Udzungwa Ecological Monitoring Centre (Udzungwa Mountains National Park)

**Annual Technical Report
Year 5 (January - December 2011)**

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Cover photo: forest interior, 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 fifth year technical report (January - December 2011), 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.

UEMC continued the primate and duiker monitoring programme in Mwanihana forest (UMNP) and in 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 12 months of census. This raised the amount of data-set to 597 census repetitions in Mwanihana (nearly 2400 km walked), and 224 in USFR (756 km walked). Overall, it is maintained a clear trend of relative population stability in Mwanihana (with possible emergence of a natural abundance oscillation patterns) and of dramatic declines in USFR. Conservation recommendations for both forests spanning from the results are proposed, and stress particularly the need for effectiveness protection of USFR, especially as it currently a proposed Nature Reserve.

Other important monitoring activities based at UEMC are conducted by the Tropical Ecology, Assessment and Monitoring network, that implements standardized monitoring aligned with several other field stations in the tropics. In 2011 the third year of consecutive monitoring of terrestrial vertebrates, vegetation and climate was completed successfully. Training and capacity building of personnel was also conducted through dedicated GIS training and through the first edition of an international summer school that involved Tanzanian students and TANAPA staff.

Additional achievements of UEMC in 2011 included:
- continued the environmental education programme with 5 primary schools, and boosted it through a pilot teacher training project;
- other environmental awareness initiatives, particularly the celebration of the World Environment Day together with TANAPA;
- continued provision of accommodation and facilitation of researchers, with the number of researchers hosted that raised to over 100;
- training based at the new hostel continued, with 3 groups hosted: a group of 12 students from Pennsylvania State University, the Trento Museum summer school (over 20 participants) and a primate conservation biology training organised by TREE field studies (USA);
- continued the 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).

The report also reviews achievements of UEMC against initial objectives set, details plans for 2012 and describes the longer-term objectives as stated in the renewed Memorandum of Understanding signed in January 2012 by TANAPA and Trento museum that extends the partnership on UEMC until 2016.

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 first MoU has run from 2006-2011, and therefore the present report closes the first phase of UEMC operations.

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/Nature 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 fifth 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. In particular, as a new MoU for 5 years has been signed in early 2012 to cover a second management phase (until 2016), the report will summarize the renewed strategic plans. 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 2008-2011).

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, an annexed 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 staff working at UEMC did not undergo major changes in 2011. 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. Moreover UEMC recruited Ms. Eunice Gervas in the mid of August 2011 as assistant house keeper. 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 in 2011 continued to sustain scholarships for personnel training. Thus, Ms Scolastica Mwasenga (former UEMC environmental education officer) was supported for the second year at Olmotonyi Forestry Training Institute to pursue certificate in forestry management (completion expected in July 2012). Mr. Richard Kishe, TANAPA employee was supported for the second year

ofat Mweka Wildlife College for diploma course programme in wildlife management–(completion expected July 2012).

2. Summary of activities planned and activities implemented

This section provides an overview of activities implemented until the end of 2011 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 as mainly related to the routine 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 as highlighted in the previous report (UEMC 2010), 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 (details below).

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

In 2011 UEMC hosted 8 long-term researchers plus a number of guest researchers visiting on shorter term basis, adding up to a total number of around 100 researchers accommodated in the hostel and houses during the 5 years of activity. Overall, the resources raised from fees for accommodation in 2011 contributed to around 50% of UEMC running costs (of which over 30% are due to revenues from training courses at the hostel).

Figure 1. The front cover of the report on Uzungwa Scarp Forest Reserve
launched on February 4th, 2011, in Dar es Salaam

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

The ranger-based monitoring, although still facing delays and pauses, is an important on-going programme, and involved 2011 additional training on use of GPS and GIS capacity (see next section). The new hostel allowed strengthening this component. In July 2011 moreover, the first edition of the summer school titled "Tropical rainforest biodiversity: field and GIS tools for assessing, monitoring and mapping" was held at UEMC during 1-14 July.

The summer school was attended by 10 international students from a range of countries (from Congo-DRC to UK) as well as 10 trainees among TANAPA ecologists (from Serengeti and Arusha

NPs), UMNP ecologists, UEMC staff and Tanzanian students. The training programme included the following modules:

1. Introduction to the Eastern Arc rainforest ecosystem: biological importance and conservation.
2. Surveying and inventorying forest vertebrates, with emphasis on primates and terrestrial mammals.
3. Habitat and human disturbance assessment for wildlife studies, with focus on vegetation sampling for habitat modeling.
4. Key monitoring tools for mammals: line-transects for primates and camera trapping for terrestrial mammals.
5. Abundance estimation methods, using primates and camera-trapped mammals as target groups.
6. Using GPS for orientation, mapping, recording points and routes.
7. Introduction to the use of GIS (Geographic Information Systems).
8. Overview of Free and Open source GIS (QGIS GRASS) and their usage to store, visualize and analyze environmental data in different formats (raster, vector, images) and from different sources such as field surveys, digital cartography, remote sensing.
9. Handling wildlife data in GIS: basic mapping and visualizing data from GPS surveys. Linking point surveys and environmental data. Advanced use of wildlife data: home range estimation and calculation of kilometric indices of abundance.
10. Habitat modeling in GIS: overview of the available methods (Habitat Suitabilty Indices, GLM Regressions, Ecological Niche Modeling, Maximum Entropy models) Application with FOSS (Free and open source software) and public domain software to create habitat suitability maps point localities/transects and presence/absence (occupancy) data, counts or abundance estimates.

Based on participants' feedback done through a questionnaire, the school was successful for both students and professionals. The mix of field practicals (4 full days) and lessons with PC exercises was particularly appreciated. TANAPA ecologists judged the school important for the aim of replicating monitoring in other parks. For example, trainers designed together with the Arusha NP ecologist and TANAPA GIS expert from Serengeti NP a primate monitoring scheme to be implemented in Arusha NP. Below are photos of the field and class training. A second edition of the school is planned for the late summer of 2012.

5. *Organize education activities for school children.*

This programme continued and consolidated in 2011 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 to strengthen this component, and in collaboration with Tanzania Forest Conservation Group (TFCG) and thanks to a small project funded through Trento Province, UEMC organized and conducted an Environmental Education Training for primary school teachers from the wards adjacent to UMNP in September, 2011.

Figure 2. A scene from Teachers Environmental Training, 15 September 2011: the Chief Park Warden, Dr. Msoffe, awarding certificate of participation.

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

The GIS database was established in July 2009 (see UEMC 2010). In January 2011, refinement of the database and further GIS training was organized by Trevor Jones in collaboration with UEMC and support of Nick McWilliams, a GIS expert from Anglia Ruskin University in Cambridge and MapAction (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.

Figure 3. Training on GIS given by Nick McWilliams of Anglia Ruskin University to park's staff and other participants in January 2012.

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 of UEMC routine activities. However, given the great relevance to UEMC activities and biodiversity assessment in UMNP, a summary report of activities and data collected is included.

