that the differences between observers are significant for Campsite 3. However, in contrast with previous report, differences between observers when all transects are pooled also became significant (P<0.05) mainly due to

the differences between results from the first and last data-sets. While the overall declining trend raises some concern, it does not appear of great magnitude and will need continued monitoring to be further interpreted.

Indeed as observed with primates, and even more so for the often rapid fleeting duikers (making their detection quite difficult), inter-observer differences may play a big role here, however at the same time the trend might indicate that snaring of duikers or other disturbance possibly associated with firewood collection might have negatively impacted this species. That Observer 3 and 4 saw duikers less frequently at Campsite 3 than Mwanihana and Sanje relative to the other observers might indicate the possible higher snaring activity occurring here, also speculated to interpret the decline in the colobus. Similarly low frequency of sightings than recorded at Campsite 3 was scored by at Msolwa during 2009 and 2010, where instances of poaching were also occasionally recorded.

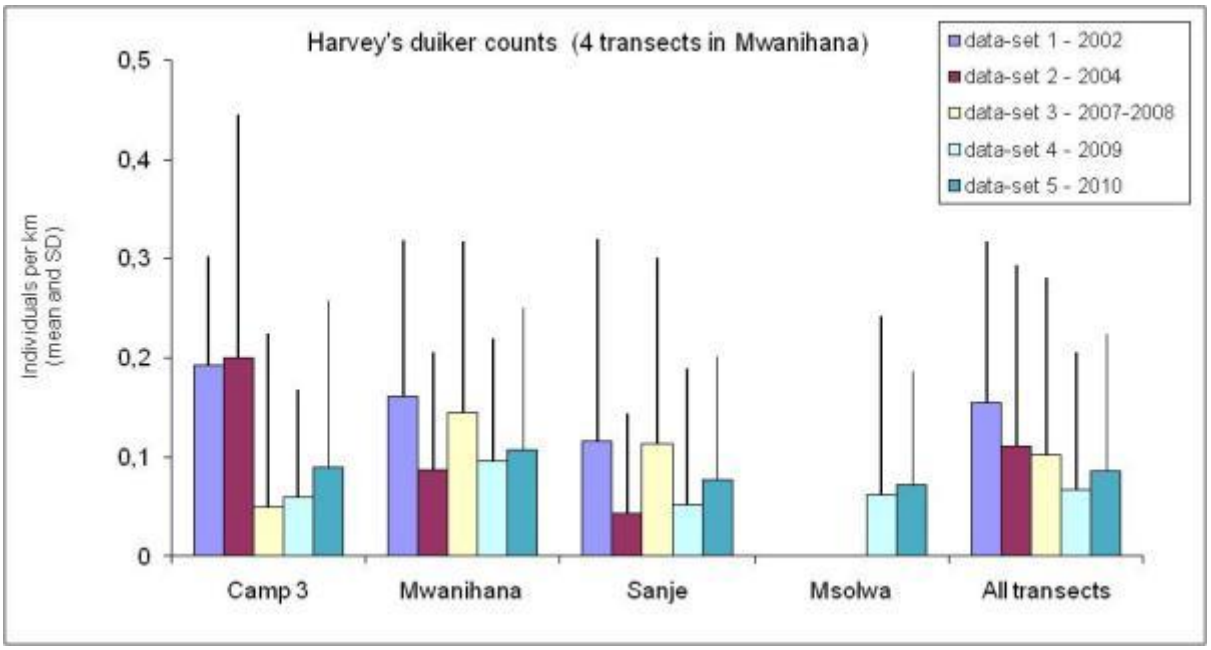


Figure 6. Results of Harvey's duiker census (individual encounters per km walked) along four transects in Mwanihana forest.

4.4. Harvey's duiker monitoring in USFR

Although sightings of Harvey's duiker in USFR are very occasional, the increased data-set reinforces the results presented earlier and confirms the low and declining abundance of this antelope (Figure 7). This is particularly dramatic for the most degraded transect, Mkaraji, that run just above Ikule village, as duikers *were never seen* during the last 3 series of census, i.e. after 2005. The trend therefore highlights a clear decline in comparison to Mwanihana, and differences in the results among data-sets are overall statistically significant (Table 7, $P<0.01$). These results match those found for primates, and hunting is definitely the underlying driver.

