IN-DEPTH STUDIES TO EXAMINE THE LONG-TERM CHANGES IN WILDLIFE BEHAVIOUR IN PROTECTED AREAS AS A RESULT OF OIL AND WATER INDUSTRIES DEVELOPMENT, CLIMATE CHANGE AND HABITAT CHANGE IN THE GREATER VIRUNGA LANDSCAPE (GVL)

S.T. Nampindo, G. Nangendo, S. Ayebare, B. Kirunda, H. Mugabe, M. Leal, and A.J. Plumptre

Inception report

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EXECUTIVE SUMMARY

The Greater Virunga Landscape (GVL) is one of the most species rich areas of contiguous natural habitat in the World. The GVL contains at least 1,409 terrestrial vertebrate species and 3,755 plant species of which 109 species are considered to be globally threatened and 241 species endemic to the Albertine Rift region of Africa. The Albertine Rift region has more threatened and endemic vertebrates than anywhere else on the African continent and the GVL is the richest part of the Albertine Rift making it one of the foremost sites for global biodiversity conservation.

The recent exploration for oil and gas in Virunga National Park within the GVL by the oil company, SOCO, and in Queen Elizabeth Park by Dominion Oil has raised concerns and much press about their conservation and long term viability. Trial drilling has already taken place in Uganda in the Queen Elizabeth National Park by Dominion Oil although no oil was discovered at that time. Greater Virunga Transboundary Collaboration (GVTC) with funding from the Dutch government commissioned a study, conducted by WCS, to assess the potential impacts that oil/gas and geothermal exploration and production could bring to the GVL and to identify the most sensitive areas for the conservation of the biodiversity of this landscape. In that study, the Greater Virunga Landscape known to be exceptionally rich in diversity and in species of global conservation concern (Plumptre et al. 2016), it was indicated that any development within a protected area will affect at least one species of conservation concern. It was noted that the more sensitive species and habitats found mainly around the lakes, where oil developments are most likely to occur, will be impacted most and recommend that production does not go ahead in the landscape, but that alternative income generating options such as greater promotion and management of tourism be explored.

This study, however, did not explore the combined effect of climate change, and oil and gas exploration on the behaviour of wildlife in the GVL. GVTC, with funding support from the Dutch government, contracted WCS to conduct an in-depth study to examine the long-term changes in wildlife behaviour in protected areas as a result of development of oil and water industries as well as climate change, and to examine the habitat change in the Greater Virunga Landscape (GVL). The specific objectives are:

1. To analyse the impacts of climate change and other factors that could lead to long-term wildlife behaviour change
2. To assess the potential and actual impacts of oil, natural gas, and geothermal exploration/exploitation on long-term wildlife behaviour
3. To assess the potential impacts of water industries on long-term wildlife behaviour
4. To analyse other factors that could lead to long term changes in wildlife behaviour
5. To map the land use land cover changes in GVL for the period between 2000 to date at an appropriate temporal mapping scale
6. Propose appropriate recommendations for managing and mitigation of adverse changes in wildlife behaviour to be included in the transboundary General Management Plan

Table of Contents

Introduction

The Greater Virunga Landscape (GVL) is located within the Albertine rift valley. It has an area of 13,209 square Kilometers. It is one of the most biodiverse landscapes in the World. It contains three world Heritage Sites (i.e. Virunga National Park, Rwenzori Mountains NP and Bwindi Impenetrable National Park), one Ramsar Site (Lake George and Edward) and one Man and Bisophere Reserve (Queen Elizabeth National Park). About 88% of the natural habitat in this landscape is protected with the possibility of expanding the landscape to the north to include an existing corridor of forest between Virunga Park and the Mt Hoyo Reserve in eastern Democratic Republic of Congo. The landscape contains a wide diversity of habitats because of its wide range in altitude from 5,100 meters a.s.l. in the Rwenzori Massif to 600 meters in the lowland forests of Semuliki (http://albertinerift.wcs.org/). Greater Virunga landscape is also under intense human pressure (http://www.africanconservation.org/). The landscape also contains two of Africa's most productive lakes, Lake George and Edward, which are important for fisheries that sustain people's livelihoods.