3. Recommendations from the inaugural stakeholders' workshop: follow-up in years 1- 5

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 goals of the summer training school.

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 and plans were to repeat the study after 3 years. Now that TANAPA banned firewood collection completely (as of July 2011), it would be important to assess changes to the ecosystem. In addition, 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.

As reported in 2010, the demography monitoring conducted in 2008-2009 was difficult as obtaining reliable and periodic counts made this programme of limited cost-effectiveness. Data on mangabey ecology and demography are still being collected on the two habituated groups 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 that will resume in 2012.

4. Ecological monitoring results: primate and forest antelope monitoring

4.1. Primate monitoring in Mwanihana forest

The Primate Monitoring Programme, established in 1997 in Mwanihana forest, uses transects following tourist trails maintained by the park.Details 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 (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),

|		4.0	320 - 590	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=92 census walks) collected by Arafat Mtui and assistant, Mokolo Kitenana (data-set 10). This ensures consistency with the data collected by Mtui during 2003-2004 and 2008-2011.

The current data-set for Mwanihana consists overall of 597 transect repetitions, equivalent to a remarkable total of **2338 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
10	ASM5 (UEMC)	February 2011 – January 2012	23	23	23	23
	All observers		165	165	166	101

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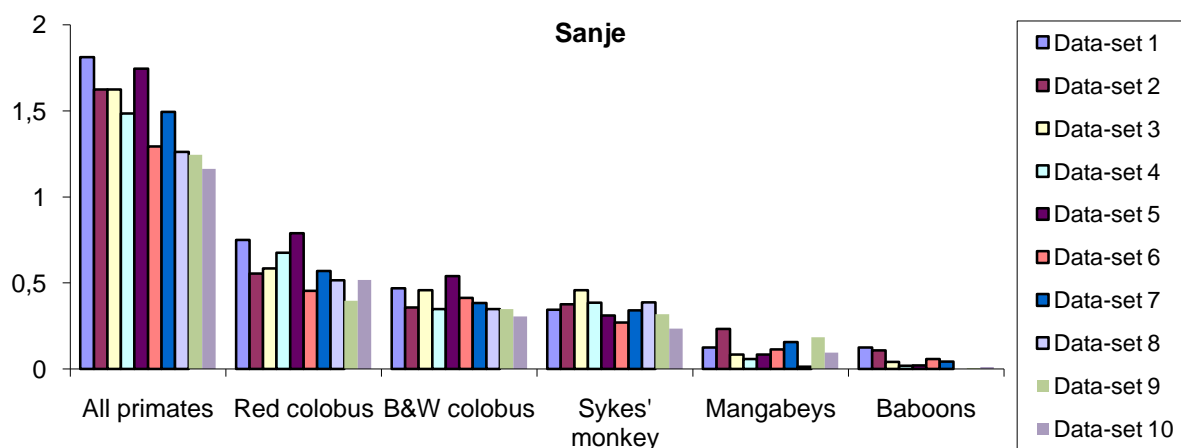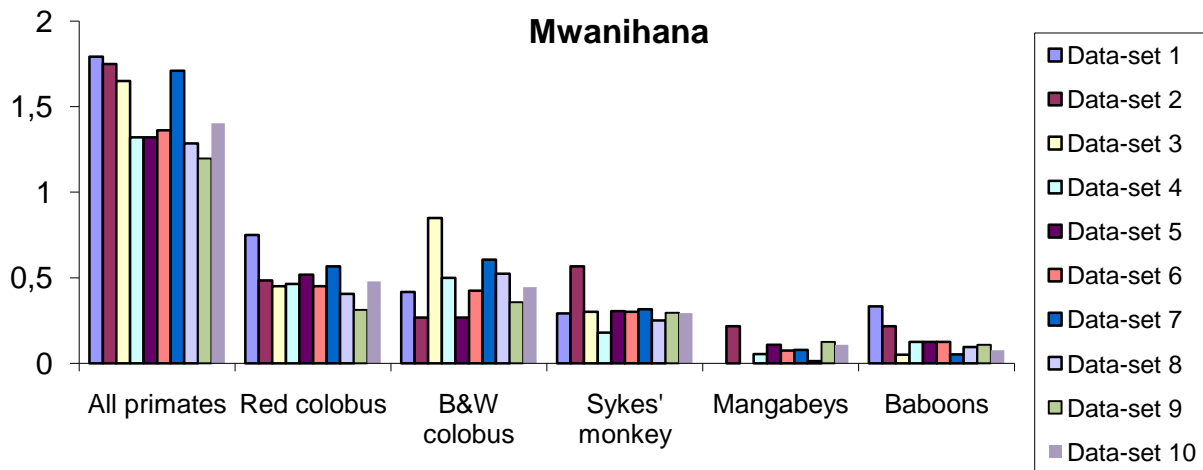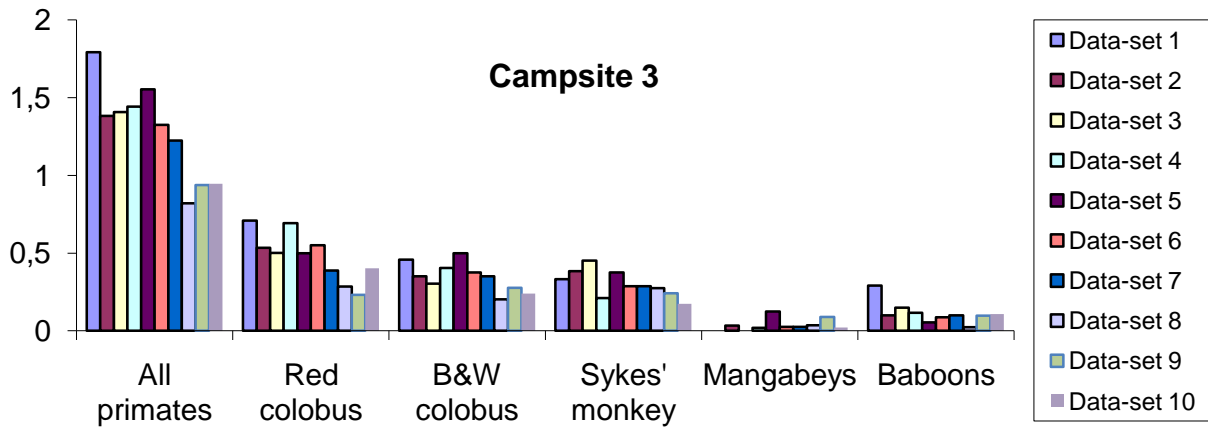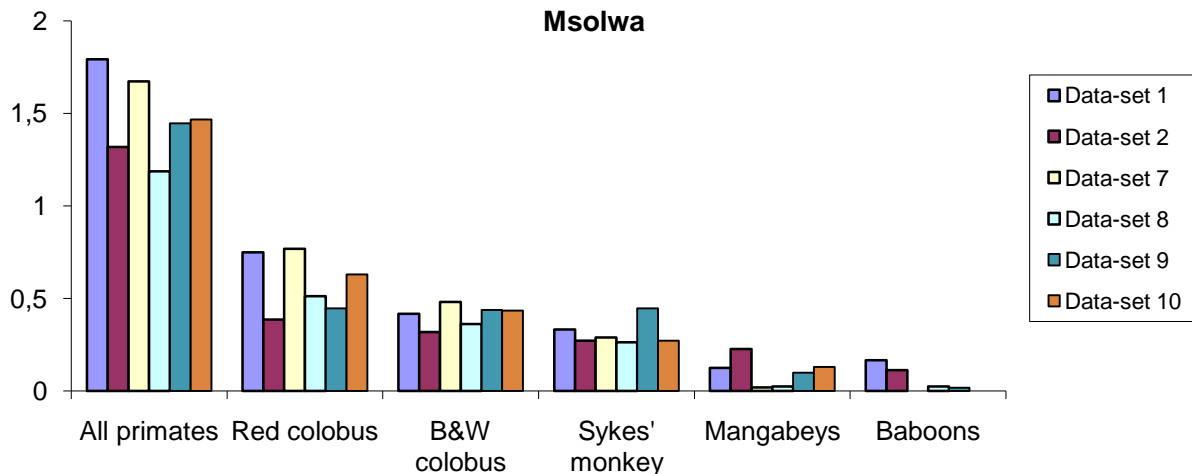
Figure 4: Results of primate monitoring expressed as the mean number of primate groups seen per km of transects for all four transects from 1998 until January 2011 (the last 4 sets of data being collected by UEMC). Data for the fourth transects (Msolwa) were collected beginning in April 2007.

