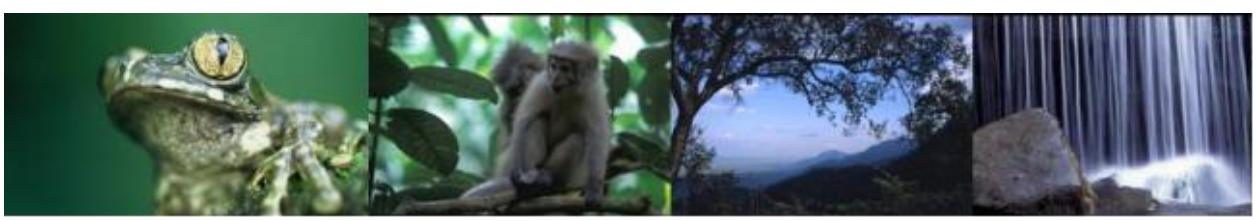
Udzungwa Ecological Monitoring Centre
(Udzungwa Mountains National Park)

Annual Technical Report
Year 9 (January - December 2015)



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Cover photo: A leopard (*Panthera pardus*) camera-trapped in Matundu forest, southern Udzungwa Mountains National Park (photo by Rasmus Gren Havmøller and Francesco Rovero).

Summary

The Udzungwa Ecological Monitoring Centre (UEMC, please visit the new website realized in 2012 at http://www.udzungwacentre.org) 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 the 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 forests. This is the ninth year technical report (January - December 2015), 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.

Generally, UEMC continued the provision of accommodation and facilitation to national and international researchers, with the overall number of researchers hosted since its opening reaching over 300 people in 2015, including 10 Ph.D. students. Besides the advisory to the Ecology Department of UMNP, training of ecologists and field assistants, and its own monitoring efforts, UEMC continued to host the TEAM project (Tropical Ecology, Assessment and Monitoring) that reached the seventh year of standardized biodiversity monitoring. Data collection in 2015 was limited to terrestrial vertebrate and climate. By using the hostel for students, UEMC facilitated important training schemes, such as the international summer school organized by MUSE, the University of Trento and the University of Copenhagen. UEMC also continued the provision of training scholarships for staff. UEMC continued the primate and duiker monitoring programme in Mwanihana forest (UMNP) and in the southern Udzungwa Scarp Forest Reserve (USNR), and the results were compared to those collected since 2002. The latest set of data raised the amount of data-set to 876 census repetitions in Mwanihana (or 3,434 km walked during 2002-2015), and 365 repetitions in USNR (1,296 km). Overall, the clear trend of relative population stability in Mwanihana continues to be confirmed by latest data, while the dramatic decline earlier reported for USNR persists, especially for the colobine monkeys. Conservation recommendations are proposed, and particularly stress the need for improving ground protection in the newly established USNR. It is also recommended that the monitoring programme continues with methodological consistency. The report also shows the quantity and quality of data collected by the TEAM programme, which also represents a very solid contributes with data collection that is standardized with that of several other field stations in the tropics.

The community conservation programme implemented by MUSE and Association Mazingira continued in 2015 under facilitation of UEMC and in close collaboration with UMNP, and major achievements included: continued the environmental education programme to 13 primary schools and 5 secondary schools; training continued for the establishment of tree nurseries and agro-forestry projects. The reports ends with a summary of activities planned for 2016 in the context of the Memorandum of Understanding that regulates the collaboration between TANAPA and MUSE for the management and objectives of UEMC.

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 MUSE - Science Museum (Trento, Italy) in partnership with Tanzania National Parks (TANAPA). The UEMC has been donated to Tanzania National Parks (TANAPA) and it is managed by MUSE under the conditions stated in a Memorandum of Understanding. The first MoU has run from 2006-2011, and the current MoU covers the period 2012-2016. This report aims to present the monitoring data collected and the overall UEMC activities conducted in the past year, as well as summarize the short and medium-term plans so that it can also serve as a strategic document. All previous technical reports can be downloaded from the UEMC website (www.udzungwacentre.org).

The aim of the UEMC is to promote and facilitate biological research and monitoring in order to increase the understanding of the Udzungwa Mountains, and to utilize the 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.

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. UEMC consists of six 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 opened, 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 structure is dedicated to enhancing training capacity. There has been a major change in terms of management and personnel in the year 2015. Mr. Philip Jacob, former UEMC coordinator, moved to Sokoine University of Agriculture (SUA), and Mr. Emanuel Martin, former TEAM site manager, moved to the College of African Wildlife Management, Mweka, both of them to cover permanent positions. Both roles were replaced by the former UEMC coordinator, Mr. Arafat Mtui, after successfully completed his undergraduate studies at the College of African Wildlife Management, Mweka. This change in coordination and the related handling over of duties were duly discussed with the Chief Park Warden. Miss.

In addition to Mr. Mtui and Dr. Rovero, MUSE's institutional representative is UEMC Director, the staff in 2015 included: a school environmental education officer, two field technicians, two gardeners, one house-keeper and four watchmen. Moreover, UEMC hosts the TEAM network project since 2009; this project is run by UEMC coordinator as a Site Manager with two field technicians and a driver.

UEMC in 2015 continued to support the co-funding of scholarships for staff training: hence, Mr. Joel Masuki, UMNP Warden has been supported through payment of fees to join the Master of Science in Natural Resources Assessment and Management at the University of Dar es Salaam; and Mr. Steven Shinyambala (UEMC/TEAM field technician) was fully supported by UEMC to join the Bachelor Degree in Environmental Planning and Management at the Institute of Rural Development and Planning – Dodoma.