Threats to biodiversity conservation in GVL

The Greater Virunga Landscape is one of the most species rich areas in Africa. It is the richest in terms of vertebrate species. More than 50% of the birds, 39% of mammals, 19% of amphibians and 14% of reptiles of mainland Africa are found within this region. The area has some of the highest densities in Africa, especially the southern part of the landscape, estimated at 400 persons per square km. Both the wildlife and humans exert pressure on the landscape. Humans exert pressure through overgrazing, burning and illegal activities such as poaching, forest products harvesting and commercial plantation agricultural expansion. Impact of these activities and how they are causing change in the landscape need to be monitored. Plumptre et al, 2010 provide baseline information about impacts of fire that can be followed up. Invasive species, especially tickberry or wild-sage (*Lantana camara*), Spear grass (*Imperata cylindrica*) and *Dichrostachys cinerea* are a major threat to the grassland areas. The wildlife grazers then have to compete with cattle from the neighboring communities for the remaining grass in the parks. In 2015, WCS was contracted by GVTC to document the existing and potential oil/geothermal projects, mapping their likely adverse negative effects on the biodiversity conservation and community livelihoods in the Greater Virunga Landscape (Plumptre et al. 2016). In 2014, WCS worked closely with Uganda Wildlife Authority (UWA), and *Institut Congolais pour la Conservation de la Nature* (ICCN) to conduct an aerial survey of the large mammal populations in the savannas of the Greater Virunga Landscape (GVL), particularly the Queen Elizabeth National Park (QEPA) in Uganda and the Virunga National Park (Virunga) in Democratic Republic of Congo (Wanyama et al. 2014).

Scope of work

The purpose of the in-depth study is to examine the long-term changes in *wildlife behaviour* in protected areas as a result of development of *oil and water industries* as well as *climate change*, and to examine the *habitat change* in the Greater Virunga Landscape (GVL). The scope of work for this study, as per the terms of reference, aim to examine achieve the following objectives within the limits of the terms of reference. The specific objectives are:

1) To analyse the impacts of climate change and other factors that could lead to long-term wildlife behaviour change
2) To assess the potential and actual impacts of oil, natural gas, and geothermal exploration/exploitation on long-term wildlife behaviour
3) To assess the potential impacts of water industries on long-term wildlife behaviour
4) To analyse other factors that could lead to long term changes in wildlife behaviour

5) To map the land use land cover changes in GVL for the period between 2000 to data at an appropriate temporal mapping scale
6) Propose appropriate recommendations for managing and mitigation of adverse changes in wildlife behaviour to be included in the transboundary General Management Plan

As such, WCS is required to perform the following tasks:

1. Prepare an inception report, including a detailed methodology, sampling framework and submit to GVTC-ES for review, discussion and approval
2. Select representative sample sites, flagship species of flora and fauna
3. Collect and analyse data
4. Prepare one brief progress report for outputs agreed upon as scheduled in the work and submit to GVTC-ES
5. Prepare a draft report for validation in a stakeholder workshop
6. Prepare final report incorporating recommendations from the validation workshop

WCS interpretation of the ToRs and proposed approach

GVTC is interested in assessing and measuring the long term changes in animal behaviour in only six months. In order for WCS to conduct the study appropriately, however, it would require a minimum of 10 years of continuous monitoring of selected species among the candidate taxa (i.e. plants, mammals, birds, reptiles, amphibians, butterflies, fisheries etc..). In addition, the study would require a suite of methodologies including radiotelemetry work (collaring of selected species e.g. elephants, lions that have large home ranges and move regularly between Uganda and DR Congo), tagging and echolocation (e.g. birds, bats) or application of mark-recapture techniques (photographic and cinematography, radar) for species that respond strongly to seasonal variation and are highly sensitive to both range and phenological shifts by migrating to other areas. For less mobile species, particularly plants, the study would require the establishment of permanent vegetation plots across the GVL vegetation gradients and sites (e.g. Virunga National Park or QENP with savannas, Bwindi (Tropical high forest), Echuya Forest Reserve (bamboo), Rwenzori or Mgahinga (alpine) and wetlands (e.g. muchuya or Nyamurilo) and life history traits and evolutionary trajectories that differ from species to species. This would also require a significantly bigger budget than what is suggested by GVTC in the ToR. As such, WCS provided this interpretation in the proposal to GVTC, which was evaluated then, with a final award to WCS.