Of focal attention in this report are the temporal variations within species and transects. The differences in abundance among species, transects and among transect portions (as presumably related to the different proportions of forest habitat represented) will not be discussed in details here (see also Rovero et al. 2006).

The inclusion of the latest data-set collected in 2011 appears not to alter significantly the trend of stability observed so far. Indeed, it rather emerges than variations are small and will likely be a combination of natural oscillations and/or intrinsic changes related to detection of primates. Thus, for example, at campsite 3, the pattern that emerged in the previous report of declining primates as especially visible to the red colobus is not confirmed, as sighting rates of colobus were higher than data-sets 9 and 8, and similar to data-set 7. Similar consideration apply to Mwanihana transect, whereby what appeared as a decline in both colobus monkeys is not confirmed. Overall, while the data-set is now robust enough for a robust and more statistical analysis than shown here (which is on-going), the major indication is that the feared and apparent declines highlighted earlier for some species may just have been natural oscillations, as observed in a number of other sites in Africa and elsewhere when longer-term data are available.

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). The lumping is justified by the fact that all four 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. Differences were tested both on the whole data-set and on data from 2002 onwards (i.e. excluding data-sets 1-3 as they are from small sample sizes and were collected by a range of different observers than from 2002, when inter-observer consistency became much higher. Only for this latter data period post-hoc comparisons are shown.
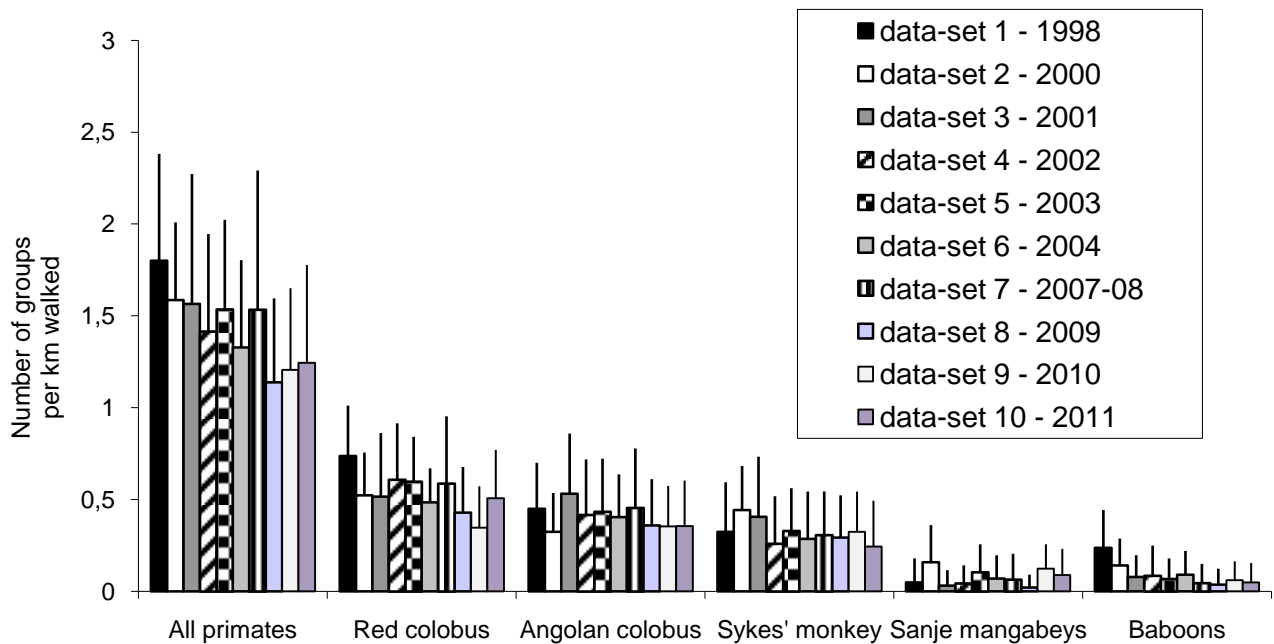
Figure 5. Results (mean number of primate groups seen per km and standard deviation) of primate census pooled for 4 transects from data collected from 1998 until January 2011 (the last 4 sets of data being collected by UEMC)

Thus, differences among observers in primate's encounter rate were significant for all specie, however when only data from 2002 are considered, important differences are only   for all primates and for red colobus (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, and the general trend described above is confirmed, with data-set 10 NOT confirming any sustained temporal trend of decline for all species and for the red colobus.

Table 3. Results of ANOVA tests on primate census results obtained by different observers. In parenthesis, the outcome for comparison of the subset of data-sets 4-10, to which post-hoc comparisons relate.

Species	F (df = 9,582 and 6,505 for comparison all and 4-10 only)	P (differences between observers)	Post-hoc comparisons significant at P<0.05 (data-sets 4-10 only)
All primates	7.19 (6.20)	<0.01 (<0.01)	Data-set 5 vs 8-9; set 7 vs 8-10
Red colobus	8.81 (10.32)	<0.01 (<0.01)	Data-set 4 vs 8-9; set 5 vs 8-9; set 6 vs 9; set 7 vs 8-9; set 9 vs 10
Angolan colobus	2.27 (1.94)	<0.05 (=0.07)	None significant
Sykes' monkey	2.91 (1.35)	<0.01 (=0.23)	None significant
Mangabeys	5.90 (6.29)	<0.01 (<0.01)	Data-set 4 vs 9; set 5 vs 8; set 7 vs 9; set 10 vs 8

Baboons	7.91 (2.10)	<0.01 (=0.05)	None significant

In addition to the emerging pattern of abundance oscillation for red colobus, no significant differences were observed for the Angolan colobus and for Sykes' monkey, especially when data from 2002 are considered. These conclusions apply to the pooled data set from all transects but no major differences emerge when single transects are considered. Data for mangabeys and baboon always need to be taken with caution, however it is also positive to remark that the feared decline of baboon may in fact not be true. The only exception may be the absence of sightings of baboons along the Msolwa transect. Low and abundance of baboon and their presence limited at the forest edge, elusiveness of mangabeys, and the terrestrial habits of bnoth species likely determine intrinsic oscillations in sightings rates, as it may especially apply to the mangabeys, for which differences are actually significant (Table 3).