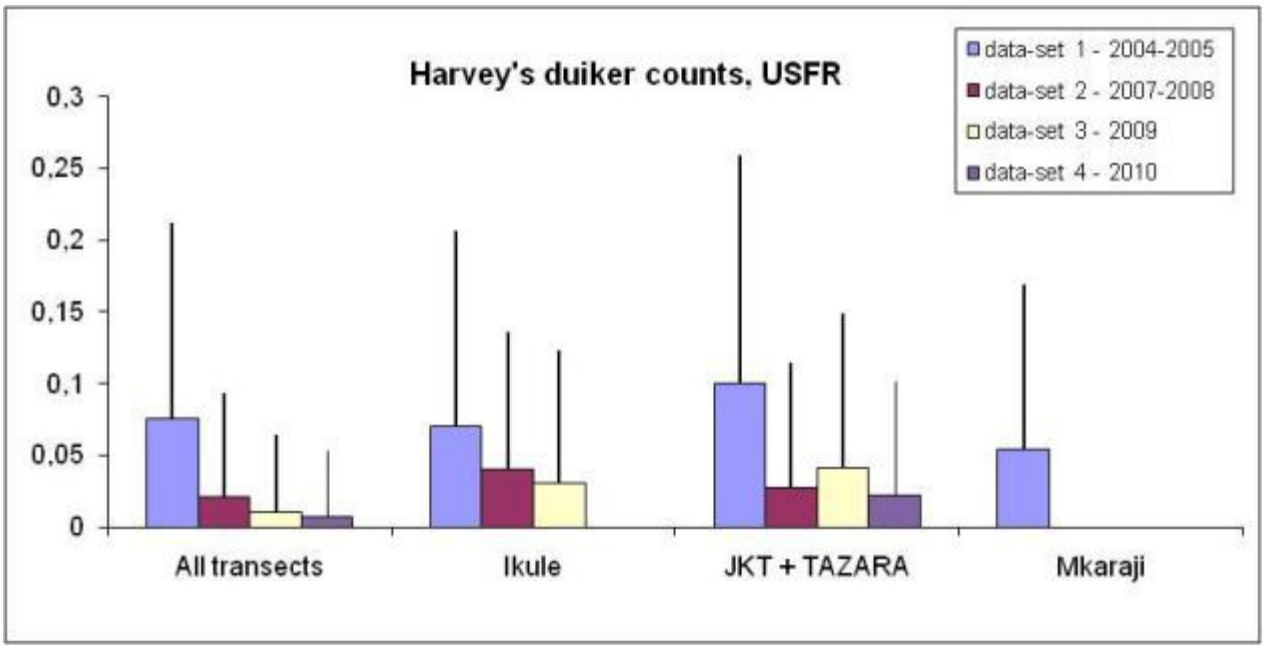


Figure 7. Results of Harvey's duiker census (individual encounters per km walked) along four transects in Uzungwa Scarp Forest Reserve.

Table 7. ANOVA results of inter-observer differences in Harvey's duiker census in USFR

Species	F (df = 3,57)	P (differences between observers)	Post-hoc comparisons significant at P<0.05*
Ikule	1.312	=0.279	
JKT+Tazara	1.426	=0.247	
Mkaraji	2.855	<0.05	
All transects	5.694	**<0.01**	Data-set 1 vs all

*Done only for pooled transect data-set

4.5. Management and conservation implications from primate and duiker monitoring

The updated set of data obtained since the 2010 report is consistent, and allows to delineate some conclusions which are relevant to park management and future monitoring efforts:

1) In Mwanihana forest within UMNP, overall results of primate monitoring suggest that relative abundance recorded in 2009-2010 seems to be slightly lower than recorded during 2000-2004. The resultant, apparent overall decline may be confused by the unusually high values recorded in 1998, that relate to a small number of transect repetitions and are therefore not very accurate. Importantly, this pattern is mainly due to the results for red colobus, and possibly, baboons. The possible decline of red colobus appears to be consistent across transects but especially marked at camp site 3. The relative abundance of Angolan colobus and Syke's appear stable overall, while considerations for mangabeys and baboons are limited by their habits and elusiveness that make detection from line-transect more complex than for arboreal species. The possible decline in red colobus will require further investigations and focused research. A new research project led by Trento Science Museum in collaboration with the German Primate Centre is starting in 2011 and

will focus on determinants of abundance in Mwanihana and other forests of the range. This should help understanding the drivers of variation for this endemic and vulnerable species.