In 2015, UEMC had an overall budget of 128 million T.Sh., as documented in the quarter financial reports sent to TANAPA over the year.

2. Summary of activities planned and activities implemented

This section provides an overview of activities implemented until the end of 2015 against the baseline goals that have been set since 2006 and summarized below (form more details the reader is referred to previous reports).

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

This fundamental activity continued through the routine primate and duiker monitoring programme and through general advisory for other ecological monitoring activities.

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 Udzungwa Scarp Nature Reserve (USNR), thus raising data for both TANAPA and Tanzania Forest Service (TFS). This is the longest dataset on *any* biodiversity component for the area. Due to the alarming situation of biodiversity destruction found in USNR as highlighted in previous reports, data for USNR are of particular conservation relevance. Moreover, all data collected by the 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, seminar room etc.).

In 2015 UEMC hosted 4 long-term researchers plus 66 guest researchers and students visiting on shorter term basis, adding up to a total number of slightly over 300 researchers accommodated in the hostel and houses during the 9 years of operations,

including 10 Ph.D. students. Overall, the resources raised in 2015 from fees related to accommodation only contributed to 15% of the overall budget, and this portion raised to 36% if the funding from the University of Copenhagen is included; this relates to support the running of their monitoring activities. UEMC continued to facilitate TEAM programme by hosting the staff and providing logistic support.

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

The international summer school training on tropical forest biodiversity, which is also a training opportunity for local staff, was conducted in August - September, 2015, where 20 participants from more than five countries and five Tanzanians attended.

5. Organize **education activities for school children**

This programme continued in 2015 thanks to the initiation of a broader community conservation programme led by **Association Mazingira**, a small Italian NGO that works with Trento Museum and in collaboration with Tanzania Forest Conservation Group (TFCG). The 3-year project is implemented in close coordination with the park's Community Conservation Service and since 2012 has expanded the Environmental Education programme originally conducted with 5 primary schools to include 13 primary schools and 5 secondary schools.

6. 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 (currently 17, see www.teamnetwork.org) continue to represent the major contribution towards this goal. Although based at UEMC, this project runs 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 in this report. Besides TEAM, at local level UEMC continued to facilitate and/or collaborate with Penn State University, the Natural History Museum of Denmark (Univeristy of Copenhagen, Denmark), Southern Tanzania Elephant Programme (formerly Udzungwa Elephant Project), and Udzungwa Forest Project/Flamingo Land, TFCG, AWF (African Wildlife Foundation) and other agencies working in the area.

3. Ecological monitoring results: primate and forest antelope monitoring

3.1. Primate monitoring in Mwanihana forest

The Primate Monitoring Programme established in 1997 in Mwanihana forest, uses transects established along tourist trails maintained by the park. Details of transect length and habitat types are reported below (Table 1). Transects are repeated every two weeks by one observer that walks slowly (1 km per hour) and records all sightings of primate

groups, together with its position, distance to each group, number of individuals (when possible) and observer's position along the transect.

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

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

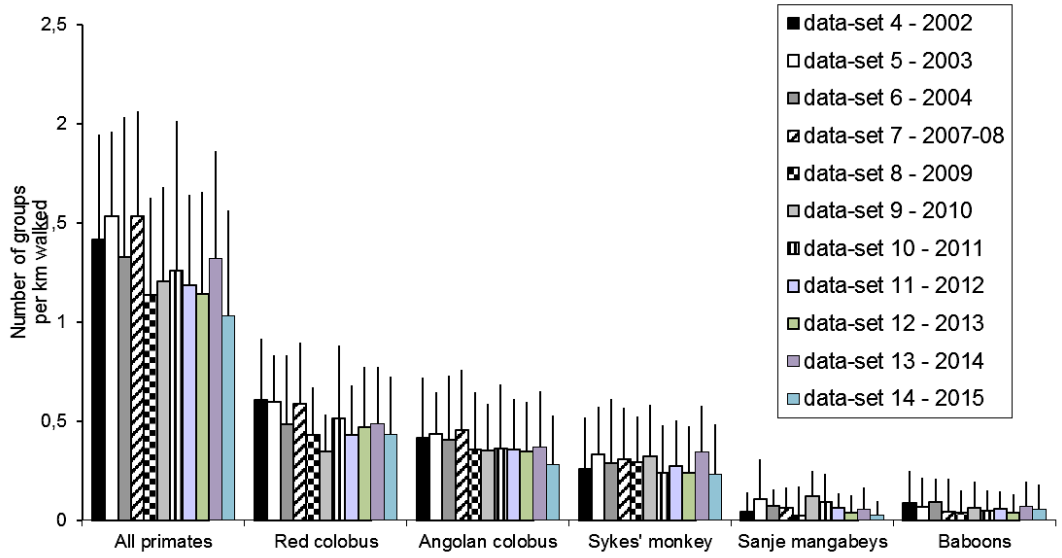
The updated list of data-sets collected by observers over the years is presented in Table 2. As elaborated in previous reports, data collected during 1998-2001 were deemed unreliable mainly because inter-observer consistency in data collection was not ensured. Therefore, it was decided not to include these data (which remains available on request), and hence the data presented here are from 2002-2015. Inter-observer consistency in data collection has been regularly checked for this data-set, and it was also ensured by minimizing the number of data-collectors.