The previous reports (UEMC 2010, 2011) 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 confirmed as being not maintained with the updated data-set. The firewood collection banning introduced since July 2011 has now created a new situation, whereby disturbance along the 1-2 km lower portion of the park has ceased. This may have potentially rapid and positive effects on the populations (for example through increased confidence and increased presence in this lower forest zone) that should also be reflected in the overall sighting rates (see below results for Harvey's duiker).

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, 13 repetitions in 2010 and 12 repetitions in 2011 (Table 4). This totaled 224 repetitions, equivalent to **756 km walked**.

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
5	ASM	February 2011 – January 2012	12	12	na	na	12	36

| All | 71 | 69 | 32 | 20 | 32 | 224 |

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 in 2009. The high-elevation, Kitolomero transect was also discontinued from 2007 because it needed camping and too much costs.

Results for each transect, and for all transects combined are presented in the following charts (Figure 4-5). For all transects, the alarming and dramatic declining trend that emerged with the previous 4 data-sets especially for the two colobus monkeys persisted through 2011, with **these 2 monkeys barely holding only along one out of 3 transects** (Ikule, the middle elevation one statistical results in Table 5). Overall, data confirm that heavy poaching and habitat degradation is threatening the colobus to near extinction. 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. Moreover, a paper in *Biological Conservation* was recently published (Rovero et al. 2012), to which we refer for a detailed analysis of the interplay of hunting and habitat degradation in affecting the primate community. The Government's endorsement of the recommendations are resulting in the forest being currently upgraded to Nature Reserve, however the process is very slow and no actual patrol has been conducted. These most recent data witness of a situation that continue to worsen and may become irreversible in very short time.

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

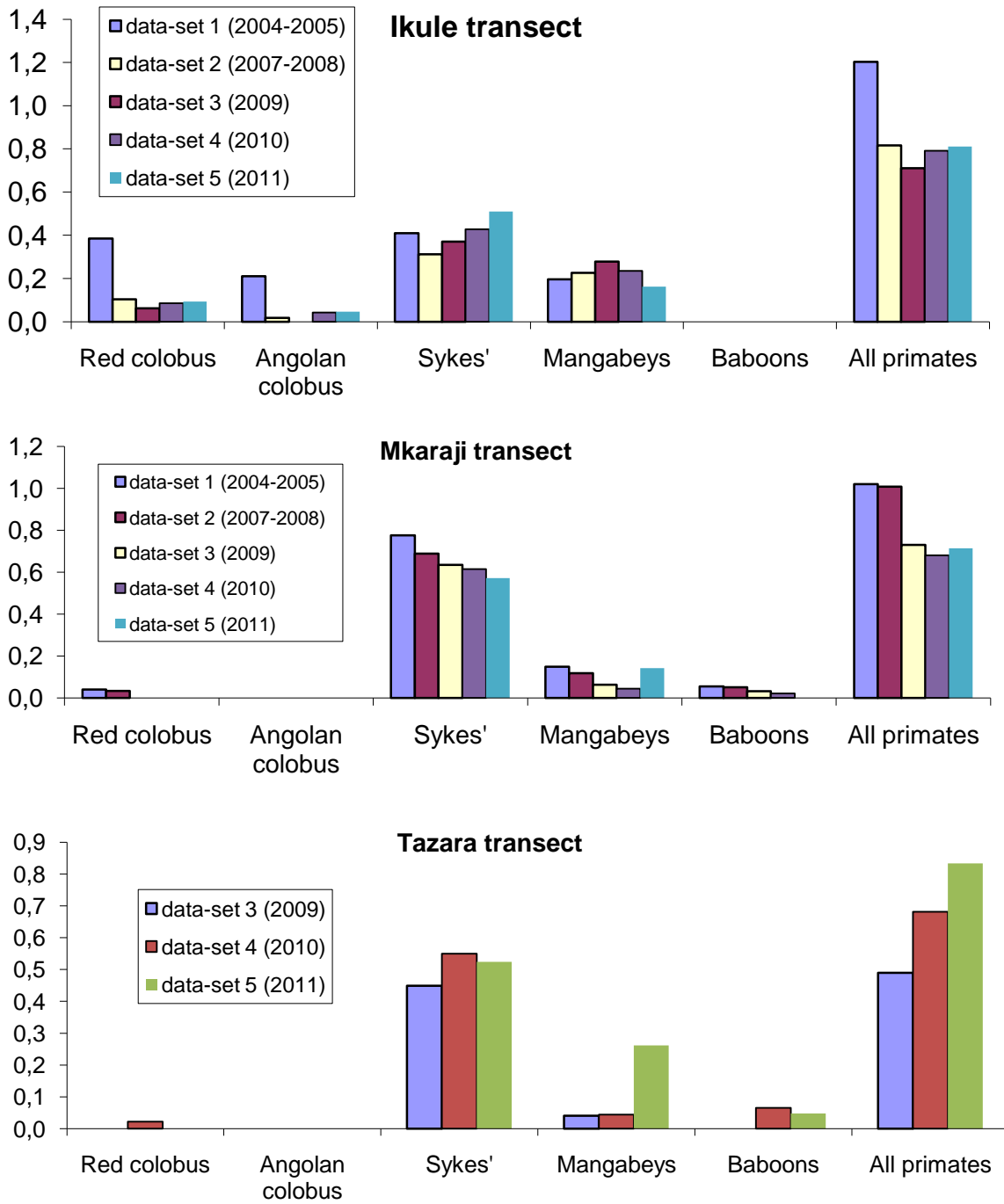| Species	F (df = 3,169)	P (differences between observers)	Post-hoc comparisons significant at P<0.05
All primates	4.84	**<0.01**	Data-set 1 vs 2,3; sets 2 vs 3,4
Red colobus	6.96	**<0.01**	Data-set 1 vs 3,4,5
Angolan colobus	6.07	**<0.01**	Data-set 1 vs all
Sykes' monkey	0.78	n.s.	None significant
Mangabeys	0.84	n.s.	None significant
Baboons	0.36	n.s.	None significant