2) Inter-observer differences in data collection remains a big issue when interpreting trends, and the only solution is to ensure that the same one or two observers continue the monitoring in the longer run. With the programme run by UEMC, this should be more easily ensured than before.

3) Harvey's duiker monitoring has confirmed the possible, serious decline for this duiker occurring overall but driven my results from Campsite 3. As this fits with the results for primates, this area (together with Msolwa area)- where poaching may have increased in recent years - should be the focus of increased patrol efforts.

4) For Uzungwa Scarp Forest Reserve, the continued monitoring has revealed the dramatic situation of under-protection of this forest, with marked differences with Mwanihana in the abundance of the canopy-dependent colobus and the red duiker. The continued declines in the abundance of these species during the period they were monitored are not surprising given the severe encroachment recorded (Rovero et al. 2010). Unless full protection is given to this forest as a matter of urgency, the colobus and duikers are bound to decline to local extinction. The comparison between the two forests indicates once again that UMNP has conducted efficient law-enforcement in Mwanihana forest despite the greater density of adjacent human population.

5. Ranger-based monitoring of large mammals in UMNP

This programme begun in 2008 with transects establishment and training of rangers. As shown in the map in Figure 9, two transects for censusing large mammals, 6 km in length and marked with aluminium tag every 100 m, were established from each of the following ranger posts: Lumemo (SE), Ruipa (SW), Udekwa (W), Mbatwa (N) and Kidatu (NE). Transects sample a variety of habitat types, from lowland deciduous and semi-deciduous forest (Ruipa and Lumemo) to woodland (Kidatu), wooded grassland, moist and dry forest (Udekwa and Mbatwa).

The planned system for monitoring implies that a phase of training data collection would be done by UEMC and UMNP assistant ecologists together with rangers allocated to this activity per each ranger post. This was done during January to August 2009 and results shown in the previous report. Responsibility for data collection was handed over to the Park rangers in August 2009, with the agreement that one trained field assistant or assistants to the park ecologist would continue to visit at least two or three ranger posts each month to assist rangers on data collection and ensure consistency and data quality. This arrangement was carried on from September 2009 to May 2010 however it was not very consistent and often the census had to be fully conducted by the trained assistants. Partly because of logistic issues (shortage of rangers, transport problems for the assistants to reach the ranger posts) partly because rangers' commitment and empowerment to collect ecological data of required quality resulted limited, in view of other important duties, especially law enforcement.

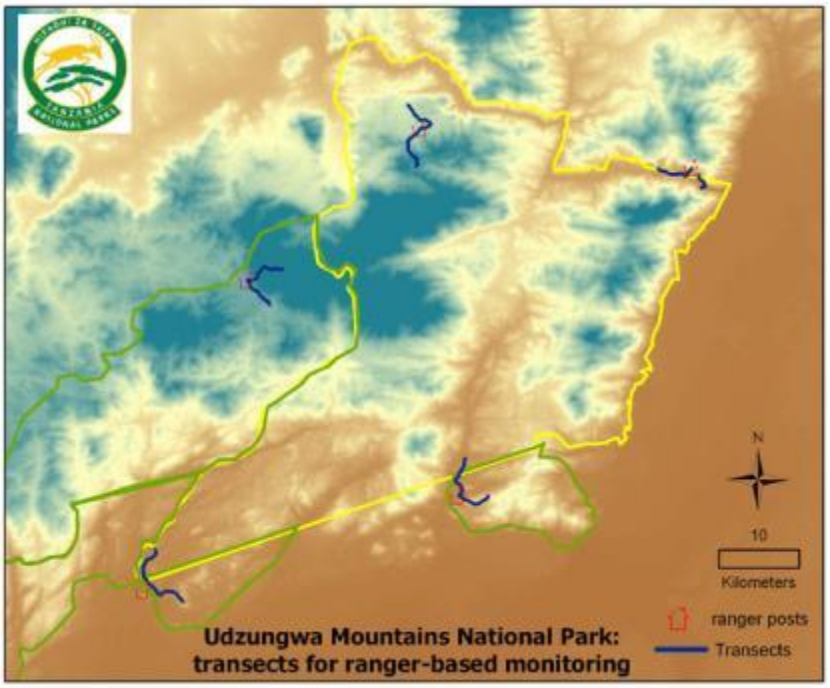


Figure 8. Map of the park (background layer shows elevation, blue being higher altitude) with transects for large mammals monitoring (blue lines) from each of five ranger posts.