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

N°	Observer	Period	Transect			
			C3	MW	SJ	MSO
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	DG	September-November 2008	6	6	4	3
9	ASM3 (UEMC)	December 2008-October 2009	21	21	21	20
10	ASM4 (UEMC)	November 2009-January 2011	28	28	28	28
11	ASM+MK (UEMC)	February 2011-January 2012	23	23	23	23
12	MK+PJ (UEMC)	February 2012 - December 2012	22	22	22	22
13	MK+PJ (UEMC)	January-December 2013	24	24	24	24
14	MK+PJ (UEMC)	January-December 2014	24	24	24	24
15	MK+PJ (UEMC)	January-December 2015	24	24	24	24
		All years	**233**	**233**	**232**	**178**

The updated data-set 2002-2015 for Mwanihana consists overall of **876 transect repetitions**, for over **3,434 km walked**. This remains the largest and longer-term monitoring data-set available for the area. The update results summarized as primate groups' encounter rate (number/km) and pooled for all transects are shown in the chart below. We do not show here the transect-specific results as we are mainly here concerned with the overall temporal trends, while site-specific variations are more relevant to habitat differences among transects.



3.2. Primate monitoring in Udzungwa Scarp Forest Reserve

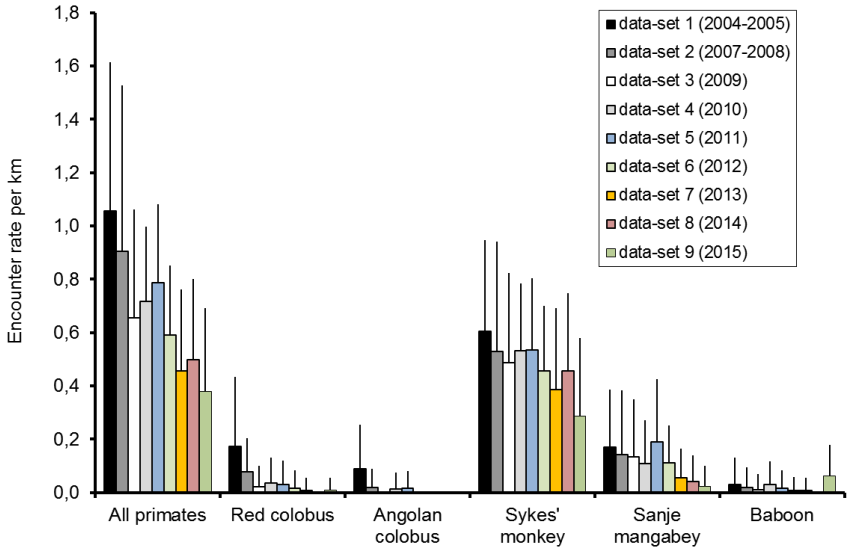
The same line-transect technique and sampling design used for censuring primates in Mwanihana was also used in the Udzungwa Scarp Forest Reserve (USNR) beginning in 2004 by F.R. and continued by UEMC coordinators and field technicians (Table 4). Effort by end of 2015 totaled **365 transect repetitions**, equivalent to **1,296 km walked**. One high-elevation transect (Kitolomero) was only used in 2004 and could not be

repeated for the difficult access. JKT transect was forced to be closed by the military station nearby, and it was therefore replaced by Tazara transect, which samples an equivalent portion of forest in terms of habitat and elevation zone.

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

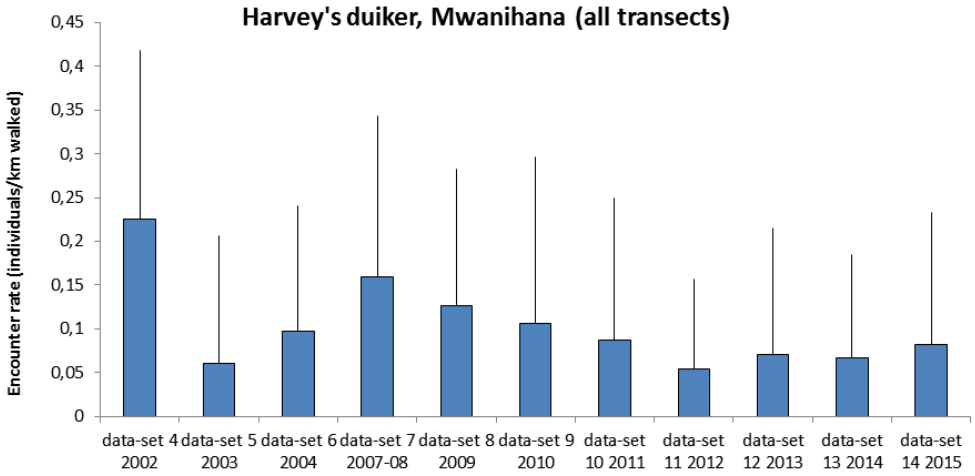
			Transect					
N°	**Observer**	**Period**	**Ikule**	**Mkaraji**	**JKT**	**Kitol**	**Tazara**	**All**
1	FR+ASM	July 2004 - June 2005	23	21	22	20	na	86
2	AMANI	January 2007 - June 2008	14	14	10	na	na	38
3	ASM	January-September 2009	9	9	na	na	7	25
4	ASM	October 2009- January 2011	13	13	na	na	13	39
5	ASM+MK	February 2011- January 2012	12	12	na	na	12	36
6	MK+PJ	February - December 2012	11	11	na	na	11	33
7	MK+PJ	January-December 2013	12	12	na	na	12	36
8	MK+PJ	January-December 2014	12	12	na	na	12	36
9	MK+PJ	January-December 2015	12	12	na	na	12	36
		All years	**118**	**116**	**32**	**20**	**79**	**365**