Figure 6. Primate census results obtained in USFR during 2004-2011: results for each of three transects currently repeated
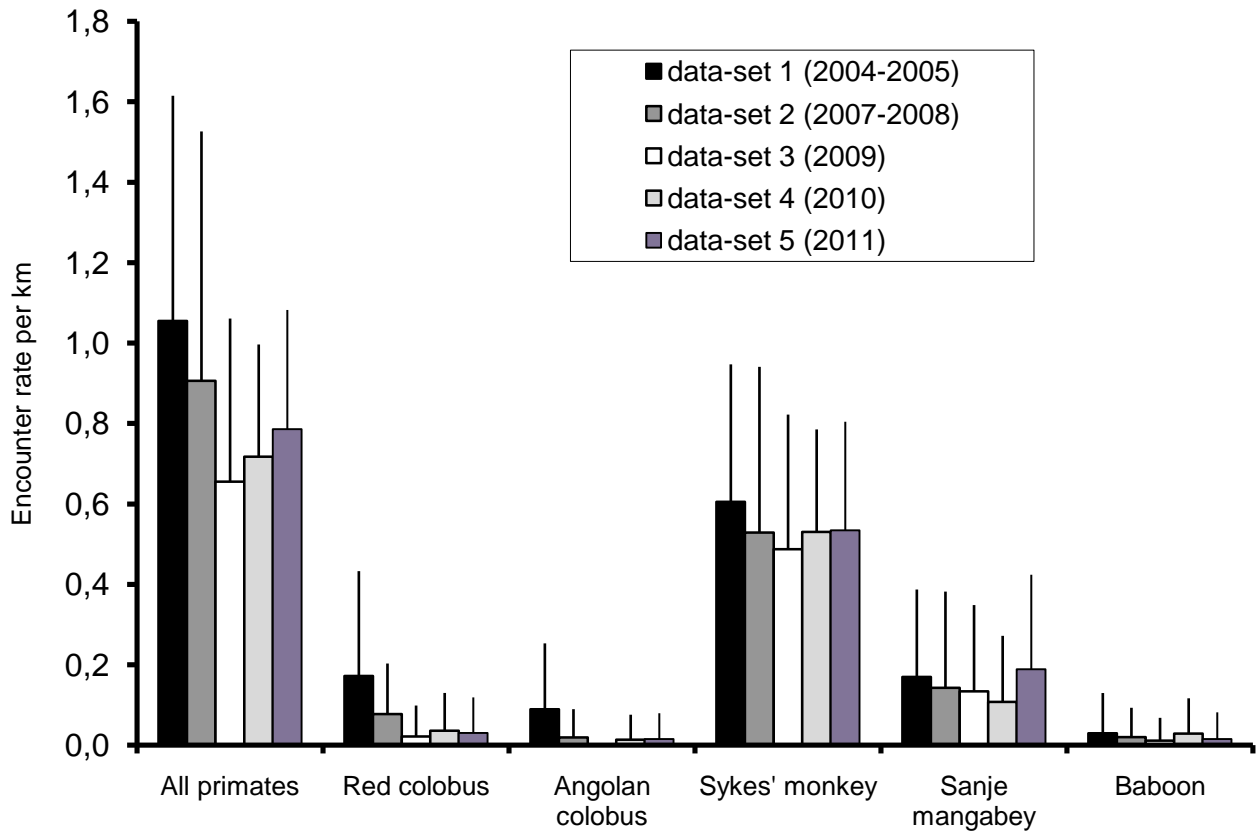
Figure 7. Primate census results in USFR: pooled transects

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 = 5,419)	P (differences between observers)	Post-hoc comparisons significant at P<0.05*
All transects	1.98	=0.08	None significant

Updated results are shown in Figure 8 for data-set 1 (F. Rovero: 2002-2003), 2 (A. Mtui: 2004), 3 (A. Kitegile and A. Mtui - UEMC: 2007-2008), and 4-6 (A. Mtui: 2009-2011) for a total of 445 transect repetitions pooling all transects. Some considerations made for the primates apply to these results as well, in that the latest data-set mark an apparent and net increase relative to previous periods. Further monitoring and refined analysis will be critical to assess whether this may be a rapid response related to the firewood banning as of mid 2011, as red duikers are normally found in good abundance in the woodland portion of the forest, which was most impacted by firewood collection. Interestingly, this increase is similar across all transects except for Msolwa, where data show a decrease. The Msolwa area is where the higher incidence of bushmeat and timber poaching is reported. It is useful to note however that the sighting rates are generally low for this species, and thus even little, random variations in sighting rates determine visible changes in mean values. Differences overall are marginally not-significant for the pooled data-set (Table 6).

Figure 8. 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 is "positive" relative to earlier ones, and similarly to Mwanihana, in that it breaks the declining trend observed earlier (Figure 9). Differences among observers remain significant (Table 7, P<0.01).
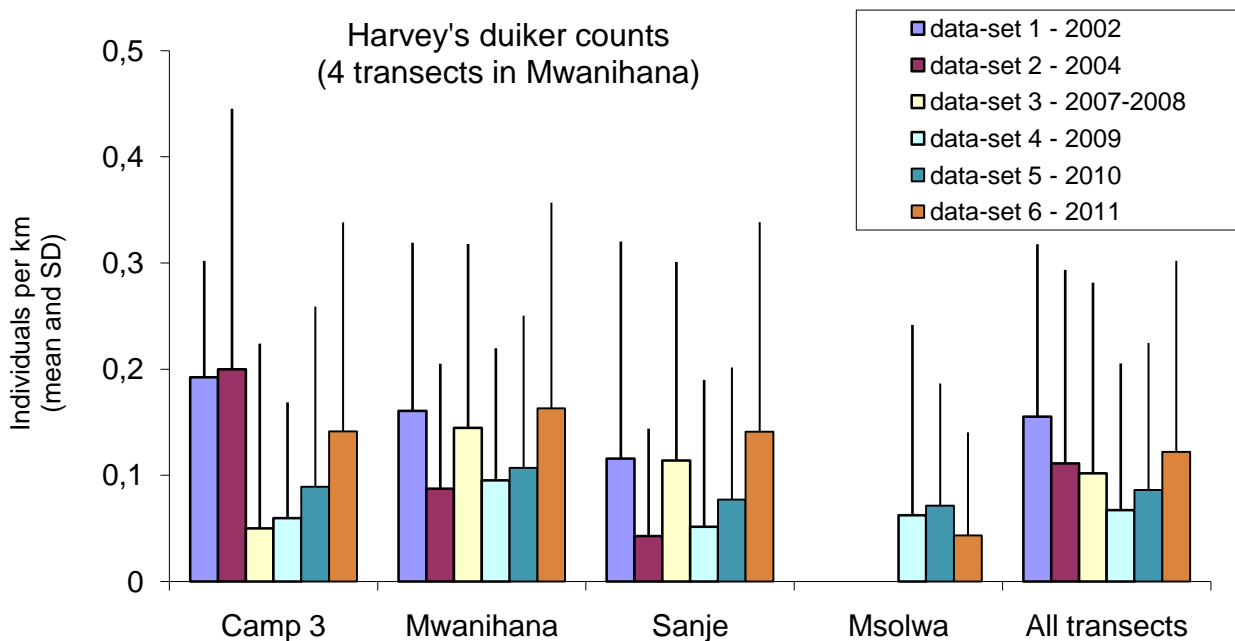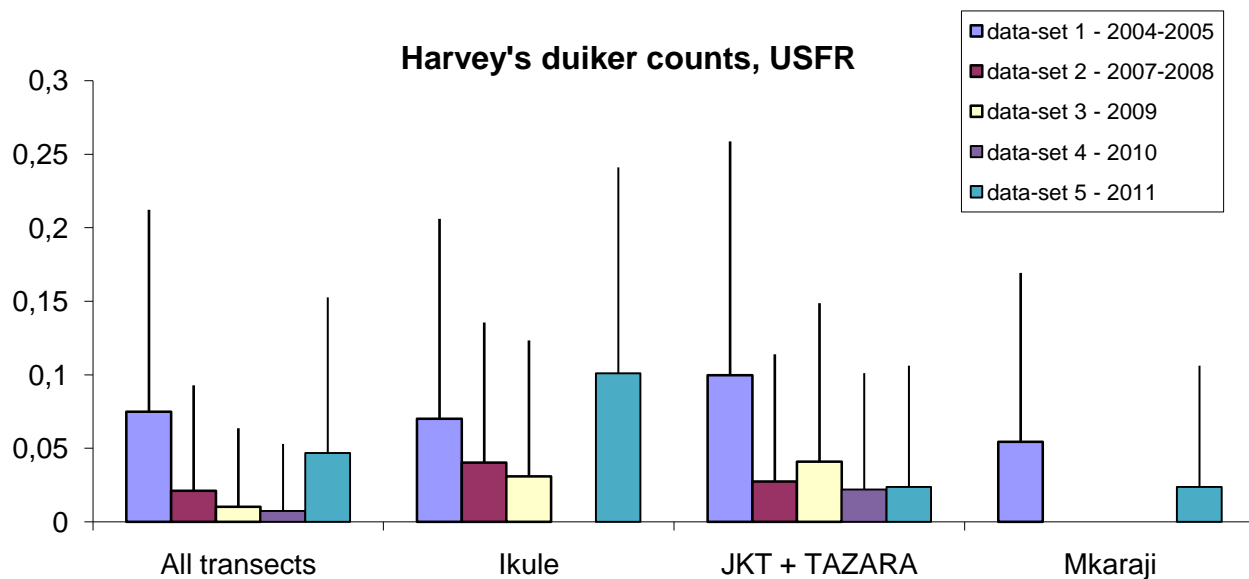
Figure 9. Results of Harvey's duiker census (individual encounters per km walked) along four transects in Uzungwa Scarp Forest Reserve.