UMNP LARGE MAMMAL MONITORING DATA COLLECTION FORM **Form num**_____

Ranger post_____ Transect_____ Date (dd/mm/year)____/_____/_____Time start (hh/mm)_____

Data collectors: rangers_____village scouts_____ Time end (hh/mm)_____

Climate: clear sky □ few clouds (<25%) □ cloudy (>50%) □ rain □ Notes:_____

Time	Position	Species	S	H	D/T	Num.	Dis: 10	Dis: 50	Dis: >50	Behaviour: feeding, moving, resting.
7:15	150 m	Buffalo	x			16		x		Moving

S= seen, H=heard, D/T= dung or track, Num= number of individuals seen or tracks or dung piles;
Dis= distance of sightings: within 10 m, within 10-50 m, further than 50 m.

Figure 9. Form for large mammal monitoring by rangers (the version actually used is in Swahili)

To assess the quality of data collected, and their comparability, we show the results for the two periods of data-collection separately (the second being partly collected by rangers), and compare

them to identify main patterns and lessons for continuation. In addition to the 4 repetitions of 10 transects realized in 2009, 3 repetitions were conducted during the second phase, raising to 70 the total number of repetitions, equivalent to 388 km walked. The total number of records collected during phase 2 was 589, which is smaller owing to the fewer repetitions, but still comparable.

	data-set 1 (January - August 2009)	**data-set 2 (Sept. 2009 - May 2010)**
n. of transect repetitions	4	3
tot transects	10	10
tot repetitions	40	30
tot km walked	207	181
total n. of records	629	589

Below, the records collected are categorized in terms of typology. The main difference is in the lower proportion of data from tracks in the second data-set, which may be due to the greater experience of field technicians involved in the first period relative to rangers. There also appear a greater proportion of sightings in the second data-sets.

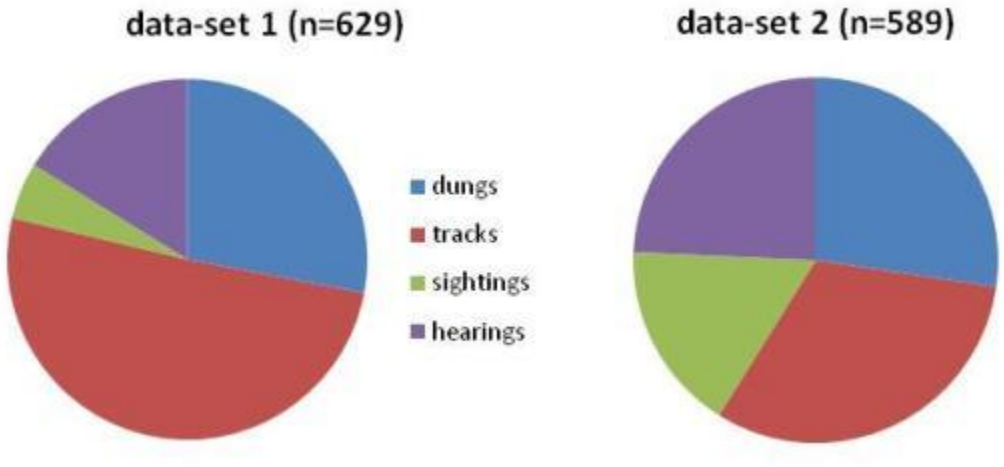


Figure 10. Chart showing the records according to type (dungs, tracks, sightings, hearings)

In this preliminary phase of the analysis, results have been lumped across transects and species have been grouped by taxonomic groups. Data were analyzed to compute mean encounter rate of species or group of species per 10 km of transects walked (Figure 11).