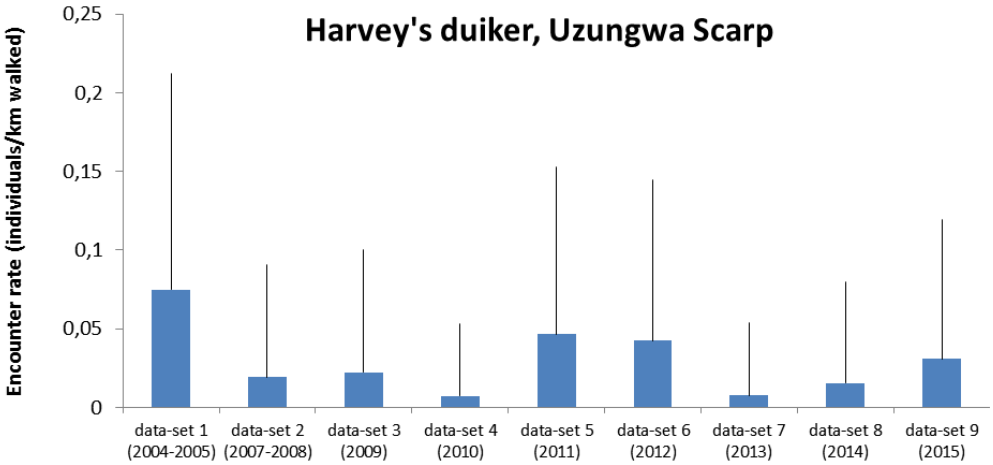
As for Mwanihana, the chart below shows the updated summary of encounter rate with time for the four transects pooled. As elaborated below, the persistent absence of colobine monkeys is critical and indicates of continued decline for these primates.



3.3. Monitoring of Harvey's duiker in Mwanihana and Udzungwa Scarp Forest Reserve

The red duiker is seen frequently enough from transects to allow for plotting encounter rate for the pooled transects. Despite the sample size is small, especially for Uzungwa Scarp, the chart below do allow for a qualitative assessment of the status and trends of these populations, with a clear, lower relative abundance in Uzungwa Scarp compared to Mwanihana.





3.4. Interpretation of monitoring results

The further increased sample size of primates and red duiker monitoring allowed to consolidate the conclusions highlighted in previous years on the status of these species in the target forests, and no important changes to this conclusions emerge from adding the 2015 data-set. That is, there continues to be a relatively stable trend for both diurnal

primates and the red duiker in Mwanihana while it continues a dramatic decline in Uzungwa scarp, which is especially evident for the colobus monkey. The apparently discordant result of baboon's encounter rate for USNR relative to previous area may be due to one or two groups that moved into the transect area from outside, hence increasing the sighting rates for this species (P. Jacob, pers. comm.). Indeed, the transect method used is much more suitable for the three arboreal monkeys (colobus and Sykes') and less informative for the predominantly ground-dwelling Sanje mangabeys and the baboons. Selective hunting of colobus in Uzungwa scarp, coupled with forest degradation, is the well documented cause of this decline as highlighted in previous reports and a number of papers. The encounter rate for Harvey's duiker in USNR remains small to highlight any trend, however the evidence that some sightings are still recorded may imply that this species has not declined further in recent years relative to earlier years.

In light of these results, the recent establishment of Uzungwa Scarp Nature Reserve, that has implied the appointment of a conservator and more staff dedicated to its management, brings hope that effective and urgent ground protection will be allocated to this forest, in time to prevent local extinctions.

We recall here that a major analysis of the primate data was published earlier in 2015 in PloS ONE (Rovero et al., 2015) using an advanced statistical approach that allowed to decipher temporal trends of estimated abundance with consideration of detectability. The analysis confirmed the significant decline in Uzungwa Scarp for colobine monkeys and the stability in Mwanihana. It also allowed to determine that variation among observers that collected data over the years do not affect the temporal trend; and that differences in abundance between dry and wet season were not significant. These results are very important as they indicate that the simple monitoring routine is indeed effective at deciphering temporal trends of threatened primate populations despite involving several observers.

4. Park-wide monitoring of large mammals

This programme has had alternating results, which are briefly summarized here. It failed, overall, to be sustained continuously: however, in view of the promising initial results, UMNP ecologist and UEMC staff reviewed the programme in 2012 and decided for continuation, with responsibility for data collection entirely shifted to trained field assistants instead of rangers. The programme was resumed towards the end of 2012 with a number of new transects established and the new system for data collection being set. Nevertheless, only few data were collected in 2013.

While the model of using trained technicians to collect data appeared to work best, in the mid of 2014 it was decided that the layout of transects should then be reduced to the initial, more limited but still comprehensive set of transects from the ranger post. These transects are more easily maintained and the logistic of their access is easier, hence involving affordable costs, that can therefore allow for sustainable and long-term data

collection. Since then few data was collected at the end of 2014 and dry season at the end of 2015 until beginning of 2016. A data-set is now available and will be considered for analysis once deem adequate for this.

5. TEAM project (Tropical Ecology, Assessment and Monitoring) in Mwanihana

Since its establishment in 2009 in the Udzungwa Mountains, TEAM project (www.teamnetwork.org) continued by conducting its seventh year of sampling. Three standardized monitoring protocols are implemented solely in Mwanihana forest: terrestrial vertebrates, vegetation and climate (see previous reports for more details).

Terrestrial vertebrates: 60 camera-trap points have been re-deployed through sampling 3 arrays of 20 camera-trap sites, sequentially. Twenty digital camera-traps (model Reconyx RM 45 Rapid Fire and Reconyx HP 500) 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. The final locations of the camera-traps were chosen upon the presence of wildlife trails and other signs. Sampling overall took place during July to November 2015.