Given the constraints explained above, WCS will proposes to approach this work in the following manner. WCS will use her own collected data as well as the species monitoring data to model the impact of climate change and water industries (our own interpretation of water industries refers to the abstraction and use of water by commercial industries with potential risk of exceeding the supply) on the long-term changes to wildlife. First, we will collate all existing information, including student theses and research done in the 1960s and 70s to document the animal distributions and vegetation change and use this information to identify the most sensitive biophysical conditions that are likely to cause a change in animal and plant behaviour. Aware that most of the known studies did not focus on changes in animal behaviour due to climate change, let alone a few that examined the social and feeding ecology, behaviour will be assessed at the level of changes in habitat suitability and species distributions of endemic and threatened species with respect to climate change. WCS has compiled maps of elephant and buffalo surveys in QENP since 1970s and these will be compared with the distribution of these mammals from the recent counts to see how they have change over time. We examined where increases and decreases in woody cover have occurred and see how it has affected large mammal distributions in QENP. We recognize that this may not be appropriate for Virunga NP since is heavily affected by heavy poaching. Detailed methodology of how each objective will be achieved is provided in the next section.

Objectives

There are five objectives of this study and a brief background and methodology of achieving them is explained for each objective.

Objective 1: To analyse the impacts of climate change and other factors that could lead to long-term wildlife behaviour change

Numerical models (General Circulation Models - GCMs) representing physical processes in the atmosphere, ocean, cryosphere and land surface are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations (IPCC 2001, 2007, 2013). While simpler models have also been used to provide globally- or regionally-averaged estimates of the climate response, only GCMs, possibly in conjunction with nested regional models, have the potential to provide geographically and physically consistent estimates of regional climate change which are required in impact analysis. A new set of scenarios referred to as Representative Concentration Pathways (RCP) were used established for use in the new IPCC climate model simulations conducted under the framework of the Coupled Model Intercomparison Project (CMIP5) of the world Climate Research Program (Taylor et al., 2012). The IPCC's Assessment Report Five (AR5) present four different sets of RCPs based on radiactive forcing scenarios namely RCP2.6, RCP4.5, RCP6.0, and RCP8.5 (van Vuuren et al. 2011). It should be noted that the baseline period for the IPCC AR5 is 1986-2005. In this study, RCP8.5, a very high end climatic change scenario will be used in the implementation of climate change impacts on wildlife behavior. By justification, there are differences among the RCPs defined by the radioactive forcing and the associated temperature change. Under RCP2.6, a more conservative pathway, the peak in radiative forcing is at approximately three watts per meter squared (~3 W/m2), (~490 ppm CO_2 equivalent) before 2100 and then declines to 2.6 W/m2 by 2100 (Clark et al. 2007; Wise et al. 2009; van Vuuren et al. 2011). In the case of RCP6.0, concentrations stabilize without overshoot pathway to 6 W/m2 (~850 ppm CO_2 equiv.) at stabilization after 2100 (Hijioka et al. 2008) while RCP8.5 is considered to be the rising radiative forcing pathway leading to 8.5 W/m2 (~1370 ppm CO_2 equiv.) by 2100 (Riahi et al. 2011; van Vuuren et al. 2011). According to IPCC (2013), global surface temperature change for the end of the 21st century is likely to exceed 1.5^{0}C relative to 1850 to 1900 for all RCP scenarios except RCP6.0. As such, the RCP8.5 is the most ideal scenario as it captures the worst case situation and any species that can adapt to these conditions will obviously coupe well under the lower climate change scenarios.

The application of the RCP scenario results is discussed in detail under the methodology section, but the temperature change under RCP8.5 is predicted to be 4-5^{0}C (IPCC 2013). While interpreting the results from the GCM, we need to be mindful that GCMs depict the climate using a three dimensional grid over the globe, typically having a horizontal resolution of between 250 and 600 km, 10 to 20 vertical layers in the atmosphere and sometimes as many as

30 layers in the oceans. Their resolution is thus quite coarse relative to the scale of exposure units in most impact assessments. Moreover, many physical processes such as those related to clouds, also occur at smaller scales and cannot be properly modeled. Instead, their known properties must be averaged over the larger scale by parameterization. This is one source of uncertainty in GCM-based simulations of future climate. The other concerns relate to the simulation of various feedback mechanisms in models concerning, for example, water vapour and warming, clouds and radiation, ocean circulation, ice and snow albedo. For this reason, GCMs may simulate quite different responses to the same forcing simply because of the way certain processes and feedbacks are modeled.