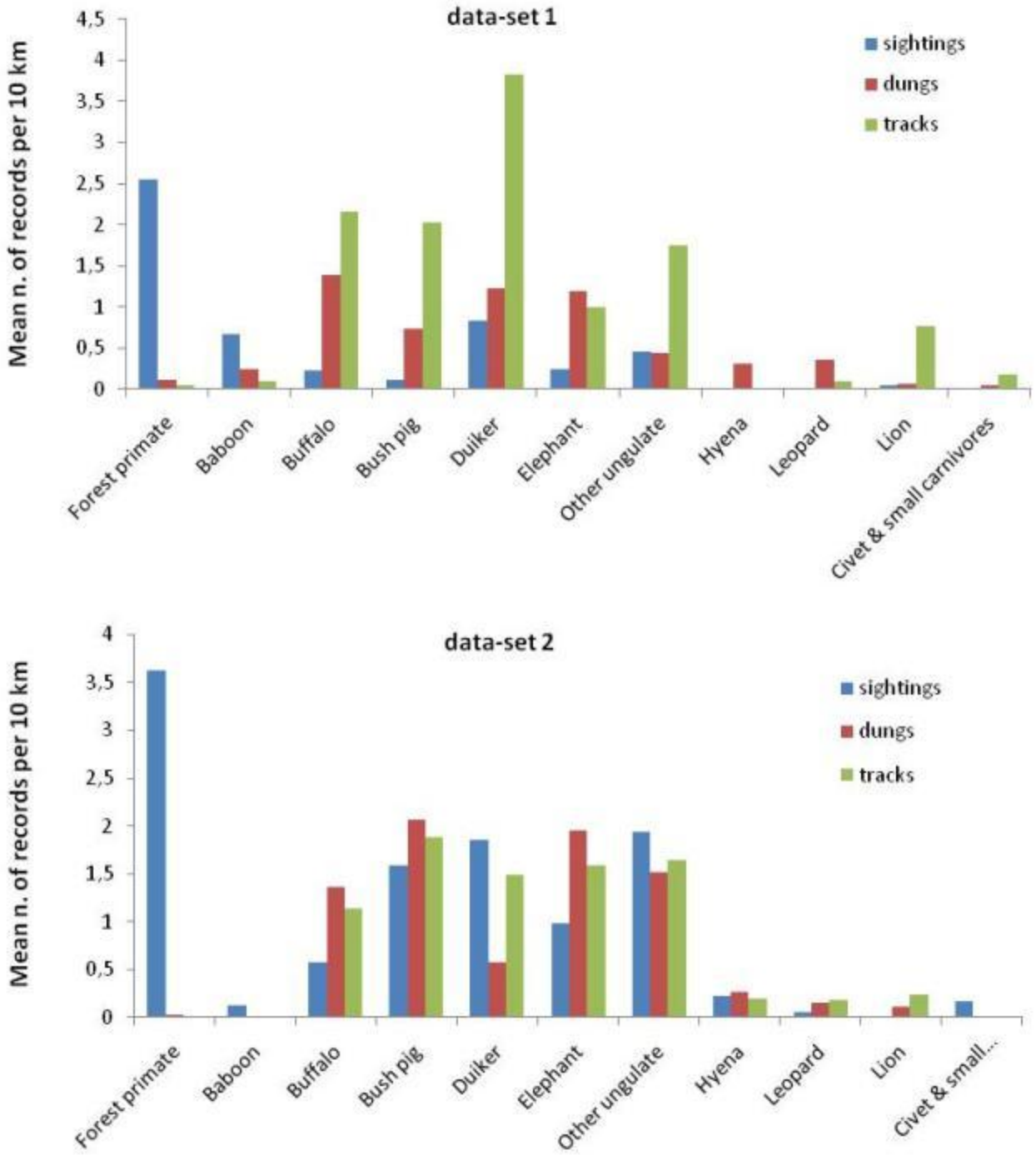


Figure 11. Results of ranger-based monitoring of large mammals conducted between January and August 2009 (above) and during September 2009 and May 2010. Data are shown as the number of records per 10 km of census.

The main consideration is that results appear to be well comparable between periods, despite the variables that may have caused differences (season, visibility through vegetation, ability to spot species, and most importantly the ability to see and recognize signs and tracks). As remarked earlier, there is a the lower amount of tracks recorded during the second period and higher sighting rates during the second period, however patterns of relative abundance are indeed consistent for most species/groups. There are some exceptions, for example the higher detection of "other ungulate" during the second period through sightings and dungs. At this stage, it is difficult to interpret these variations, which should be considered as a solid baseline to which add

more data and accumulate a consistent sample size for analysis that look at the effect of space (ranger posts) and time.