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

Species	F	P (differences between observers)	Post-hoc comparisons significant at P<0.05*
All transects	3.70	**<0.01**	Data-set 1 vs 4

*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 of a maintained overall stability in primate population over time, with a possible emerging pattern of natural oscillation in abundance that would fit with trends from longer-term monitoring elsewhere. Thus, apparent decreased supposed earlier, especially for red colobus, are not confirmed by the increased data-set. Continued monitoring is highly recommended.

2) Inter-observer differences in data collection should progressively stabilize as the set of data collected by UEMC is increasing.

3) Within Mwanihana, there is still evidence (from both primates and Harvey's duikers, and from all occasional observation reported) that the northern sector (accessed from Msolwa) remains the more disturbed by encroachment for poaching of bushmeat and timber. Thus, enforced patrol along this sector is recommended.

4) For Uzungwa Scarp Forest Reserve, monitoring continues to reveal a 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. Management recommendations are detailed in Rovero et al. (2012): the upgrading to Nature Reserve needs to be urgently accompanied by effective protection on the ground.

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 10, 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).

Figure 10. 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.

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, at monthly intervals and using a standard form (Figure 11). This was done during January to August 2009 and results shown in the 2010 report (UEMC 2010). 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 (UEMC 2011) 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. As a result, the monitoring did not continue through the beginning of 2011.

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

Nevertheless, the main consideration from data-analysis as reported earlier (UEMC 2011) was that results appeared 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). There was a the lower amount of tracks recorded during the second period and higher sighting rates during the second period, however patterns of relative abundance were consistent for most species/groups.

Due to this promising results, park management and UEMC staff reviewed the programme in 2011 and decided for continuation, with greater assignment and responsibility placed on trained assistants rather than on rangers. As such, the programme resumed towards the end of 2011. The outcome of this, along with any result, will be presented in the next report.

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 14.
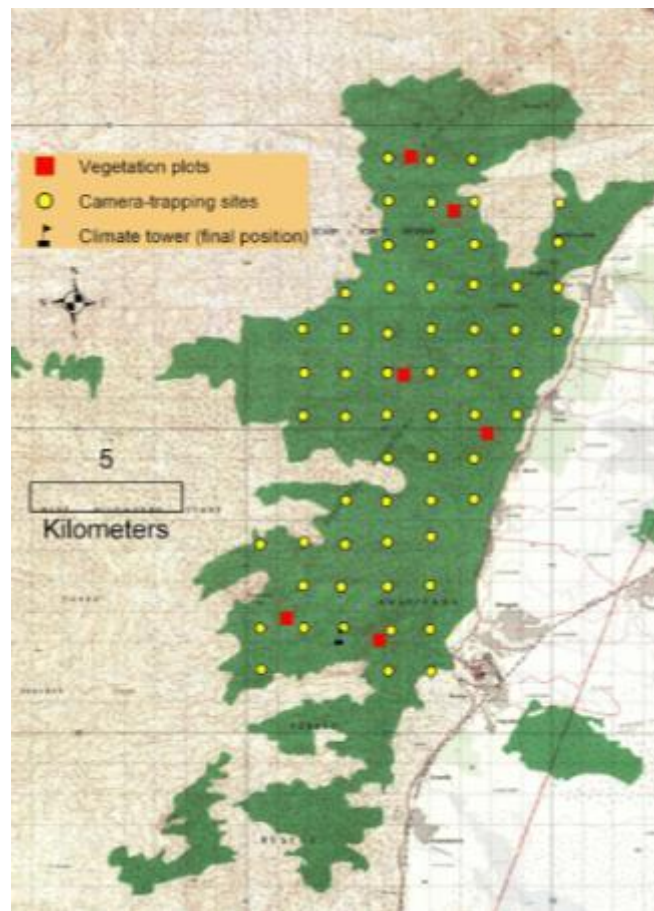

Figure 14. Map of Mwanihana forest, Udzungwa Mountains National Park, with final locations of TEAM sampling points: 60 camera-trap points, 6 vegetation plots and 1 climate recording tower

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.

In 2011, 59 of 60 camera-traps worked and produced a total trap-effort of 1626 camera-days (mean of 27.1 per camera). Twenty-eight mammals were trapped, as reported in the table below. Species are ordered by decreasing number of events (24-h periods during which an animal was recorded); the number of successful cameras at trapping each species is also shown. Serval cat (Figure 15) and cane rat represent new camera-trapped species for the area (although their presence was known).