Table 5 presents the updated synthesis of results from camera-trapping for 2009-2015 sampling. A range of 12,000 – 28,000 images were produced each year, totaling over 131,000 images. Given that camera traps shoot in continuous (thus the same individual animals would be photographed more than once within minutes), data from raw images are first screened to calculate the number of images per day and/or per hour, which are deemed independent 'events' of animal passages in front of the camera.

Table 5. Sampling effort and summary results for TEAM's terrestrial vertebrate sampling during 2009-2013.

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Num of camera set	60	60	60	60	60	60	60
Num of cameras functional	58	59	59	60	59	59	60
Camera-trap days (24 h periods)	1818	1874	1829	1842	1818	1812	1825
Mean camera-trap days per camera	31.3	31.8	31	30.7	30.8	30.8	30.4
Total number of images recorded	11147	12736	14737	20620	22122	28188	21706
Total number of events (1-hr interval)	1259	1547	1593	1615	1941	2197	1801
Total mammal species recorded	**27**	**27**	**28**	**25**	**26**	**28**	**27**

Descriptive analysis revealed that with 32 species trapped overall, a very high portion of the mammalian community known for Udzungwa was recorded in Mwanihana, the cumulative checklist with species' detection events per year being presented in Table 2. Trap-rate (number of events per sampling effort) is used as a gross index of relative abundance and allows to highlight those species that are most frequently encountered (the top 5 species trapped in decreasing order are: giant-pouched rat bushy-tailed mongoose, Harvey's duiker, Sanje mangabey and grey-faced sengi or elephant-shrew).

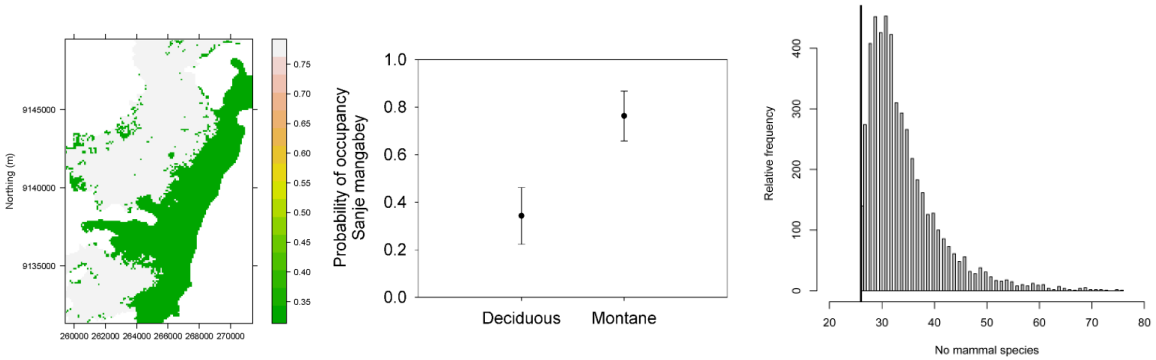
Table 2. List of mammals camera-trapped by the TEAM project and photographic events per year (y2009-y2015). NA indicates species not detected in that year.

Common name	Latin name	y2009	y2010	y2011	y2012	y2013	y2014	y2015
Marsh mongoose	*Atilax paludinosus*	3	3	13	5	6	4	1
Bushy-tailed mongoose	*Bdeogale crassicauda*	130	308	295	318	419	352	351
Harvey's duiker	*Cephalophus harveyi*	367	250	271	380	394	476	380
Abbott's duiker	*Cephalophus spadix*	61	53	56	30	52	51	51
Sanje mangabey	*Cercocebus sanjei*	73	100	118	152	129	149	143
Sykes' monkey	*Cercopithecus mitis*	21	9	12	21	19	26	28
African civet	*Civettictis civetta*	1	NA	NA	NA	NA	NA	1
Angolan colobus	*Colobus angolensis*	1	2	1	2	3	1	3
Giant pouched-rat	*Cricetomys gambianus*	276	353	380	313	443	601	424
Spotted hyena	*Crocuta crocuta*	NA	4	3	NA	NA	NA	NA
Tree hyrax	*Dendrohyrax validus*	23	42	36	50	58	32	65
Lowe's genet	*Genetta servalina*	18	64	54	59	37	67	41
Human	*Homo sapiens*	2	3	NA	1	NA	NA	NA
Hystrix	*Hystrix africaeaustralis*	11	1	NA	2	NA	2	4
Serval cat	*Leptailurus serval*	NA	NA	1	NA	NA	NA	NA
Savannah	*Loxodonta*	11	5	7	13	9	5	7

elephant	*africana*							
Honey badger	*Mellivora capensis*	7	6	7	13	12	10	16
Banded mongoose	*Mungos mungo*	2	7	1	NA	2	9	2
Common name	**Latin name**	**y2009**	**y2010**	**y2011**	**y2012**	**y2013**	**y2014**	**y2015**
African palm civet	*Nandinia binotata*	2	7	9	11	9	6	13
Suni	*Nesotragus moschatus*	114	135	91	87	165	211	99
Leopard	*Panthera pardus*	8	2	7	6	3	4	2
Yellow baboon	*Papio cynocephalus*	3	NA	2	NA	1	3	1
Tanganyika mountain squirrel	*Paraxerus vexillarius*	46	60	59	40	59	78	39
Four-toad sengi	*Petrodromus tetradactylus*	3	7	36	12	15	1	23
Bushpig	*Potamochoerus larvatus*	18	23	16	22	24	44	23
Udzungwa red colobus	*Procolobus gordonorum*	5	2	8	2	3	2	10
Chequered sengi	*Rhynchocyon cirnei*	4	4	8	NA	1	6	5
Grey-faced sengi	*Rhynchocyon udzungwensis*	45	88	95	61	69	52	58
African buffalo	*Syncerus caffer*	4	5	3	3	7	1	4
Cane rat	*Thryonomys swinderianus*	NA	NA	2	4	1	1	NA
Bushbuck	*Tragelaphus scriptus*	NA	4	2	8	2	3	7