Overall, the programme continued to give promising results, and it is therefore highly recommendable its resume and continuation in the future. It will remain to assess to what extent rangers will effectively be involved, and we believe the continued support of trained field technicians will be required.

6. TEAM biodiversity monitoring in Mwanihana

Since 2009, Udzungwa is one of the site of TEAM network, a pan-tropical series of sites all implementing standardized protocols. The network has about 18 sites across the world with five of them being found in Africa. In Tanzania there is only one project run by Trento Museum under TAWIRI and Tanapa permits, and based at UEMC to which it contributes with rent and logistic support (for example satellite internet). Field sampling is implemented in Mwanihana forest. The protocols implemented, including the amount of data collected, are summarized below (see http://www.teamnetwork.org/en/protocol for detailed protocol description); the location of sampling points and plots is shown on the map in Figure 10.

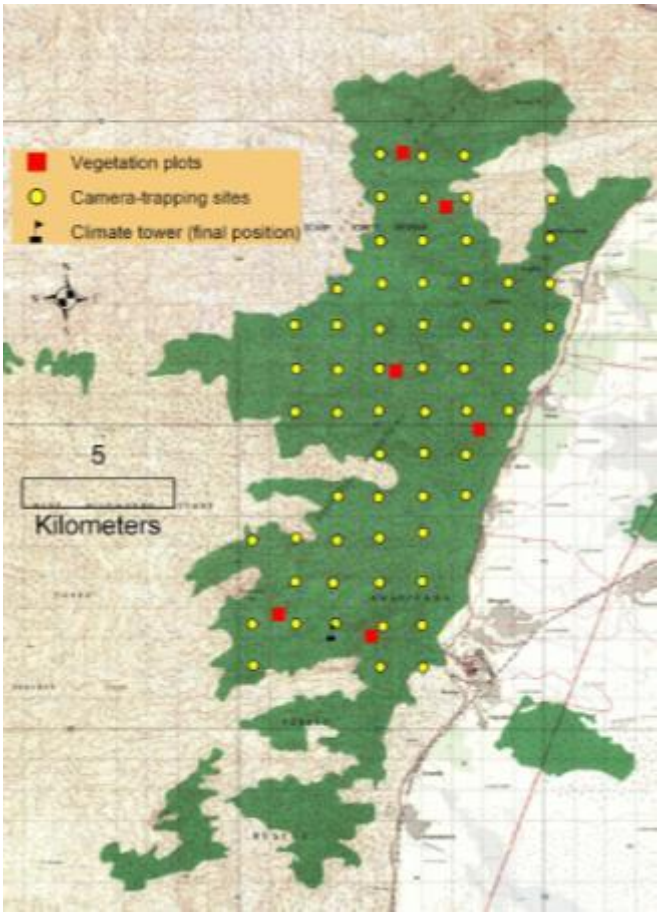


Figure 12. Map of Mwanihana forest, Udzungwa Mountains National Park, with final locations of TEAM sampling points: 60 camera-trap points, 6 vegetation plots and 1 climate recording tower

Terrestrial vertebrates: 60 camera-trap points have been implemented through sampling 3 arrays of 20 camera-trap sites, sequentially. Twenty digital camera-traps (model Reconyx RM 45 Rapid Fire) have been used, each set to work for 30 days. The camera-trap were distributed at a density

of 1 camera every 2 km^2. Locations were pre-loaded in a GPS unit and actual points were located in the field by the field team. This exercise is being repeated annually. In 2009 and 2010, 28 species of mammals were recorded from over 10,000 images collected every year. The list of mammals is reported below, together with the number of camera-trap events (24-h periods during which an animal was recorded) and the trap-rate (events divided by sampling time).