Latin name	Common name	Successful trap-site	Events
Cricetomys gambianus	Giant pouched rat	57	108
Bdeogale crassicauda	Bushy-tailed mongoose	59	99
Cephalophus harveyi	Red duiker	58	91
Cercocebus sanjei	Sanje mangabey	52	69
Rhynchocyon udzungwensis	Grey faced sengi	24	52
Neotragus moschatus	Suni	39	49
Genetta servalina	Servaline genet	42	43
Cephalophus spadix	Abbot's duiker	50	39
Paraxerus vexillarius	Tree squirrel	28	39
Dendrohyrax arboreus	Tree hyrax	29	30
Petrodromus tetradactylus	Four toed sengi	6	28
Potamochoerus larvatus	Bush pig	24	15
Cercopithecus mitis	Blue monkey	26	11
Atilax paludinosus	Marsh mongoose	10	10
Nandinia binotata	Palm Civet	11	9
Procolobus gordonorum	Iringa red colobus	12	8
Rhynchocyon cirnei	Chequered sengi	7	8
Loxodonta africana	African Elephant	11	7
Mellivora capensis	Honey badger	15	7
Panthera pardus	Leopard	8	7
Syncerus caffer	African buffalo	7	3
Crocuta crocuta	Spotted hyena	4	2
Papio cynocephalus	Yellow baboon	4	2
Thryonomys swinderianus	Marsh cane rat	1	2
Tragelaphus scriptus	Bush buck	5	2
Colobus angolensis	Black and white colobus	3	1
Felis serval	Serval cat	1	1
Mungos mungo	Banded mongoose	8	1

Figure 15. Camera–trap image of a serval cat, an elusive carnivore captured on camera for the first time in Mwanihana forest.

Vegetation: the 6 vegetation plots, established in 2008, of 1 ha each, have been re-sampled by measuring all tagged trees and lianas above 10 cm DBH (diameter at breast height). 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 ranged between 446-710 (mean 546), and the number of species ranged from 20-48 (mean 34). The updated set in 2011 gave the results as in the Table below: the number of stems ranged from 463-722 and the number of species ranged from 22-44.

Plot (name and altitude)	Number of stems	Number of species
Plot 1 (Gologolo chini) 1127 m a.s.l	463	37
Plot 2 (Gologolo juu) 1795 m a.s.l	551	44
Plot 3 (Sanje Chini)778 m a.s.l	470	22
Plot 4 (Sanje juu) 1425 m a.s.l	722	54
Plot 5 (Campsite chini) 781 m a.s.l	482	26
Plot 6 (Campsite juu) 1519 m a.s.l	610	43
Total	3298	129

The table below lists the tree species ordered by the number of stems (species that are represented by at least 20 stems are shown).

Species	Num. of stems (all plots)
Parinari excelsa	249
Tabernaemontana pachysiphon	227
Rawsonia lucida	215
Garcinia kingaensis	202
Strombosia scheffleri	192
Funtumia africana	161
Cassipourea gummiflua	150
Strychnos mellodora	114
Cleistanthus polystachyus	95
Leptonychia usambarensis	84
Alsodeiopsis schumannii	80
Vepris amaniensis	79
Unknown unknown	74
Beilschmiedia kweo	71
Drypetes gerrardii	66
Cola greenwayi	65
Doispyros amaniensis	61
Zanthoxylum gilletii	52
Craterispermum schweinfurthii	41
Rothmannia unknown	38
Baphia unknown	37
Lettowianthus stellatus	37
Chrysophyllum gorungosanum	35
Vepris simplicifolia	33
Grewia mildbraedii	31
Cassipourea gummiflua	30
Cephalosphaera usambarensis	30
Drypetes parvifolia	29
Lagynias pallidiflora	29
Xymalos monospora	27
Drypetes unknown	26
Oncoba welwitschii	26
Cassipourea malosana	25
Coffea unknown	25
Syzygium guineense	25
Lagynias rufescens	24
Synsepalum cerasiferum	24
Coffea mongensis	22
Placodiscus amaniensis	22
Anthocleista grandiflora	21
Macaranga capensis	21

A preliminary analysis of DBH size classes distribution was also done for 2011 data and is shown in the table below. The far majority of trees falls in the 10-20 cm DBH class, and overall most trees are within 50 cm DBH.

DBH class (cm)	Num. of stems						
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Total
10=20	311	291	273	470	285	358	1988
20=30	36	102	88	131	114	125	596
30=40	37	56	43	40	43	49	268
40=50	30	44	23	25	18	39	179
50=60	15	24	10	21	12	10	92
60=70	6	12	12	15	3	5	53
70=80	6	6	8	7	5	7	39
80=90	5	7	6	1	2	10	31
90=100	4	3	3	5	0	1	16
>100	8	6	4	7	0	6	31

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 and Figure below) - 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. In 2011, the battery and solar panel were stolen presumably by poachers, and therefore in agreement with UMNP management the tower was further secured by locking systems for both components.

Figure 16. TEAM staff mounting a locking system for the solar panel at the climate station.

As of 2011 moreover, the TEAM climate station has been registered with the Tanzania National Meteorological Agency (TMA), following agreement on data-sharing and an inspection of the site by TMA staff. This is the first TEAM climate station to be registered with the relevant national agency.