Since 2012, a consistent effort to analyse data begun. This included descriptive analysis, species-specific analysis and occupancy modelling, allowing for determining presence/absence of species under a rigorous statistical framework. An example of results for the grey-faced sengi or elephant-shrew is in Rovero et al. (2014, details in reference list, paper freely available here: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0103300). The core species' modelling analysis uses occupancy (sites occupied on sites sampled) as the state variable of abundance and allows for assessing the influence of environmental covariates. For example, and as shown in previous reports, in the figure below (left) a spatially-explicit model of the Sanje mangabey is shown, indicating that this endemic monkey prefers highly the montane forest versus the lowland forest. In the right chart, instead, is

an example of result of community analysis, whereby the species richness is estimated using a Bayesian framework that allows to estimate species with account for imperfect detection. The chart shows that while the observed species richness is typically around 26-27 (varying little every year), the true number of species is above 30 (32-34) which fits with evidence using various complementary evidence.



Left: occupancy model for the Sanje mangabey in Mwanihana forest with chart of occupancy probability values (and S.E.) in deciduous and montane forest. Right: distribution of the estimated species richness using data from 2009 according to a Bayesian modeling framework (from Rovero et al. 2014).

Following this important, baseline analysis, we also here report on some of the ensuing analytical efforts. Emanuel Martin for his Ph.D. produced a paper on habitat associations of selected species with habitat data collected at each camera trap site including detailed vegetation assessment (Martin et al. 2015, Tropical Zoology). The results provide ecological insights for most species, which is novel and is of conservation relevance. Results are summarized in the two following tables extracted from the paper, the first (Table 1 in Martin et al. 2015) lists the habitat covariates used and the second (Table 3 in the paper, see below) shows the results of regression analysis between camera trap rate and these covariates.

Table 1. Vegetation variables measured in plots centred on camera-trap sites, and used to analyse habitat associations of forest mammals in the Udzungwa Mountains of Tanzania. Redundant variables that were not used in the regression analysis are reported in the footnotes.

Type of plots for the measurements	Variables used in the regression analysis (abbreviation)
20 large trees (>10 cm DBH)	Stem density (SD1) Mean basal area (MBA1) Diversity (Simp1)[a]
20 small trees (5–10 cm DBH)	Mean basal area (MBA2) Diversity (Simp2)[b]
3x3 m plots	Small trees stem density (SD3) Diversity (LogSimp3)[c]
1x1 m plot (forest floor cover)	Herbaceous layer and seedlings (Herbs_Seedl)[d] Sum of deep and very deep leaf litters (SumDepthD_VD) Visibility[e] Distance to the National Park border (DistToNPBorder)[f] Distance to the Forest Edge (DistToForestEdge)[f]

[a]Simp1 correlated with richness 1 ($r = 0.9$, $p < 0.01$, $n = 59$).
[b]Simp2 correlated with richness 2 ($r = 0.8$, $p < 0.01$, $n = 59$).
[c]LogSimp3 correlated with richness 3 ($r = 0.8$, $p < 0.01$, $n = 59$).
[d]Herbs_Seedl correlated with leaves ($r = -0.7$, $p < 0.01$, $n = 59$).
[e]Measured 20 m from the centre of the plot.
[f]Calculated by using ArcGIS version 10.

Table 3. Results of generalized linear models with Poisson error distribution habitat predictors of abundance of nine mammals that had adequate camera trapping events for the analysis (>20). Both the deviance and the significant outcomes of the effects of covariates on trap events are indicated, along with their directionality. See Table 1 for abbreviations of covariates.

Species	Significant covariates	Estimates (SE)	*p*-value	Deviance (%)
Sanje Mangabey	MBA2	− 510.933 (280.192)	0.074	5.8
Bushy-tailed mongoose	LOGSD3	− 1.675 (0.490)	< 0.05	21.9
	Simp1	0.088 (0.048)	0.072	
	SumDepthD_VD	− 1.365 (0.691)	0.053	
Lowe's servaline genet	DistToNPBorder	0.000 (0.000)	< 0.05	43.5
	LOGSD1	1.937 (1.036)	0.067	
	Simp1	0.239 (0.067)	< 0.001	
	Visibility	− 0.030 (0.015)	< 0.05	
	Herbs_Seedl	−0.052(0.021)	< 0.05	
Giant pouched rat	Simp1	0.110 (0.066)	0.098	30
Tanganyika mountain squirrel	LOGSD1	− 2.260 (1.312)	0.091	14.5
	LOGSD3	3.214 (1.472)	< 0.05	
Gray-faced sengi	Simp2	0.165 (0.080)	< 0.05	29.8
	Simp3	0.190 (0.073)	< 0.05	
Abbott's duiker	DistToNPBorder	0.000 (0.000)	< 0.001	14.5
Suni	DistToForestEdge	− 0.000 (0.000)	< 0.05	30.9
	DistToNPBorder	− 0.000 (0.000)	0.08	
	LOGSD3	− 1.860 (0.846)	< 0.05	
	Visibility	0.030 (0.009)	< 0.01	
Bush pig	DistToNPBorder	0.000 (0.000)	0.055	63.7
	DistToForestEdge	− 0.000 (0.000)	< 0.05	
	LOGSD1	2.221 (1.307)	0.089	
	LOGSD3	−6.141 (1.814)	< 0.001	
	Simp2	−0.468 (0.129)	< 0.001	
	Simp3	−0.316 (1.286)	< 0.05	
	MBA1	2.150 (0.552)	< 0.001	
	Herbs_Seedl	−0.089 (0.034)	< 0.01	