WCS explored the possibility of using the recently released Shared Socioeconomic Pathways (SSP) (https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=about) to the proposed climate change modelling for selected species, however, we decided that this might be time consuming and also yield insignificant results. The SSPs are part of a new framework that the climate change research community has adopted to facilitate the integrated analysis of future climate impacts, vulnerabilities, adaptation, and mitigation. The new scenarios provide detailed information on energy, land-use, and emissions projections for the SSPs (Riahi et al, 2016). A narrative of the main characteristics of the future development path of an SSP is well described by O'Neill et al, (2012). The recently released scenario data complement earlier information on the basic economic and demographic elements of the SSPs developed in March 2013. The idea was to use SSP5 scenario family, which is characterized by rapid and fossil-fueled development with high socio-economic challenges to mitigation and low socio-economic challenges to adaptation so that it is consistent with RCP8.5. The SSP5 baseline scenarios exhibit very high levels of fossil fuel use, up to a doubling of global food demand, and up to a tripling of energy demand and greenhouse gas emissions over the course of the century, marking the upper end of the scenario literature in several dimensions (van Vuuren et al. 2014; O'Neil et al. 2014; Kriegler et al. 2014; Riahi et al, 2016; Kriegler et al. 2017). These scenarios are currently the only SSP scenarios that result in a radiative forcing pathway as high as the highest Representative Concentration Pathway (RCP8.5). This paper further investigates the direct impact of mitigation policies on the SSP5 energy, land and emissions dynamics confirming high socio-economic challenges to mitigation in SSP5.

Climate change in Greater Virunga Landscape and previous climate change studies

The Greater Virunga Landscape experiences a varied climate, largely as a result of the influence of the high mountains. In the highlands, the climate is temperate, although at lower altitudes it is hot and humid. Rainfall distribution is bimodal, that is, March to May, and mid-September to mid-December alternated with drier spells each year. Annual rainfall is highly varied at a local scale from 500 millimetres (mm) at Lake Edward, 900-1,500 mm on the plains south of the Lake Edward, decreasing highly on the volcanoes but on the west slope of the Ruwenzori orographic precipitation is almost 3,000 mm. Precipitation in the Rwenzori Mountains is bimodal; wetter periods occur from March to May and August to November. Apart from the seasonal control on precipitation exerted by movement of the ITCZ, there is a strong orographic effect on local precipitation. Mean annual precipitation from 1964 to 1995 recorded at Kilembe at an elevation of 1370 m above mean sea level (mamsl) is 1540 mm/year whereas this flux drops to 890 mm/year just 11 km away but 410 m lower in elevation at Kasese Airport (960 mamsl) (Taylor et al. 2009; Anton et al. 2009). These mountains have heavier snowfall than Mounts Kenya or Kilimanjaro, are permanently ice and snow-covered and carry small retreating glaciers. The high altitudinal range (700 – 5100 m) results in marked climatic variations with a consequent diversity of habitats. The mean annual temperature also varies from year to year between 20ºC and 23ºC with a 15^0C diurnal range.

Using three approaches, WCS conducted a study to identify and determine where corridors should be located in the Albertine Rift to increase resilience to climate change using 18 biophysical predictor variables analyzed in the Maxent software package (Ayebare et al. 2013; Seimon, Picton-Phillipps and Plumptre, 2012). First, modelling of endemic and threatened species distributions for large mammals, birds and plants to identify their distributions both under current climate and in the future under predicted climate change using the A2 GCM scenario based on the methodology of Willis et al. (2009). Second, model the distribution of the main vegetation types that form the specific habitat types of GVL and predict how these will change under future climate changes based on the methodology of Ponce-Reyes et al. (2011). Third, used an approach that identifies abiotic gradients in the GVL, particularly those that are relatively steep based on the methodology of Game et al. (2011). These three approaches are described in detail in WCS report (Ayebare et al. 2013). Briefly, the first approach involved modelling the current and predicted (in 2080) distributions of 93 endemic and threatened large mammals, birds and plants; 2) modelled five key vegetation types both currently and in 2080; and 3) identified gradients in abiotic conditions which are likely to support a diverse set of habitat types today and under future climate change. The approach builds upon work by Game et al. (2011) and it was the first time that such a three pronged approach was used to identify corridors.