Most relevant parameters measured (temperature and rainfall) are summarized in the profiles below (Figure 16).
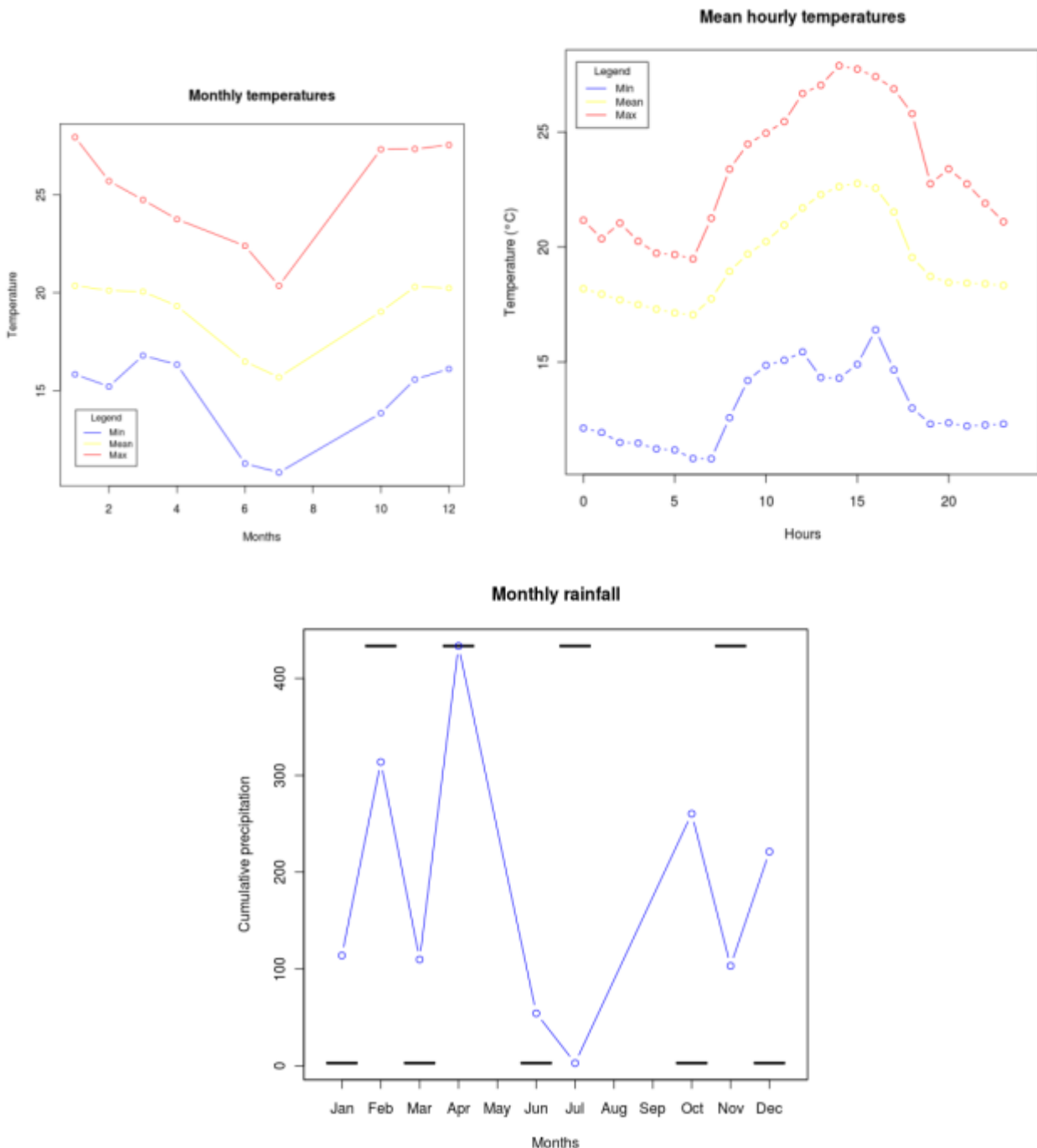

Figure 17. Climate profiles for 2011: monthly (above left) and daily (above right) temperature (min, average, max) and monthly cumulative rainfall (below).

A more comprehensive and detailed analysis of TEAM results is on-going and will be included in the dedicated annual report for the Tanzania Wildlife Research Institute.

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 2011: 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 150, so UEMC roughly reached 1500 students in 2011.

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.

Also, in collaboration with Tanzania Forest Conservation Group (TFCG) and thanks to a small project funded through Trento Province, UEMC organized and conducted an Environmental Education Training for primary school teachers from the wards adjacent to UMNP in September, 2011. The training targeted 42 teachers of 21 primary schools, 5 ward education officers and 3 government officers from Mang'ula division. The aim of training was to achieve and educate students by educating their teachers, identify basic environmental education skills in the Ministry of Education and Vocation Training EE guidelines, as well as applying Environmental Education skills to integrate environmental education in school subjects. At the end, each schools was provided with 4 copies of the environmental education manual prepared by TFCG.

Figure 18. A scene from celebration of the World Environment Day, 5 June 2011: on the right, the outreach warden, Mr. Wilbroad Mamuya, 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. In addition, the celebration of the World Environmental Day (June 5th) was organized and held at Mang'ula village. Preparation of this event involved planning with UMNP outreach warden, and liaising with the District Education Officer, Ward Education coordinators, 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 thousands of people attending. It was conducted with the participation of the group of students from Pennsylvania State University (see photos above).

8. Activities planned for 2012 and strategic planning for the next 5 years

UEMC plans to conduct the following activities in 2012:

- ➢ continue the primate and duiker monitoring with the standard, monthly frequency in Mwanihana and USFR;
- ➢ resume the ranger-based monitoring and establish a sustainable system that can ensure data-collection, including allocating necessary resources so that two trained assistants are responsible for collecting data along with rangers at least once per month at 5 ranger posts;
- ➢ conduct at the end of August 2012 the second edition of the summer school on field and GIS tools and co-organize with TANAPA ecological monitoring dept. and the GIS unit the participation and training dedicated to park ecologists, with a view to support standardization of monitoring protocols across forest parks;
- ➢ linked to the above, strengthen training to ecology dept. and law enforcement on use of GPS and GIS.
- ➢ review and update the UEMC web-site, which is currently outdated.
- ➢ continue and expand the environmental education programme, by increasing the number of schools involved and by initiating teachers' training. In addition, UEMC will begin to support community awareness activities as especially related to the adoption of sources of energy alternative to firewood collection, which is highly needed to sustain the firewood ban enacted in 2011.
- ➢ continue and consolidate implementation of TEAM project, that will enter into its fourth year of monitoring.

UEMC has also reviewed its longer-term plans in view of the signing of a new agreement that was signed on January 2012. The MoU deems an extended collaborative phase for further 5 years a mutual, important opportunity for both TANAPA and MdS.

The main objectives of the second phase of UEMC activities are reported below:

- ➢ Strengthen training activities in ecological monitoring especially for Park rangers and the Ecology department, so that on-going monitoring efforts such as primate monitoring in Mwanihana and the ranger-based monitoring of large mammals across the park becomes fully integrated in UMNP routine activities. This includes support to UMNP for relevant field and office equipment.
- ➢ Continue and enhance training schemes based at the hostel, such as the "Udzungwa summer school" organized in 2011, that involve TANAPA personnel among other national and international participants; special attention will be placed on Tanzanian university

students, especially to facilitate those special higher education programmes where students in wildlife conservation can use the UEMC to conduct their research and training. In this way, UMNP can become a model for biological monitoring in the country especially for forest parks.

➢ Continue to facilitate or directly support scholarships to TANAPA staff and UEMC employees. In particular, ensure that at least 1 scholarship per year is granted to TANAPA staff.

➢ Since it is critical to raise positive public attitude towards UMNP and to promote local socio-economic sustainability, UEMC will strengthen facilitation of community education and community-based conservation initiatives, as initiated in 2007 with the involvement of 5 primary schools around Mang'ula.

➢ As an overarching initiative that goes beyond UEMC management, the parties will consider establishing a formal, long-term partnership between TANAPA and MdS especially in view of the realization of MUSE, Trento's new museum that will be inaugurated in 2013, and that will include a greenhouse dedicated to the Udzungwa Mountains.

➢ Towards this end, and pending securing the necessary funds, MdS will support the realization of a Visitor Information Centre at UMNP that can combine the needs for tourism development as well as function as an interpretation and education centre for local communities and schools. Regardless of funding availability, MdS will provide its expertise to propose a design for the structure and related exhibits. Collaborative and multi-lateral fund-raising will be done by the parties to realize the implementation of the project. Similarly, collaborative research may be extended to related planned activities in the tourism sector that can enhance revenues to UMNP, e.g. canopy walkways and others that diversify tourism activities offer.

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.

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