A second paper by Martin (Martin et al. 2016, *African Journal of Ecology*) addressed the seasonal variation of occupancy and detectability especially in relation to variations in rainfall. This analysis was done by repeating the sampling in the wet season at a selected pool of sites, and could be done on 6 species only due to limited data. Results are not shown in details as they are not published yet, however they basically indicate that there is no substantial variation of estimated occupancy and detectability with rainfall seasonality, with a trend for lowered detectability in the wet season and also poorer performance of camera trapping due to moisture and rainfall.

In addition, with the accumulation of data from 7 years (2009-2015 inclusive), temporal analysis has also continued. Preliminary results shows interesting trends with an apparent increase in the rate with which some species are detected by camera trapping, a pattern which may be related to decreasing human pressure on the forest as a result of both the banning in 2011 of firewood collection, and also a possible decrease in illegal poaching which is documented, qualitatively, by a reduction in the number of snares removed by TANAPA rangers when escorting every year the field team. All these remains unpublished data which will be duly reported following the on-going analysis.

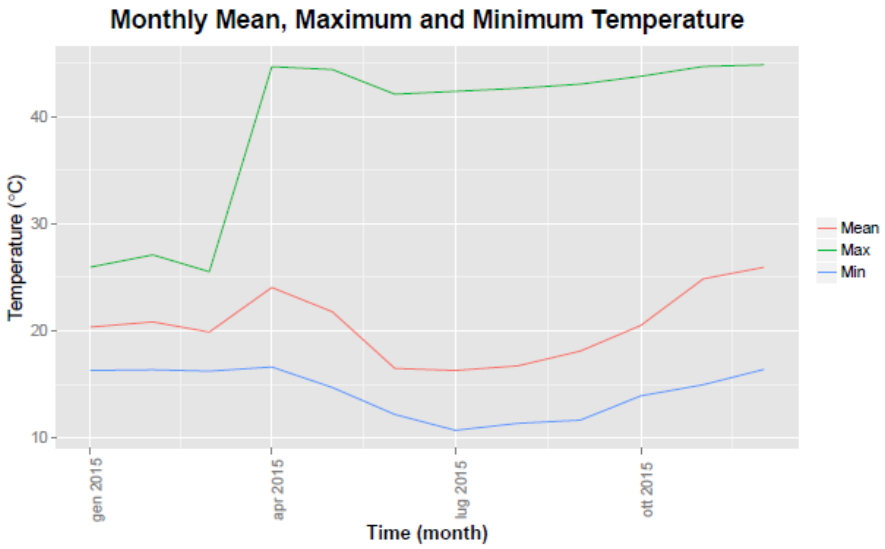
Lastly, Udzungwa TEAM data, being open-access as for the whole TEAM data policy, continued to be used in global analysis of all TEAM data by a number of scientists, and two papers (Beaudrot et al. 2015, Ecological Applications, and Beaudrot et al. 2016, PLOS Biology) have been published and are of particular significance. The first evaluate the relationship between vertebrate diversity as measured by camera trapping and carbon stocking as measured by the vegetation plots. The relationship appeared poor and

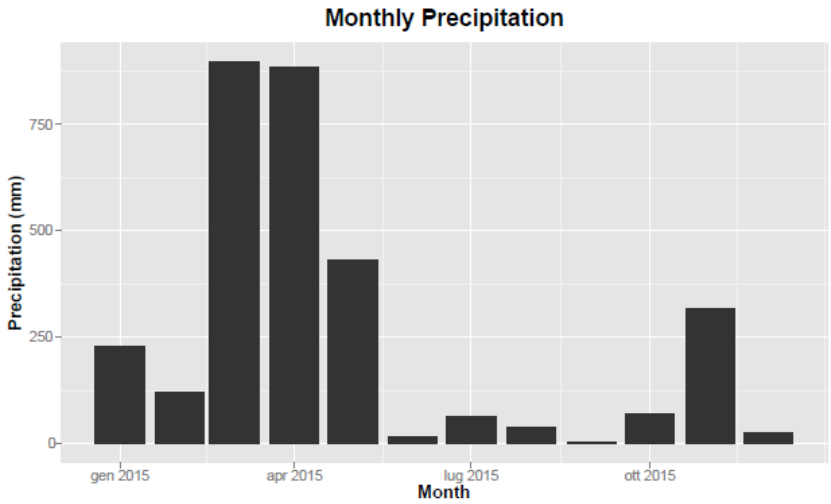
indicate that forest conservation for animal diversity not necessarily correlate with carbon stocking. The second paper is the first global and temporal analysis of camera trapping data, and produces the global trends for >500 populations of terrestrial mammals and birds finding overall positive or stable trends for 40% of these, declining trends for 22% and the rest are populations for which there are not enough data to detect trends.