#	Taxonomic group	Common name	Latin name	N. events	Trap-rate
1	Afrotheria	Tree hyrax	*Dendrohyrax arboreus*	34	1,84
2		Elephant	*Loxodonta africana*	10	0,54
3		Four-toad sengi	*Petrodromus tetradactylus*	5,5	0,30
4		Chequered sengi	*Rhynchocyon cirnei*	6,5	0,35
5		Grey-faced sengi	*Rhynchocyon udzungwensis*	46	2,49
6	Carnivores	Marsh mongoose	*Atilax paludinosus*	3	0,16
7		Bushy-tailed mongoose	*Bdeogale crassicauda*	231,5	12,54
8		African civet	*Civettictis civetta*	1	0,05
9		Spotted hyena	*Crocuta crocuta*	4	0,22
10		Lowe's servaline genet	*Genetta servalina lowei*	41	2,22
11		Honey badger	*Mellivora capensis*	7	0,38
12		Banded mongoose	*Mungos mungo*	6,5	0,35
13		African palm civet	*Nandinia binotata*	4	0,22
14		Leopard	*Panthera pardus*	5	0,27
15	Primates	Sanje mangabey	*Cercocebus sanjei*	126,5	6,85
16		Sykes' monkey	*Cercopithecus mitis*	16	0,87
17		Angolan colobus	*Colobus angolensis*	1	0,05
18		Yellow baboon	*Papio cynocephalus*	4	0,22
19		Udzungwa red colobus	*Procolobus gordonorum*	3	0,16
20	Rodents	Giant pouched-rat	*Cricetomys gambianus*	339	18,36
21		Cape porcupine	*Hystrix africaeaustralis*	6,5	0,35
22		Tanganyika mountain squirrel	*Paraxerus vexillarius*	54,5	2,95
23	Ungulates	Harvey's duiker	*Cephalophus harveyi*	330,5	17,90
24		Abbott's duiker	*Cephalophus spadix*	56,5	3,06
25		Suni	*Neotragus moschatus*	131,5	7,12
26		Bush pig	*Potamochoerus larvatus*	27	1,46
27		African buffalo	*Syncerus caffer*	5,5	0,30
28		Bushbuck	*Tragelaphus scriptus*	4	0,22

Vegetation: 6 vegetation plots, of 1 ha each, have been sampled by measuring all trees and lianas above 10 cm DBH (diameter at breast height). Plots were already established by Dr. Marshall and colleagues in the framework of the Valuing the Arc project. Measuring implied camping in the proximity of the plot for 7-10 days. Each tree was tagged and the point of measurement (POM) marked when the plot was established; we measured DBH (recording the increment due to growth) and recorded the condition of the tree, if changed. The number of trees recorded per plot in 2009 and 2010 ranges between 446-710 (mean 546), and the number of species ranges from 20-48 (mean 34), as detailed below in the Table below.

Plot #	plot site	Altitudinal zone and m a.s.l.	N. stems	N. species
1	Gologolo (north)	(mid) 1127	446	34
2	Gologolo (north)	(high) 1795	544	44
3	Mwanihana (central)	(low) 778	466	20
4	Mwanihana (central)	(mid) 1503	710	48
5	Campsite 3 (south)	(low) 796	482	24
6	Campsite 3 (south)	(high) 1510	606	36

Climate: the Automatic Weather Station (AWS) provided by Campbell Scientific was set-up initially in proximity of the UMNP headquarters, to ensure the proper functioning and easy access. Temperature, humidity, rainfall and solar radiation were measured continuously by sensors mounted on a tripod and powered by a battery charged by solar panels. Data were recorded by a digital data-logger and saved on a memory card. The tower was moved in April 2010 within the forest (southern part) to an area at 1.183m a.s.l. (see map) - about 5 km inside the Park near a tourist trail loop starting from the Campsite 3 main gate. Data on different weather parameters are collected from the data logger. Data from the card are downloaded and subsequently uploaded to TEAM website for public use. There are currently plans to incorporate the data collection into the Tanzania National Meteorological Agency following agreement on data-sharing.

Further details on results from data-collection in 2010 will be included in the report compiled for TAWIRI.

7. School education activities

UEMC initiated this programme towards the end of 2007 with five nearby primary schools in Mang'ula, namely Mlimani, Mwaya, Mgudeni, Mang'ula A and Msalise primary schools. The programme continued successful throughout 2010: class lessons on environmental education were carried out regularly, and other activities included continuing school trees nurseries, tree planting around the schools, study tours, poster competitions and other games. The environmental programmes worked with standard 5 and 6 classes in each school, each class receiving one teaching period of 40 minutes per week. The average number of students per class was 155, so UEMC roughly reached 1550 students in 2010.