In their study, Ayebare et al. (2013) used future model projections for 2080 calculated from three general circulation models (CCCMA: CGCM2, CSIRO: MK2 and HADCM3) and one (A2a) Intergovernmental Panel on Climate Change Special Report Emissions Scenario (IPCC 2007). The A2a scenario/storyline assumes a very heterogeneous world with high population growth, slow economic development that is regionally oriented and slow technological change that is slower and fragmented than other story lines (IPCC 2007). The Special Report Emissions Scenarios (SRES) are grouped into four scenario families (A1, A2, B1 and B2) that explore alternative development pathways, covering a wide range of demographic, economic and technological driving forces and resulting GHG emissions. Unlike the Shared Socioeconomic Pathways that were used in the IPCC Assessment Report Five (IPCC, 2013), the SRES scenarios do not include additional climate policies above current ones. Potential corridor areas were identified as those areas of overlap between current and future distributions of species and vegetation types and for the geophysical features the areas of steepest gradients were identified that minimized the area of the Rift selected. With funding from MacArthur Foundation, WCS also conducted the first ever climate change study assessing the impact of climate change on biodiversity in the Albertine Rift (Seimon et al. 2009) and established five automated weather stations in 2011 in Uganda's portion of the Albertine Rift, and three of these are located in GVL. This data will be used to validate the model results. We have locally generated data on top of the over 60 years of hydroclimatological data we collected for the entire AR during the inception of the climate change work in 2009, and working in partnership with partnership with the Appalachian State University, Boone, North Carolina and the National Center for Atmospheric Research Center (NCAR) has used the NCAR's Community Earth System Model (CESM) to model the impact of climate change on the African Great Lakes Region ecosystems (Seimon, Lawrence, and Nampindo, 2015) and currently modeling the distribution of tsetse flies with respect to climate change using high resolution products from CESM. WCS has access to these high resolution climate change model products for use to assess the impact of climate change on wildlife. We will use this experience to implement the type of analysis that will answer objectives 1-4.

Impacts of climate change on wildlife

There is enormous peer-reviewed literature on climate change impacts on wildlife globally (IPCC 2007) and GVL in particular (Araujo et al. 2004; Seimon et al. 2009; Garcia et al; 2012; Ayabare et al. 2013) We will also compile and summarise the results of publications that have looked at global warming impacts for this region to generate an assessment of species most likely to be impacted by climate change. Climatic variations, particularly in precipitation, affect the production of plant material and hence, indirectly, the carrying capacity of the ecosystem. Recent research also points to climate change and the increasing frequency of droughts as a major threat to elephant populations in the Sudano-Sahelian region (Bouché, 2012). The modelling results of the climate change impact on age-specific elephant population dynamics in GVL, a study that was conducted by Simon Nampindo as part of his PhD (Nampindo, 2014; chap4: pp 161-267) noted potential climate change impacts that will affect wildlife distributions, specifically the elephants. Budongo Conservation Field Station has been monitoring the changes in tree phenology in Budongo Forest Reserve and have noted a decline in fruiting of trees. This type of information will be used to inform the study.