Vegetation: the six vegetation plots located across the altitudinal gradient in the forest have been established in 2008 to measure trees above 10 cm DBH, and were re-measured during 2009-2014 (see previous reports for details). However, due to a review of this protocol by the TEAM programme, and a revision of the sampling design, vegetation sampling was not conducted in 2015, meaning that plots were not re-measured. It is likely that sampling will be reduced in frequency with re-measurements conducted every 3 or 5 years.

Climate monitoring: Through the use of an automatic weather station, TEAM project continued to collect data on four weather parameters namely rainfall, solar radiation, temperature and relative humidity. Once the data have been retrieved from the data-logger, they immediately become uploaded into TEAM website http://www.teamnetwork.org/data/query for public consumption freely of charge but after adhering to the TEAM data use policy. The climate station worked with mixed efficiency in 2015. The most serious problems was the theft of the solar panels towards the end of the year. The incident was immediately reported to the park management and measures were taken to replace the solar panel (which was locked) and increase the security through making a new locking system.

As per data collected, some sensors including T/HR has some problems that altered the profiles obtained. Data were analysed using automatic report-generation routines in software 'R' and developed by TEAM Head office. Below, a sample of climate profiles (relative humidity and rainfall) generated for all of 2015 are shown, while additional data and information are provided upon request. The first profile (temperature) shows that from march the maximum values are too high, as a result of the sensor producing spikes alternated to correct values. This means that the mean values are correct. For any ad-hoc use of these data it will be possible to remove the spikes and produce corrected profiles for specific periods.





6. School education and community conservation activities

The community conservation programme initiated in 2012 under Association Mazingira continued as an independent project working closely with UEMC and UMNP, under coordination of Mr. Pima Nyenga. The first, three years phase of this project ended in 2015, however activities are continuing in 2016 and strategies for long term continuation are being made, also in parallel with the Visitor Information Centre project.

Activities with schools ranged from lessons in class and visits to the park and night cinema projections. UEMC initiated this programme towards the end of 2007 with 13 nearby primary schools in Mang'ula, namely Mlimani, Mwaya, Mgudeni, Mang'ula A and Msalise primary schools.

Ichonde, Kisawasawa, Sanje, Kiberege, Darajani, Udzungwa, Tumaini, and Sonjo and 4 were secondary school (Bokela secondary school, Kisawasawa, Udzungwa, and Mang'ula: class lessons on environmental education were carried out regularly, where students have been taught class lessons on eco-tourism, environmental degradation drivers and mitigation measures, energy serving stoves construction, sustainable uses of forest products and proper management of the forest. Study tour to various areas within the Udzungwa Mountains National park was conducted. This involved a visit to rubber plantation in Mwaya village. 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 3,220 students in 2015.

Photographs above: snapshots of community conservation activities, field trip and Park visit.

In addition, other community conservation components have been activated, as follows. Monitoring of farms on Alley cropping project has been done in Mang'ula A, Ichonde, Mkasu, and Kisawasawa, Mang'ula primary and secondary schools. The programme also continued with monitoring of mud stove and briquette technologies to the 14 villages, where 10 new mud stoves were constructed at Kiberege.

6.1 Construction of the Visitor Information Centre

In 2015 the construction of the Visitor Information Centre (VIC) continued well. The TANAPA Hydraform machine to construct the eco-friendly bricks was brought it to the site and serviced. Preliminary laying of the foundation and construction of the store for storing materials and bricks in view of the Hydraform training was done in February/March, 2015. Laying of the foundation to full completion was done in mid-2015. Hydraform bricks were produced during the training and sample were taken to Dar for testing. At the time of writing this report (May 2016) the podium is being erected, 10,000 bricks for the main structure are being made, and wall construction is forthcoming. It is anticipated that construction of the VIC will be finished by the year 2016/early 2017. Meanwhile, design and budgeting for the exhibit begun as a collaboration between MUSE and the Natural History Museum of Denmark, with the aim of completing a layout to be shared with TANAPA in the summer of 2016.

Collage of different phases of the early stages of the building, including a rendering of the structure (bottom right).

7. Activities planned for 2016 and strategic planning

UEMC plans to conduct the following activities in 2016:

- continue the primate and duiker monitoring with the standard, monthly frequency in Mwanihana and USNR;

- continuation of the VIC construction in alliance with TANAPA and other partners, with an aim of finishing the building in 2016/early 2017 and realization of the exhibit initiated by the end of 2016; the goal is to inaugurate the VIC in 2017 (25^{th} anniversary of the establishment of the park);
- continue to support with technical advisory and training the park-wide monitoring of mammals and help establishing a sustainable system that can ensure data-collection; this includes conducting the fifth edition of the summer school that will be open to TANAPA ecologists from UMNP and elsewhere;
- continue to support and facilitate the environmental education programme and the environmental cooperation activities by Association Mazingira, which was resumed in 2016 for the second phase;
- continue and consolidate implementation of TEAM project that will enter into its eighth year of data collection.

UEMC also plans to consolidate the long-term collaboration with other institutions and programmes operating in the area, in primis the Natural History Museum of Denmark and the Pennsylvania State University, towards developing common way forward for the long-term support to UEMC, in collaboration with TANAPA, as a facility that remains of critical importance for maintaining and bosting research and conservation efforts in Udzungwa. This is especially relevant at times of rapid changes in the Kilombero valley as related to agricultural and infrastructural developments, as well as population growth, representing a potential increasing threat to the outstanding biodiversity and the associated ecosystem services provided by the park and other protected areas. Towards this end, major focus in 2016 will be placed on developing a proposal for a renewed management strategy as a collaborative effort between MUSE (and partners) with TANAPA, begin a focal dialogue on modalities and reach an agreement by the end of 2016.