With the support of UMNP, UEMC has been taken one class from every school on a field trip to hike in the National Park. Also UEMC has been doing the same to take them to the plantation forest to see the differences between plantation and natural forests. Trips were greatly appreciated by the students, and they involved about 40 students and two school teachers each time.

Figure 13. A scene from celebration of the World Environment Day, 5 June 2010: the Chief Park Warden, Dr. Mosffe, addressing the villagers and school students.

Among the most appreciated activities, besides the school trips to Njokamone trail, Sanje falls and trip to Mikumi National Park, have been the cinema nights shown to five villages adjacent UMNP, during which nature documentary and photographic portfolios are projected in large screens. Finally, the programme hosted the World Environmental Day (June 5th) that was held at Mang'ula village. Preparation of this event involved planning with UMNP outreach warden, and liaising with the District Education Officer, Ward Education coordinator, and village chairmen to present the initiatives. Subsequently, meetings and workshops with the head teachers of primary schools were held to plan the activities in details. The celebration was a success, with a few thousands of people attending. It was conducted with the participation of the group of students from Pennsylvania State University (see photo).

8. Activities planned for 2011

UEMC plans to conduct the following activities in 2011:

- continue the primate and duiker monitoring with the standard, monthly frequency in Mwanihana and USFR;
- continue to support and facilitate the ranger-based monitoring, including allocating funds and one trained assistant to help collecting data at least once per month per ranger post;
- conduct in July 2011 the first edition of a summer school titled "Tropical forest biodiversity: GIS and field tool for assessing, monitoring and mapping" dedicated to both university students and park ecologists, with a view to support standardization of monitoring protocols across forest parks. Related to this, facilitate other training activities organized by

international universities (e.g. Pennsylvania State University) and facilitate the use of the hostel for practical training by Tanzanian universities wildlife advanced courses;
- in view of the ban of firewood collection set for June 2011, facilitate the park to promote public appreciation (including through the current environmental education programme) and support the communities to access to alternative sources of energy.
- continue and expand the environmental education programme, by increasing the number of schools involved and by initiating teachers' training.
- continue and consolidate implementation of TEAM project.

Finally, in close consultation with UMNP management, UEMC intends to review achievements and mid-to-long-term plans and discuss the mutual opportunity to extend the collaboration beyond 2011. Besides the on-going ecological monitoring, technical training and community education work, additional key components for an extended collaboration that have been discussed jointly are the support to establish a Visitor Information Centre (and more generally, support to boost to eco-tourism and community appreciation of the park), the need to tackle the outstanding conservation conflicts (including the escalating human-elephant conflict) through landscape-level conservation planning, the long-term view to make of Udzungwa a model of biodiversity monitoring for other forest parks in the country. This last remark would include the progressive handing-over of TEAM project in the long run.

References

Relevant reports for downloading and a complete list of references for research conducted in Udzungwa can be found in the UEMC website. Directly relevant to this report are the following:

Rovero F., Struhsaker T.T., Marshall A.R., Rynne T.A., Pedersen U.B., Ehardt C.L., Butynski T.M. and Mtui A.S. 2006. Abundance of Diurnal Primates in Mwanihana Forest, Udzungwa Mountains, Tanzania: a Multi-observer Comparison of Line-transect Data. *International Journal of Primatology*, 27: 675-697.

Rovero F. and A. Mtui 2006. Comparing multi-observer, line transect data for primate monitoring: a case from the Udzungwa Mountains of Tanzania. Proceedings of the 21st Congress of the International Primatological Society. International Journal of Primatology, 27 (Special Issue): abstract #350.

Rovero F., Mtui A., Kitegile A., Nielsen M., Jones T., 2010, *Uzungwa Scarp Forest Reserve in crisis. An urgent call to protect one of Tanzania's most important forests*, Dar es Salaam, Tanzania.

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UEMC (Udzungwa Ecological Monitoring Centre) 2010. Technical report, year 3 (January-December 2009). Unpublished report to Tanzania National Parks. Available at http://www.udzungwacentre.org/mrd.asp?code=23