Approach for achieving objective one

This objective will be achieved through estimating the current and future suitable distribution areas of endemic and threatened species (large mammals, birds, plants) in the landscape following the same methodology used by Ayebare et al. (2013). The current suitable habitat will be estimated by using climatic, hydrological, topology and drivers of human activities as predictor variables. The future suitable distribution areas will be estimated using the new Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) data based on Representative Concentration Pathways (RCP) for greenhouse gas scenarios RCP8.5 for time period 2070. We will use the results of the current and future distributional areas estimated the for endemic and threatened species in the Albertine rift (Ayebare, et.al 2013) and model about half of the endemic and threatened species that we selected for the previous study (listed provided at the end of this report) and perform the same analysis based on the most recently released Global Circulation Models by Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5), already discussed in the previous section. Due to differences in geographical modelling scale between Albertine Rift and GVL, we will refine the vegetation cover first to avoid errors associated with modeling software, Maxent which models suitable habitat and not where the species actually occurs. For example, forest species occurring in savannas or in land outside the landscape, such places are likely to be selected as suitable, yet no record of species occurrence is known. We will then compare the results with our previous species distribution model results. These results will be comparable because i) same species will be selected for modeling using the IPCC AR5 CIMP5 data, ii) same suite of covariate variables in Table 1, and iii) the temperature change for SRES A2a estimated at 2.0-5.4 ^{o}C (IPCC 2007) is comparable with that of RCP8.5 estimated at 4.0-5.0 ^{o}C (IPCC AR5, 2013). In addition, WCS modelled nine landscape species for the GVL using human impacts and habitat, these will also be utilized to parameterize them with the current models. The results of this study will be collaborated with findings of another study by Justin, Mugabe, and Plumptre who are assessing the importance of biotic interactions in determining range limits within the avifauna communities of the Albertine Rift, focusing mainly on two Ugandan national parks: Mgahinga Gorilla National Park, first surveyed in 2004, and Rwenzori Mountains National Park, first surveyed in 2002 and most recently, both national parks resurveyed in 2016 by the Wildlife Conservation Society. By doing so, we will validate the previous results and identify the potential impacts of climate change on wildlife, particularly the likely contraction or shrinking of the current suitable areas for selected species in the future and any signs of upward shift along the altitudinal gradient.

Table 1. Covariates used for modelling the distribution of endemic and threatened species in the GVL

Covariate	Description of Variable
Bio2	Mean daily temperature range
Bio7	Temperature annual range
Bio6	Minimum temperature of coldest month
Bio5	Maximum temperature of warmest month
Bio12	Annual precipitation
Bio17	Precipitation of driest quarter
Bio16	Precipitation of wettest quarter
Cloud mean	Annual normal percent cloud cover
Cloud max	Maximum cloud cover for each pixel
DEM	Digital elevation model
Aspect	Direction a slope is facing
Slope	Rate of maximum change in elevation
Eastness	Orientation East - West
Northness	Orientation North- South
Drainage basins	Topographically delineated area drained by a stream system
Roads	Distance to nearest road
Lithology	Geologic parent material
Rivers	Distance to nearest river

Limitations and challenges

Attribution of the actual changes in wildlife behaviour due to climate change will be very difficult. However, WCS will rely heavily on long term study results as well as repeat studies that have been conducted in the landscape to try and link the change in wildlife behaviour to climate change. For example, WCS has bird survey data from the Rwenzori massif from 2002 and 2016 which can be compared for changes in bird distributions as a result of climate changes in the park. WCS has also compiled rainfall data for Queen Elizabeth, Kasese, Kisoro, Tea estates near Fort portal and Goma up to 2010 and these data will be updated to as recent as possible. The information so far indicates a general warming of 1-2 ^{o}C with slight increase in rainfall. The prediction is that this could start to push the savanna areas of the GVL towards denser woodland and even forest as rainfall increases in the landscape. We will collect more rainfall data from available sources such as tea estates, Uganda National Meteorology Authority, WCS weather station, ITFC TEAM weather data at Bwindi. We will also analyse the QENP elephant movement data to assess the most preferred habitats and their seasonal movements, but this will be difficult to link it to climate change. We will also be mapping the fire frequency over the past 15 years and try to correlate the results with climate variability as well as relate it to species use of the habitats.

Objective 2: To assess the potential and actual impacts of oil, natural gas, and geothermal exploration/exploitation on long-term wildlife behaviour

Uganda has the most advanced exploration in oil and gas of the three countries, with a number of oil exploration blocks designated in the Landscape from EA3b comprising the Semliki Basin, to EA4b in the Ishasha sector of QENP (Figure 1), although the majority of exploration has taken place further north in the Murchison-Semliki Landscape. Geothermal exploration has also taken place within exploration blocks in Semliki and Queen Elizabeth (Figure 1). A study commissioned by GVTC and conducted by WCS (Plumptre et al. 2016) documented the existing and potential oil/geothermal projects, mapped their likely adverse negative effects on the biodiversity conservation and community livelihoods in the Greater Virunga Landscape.

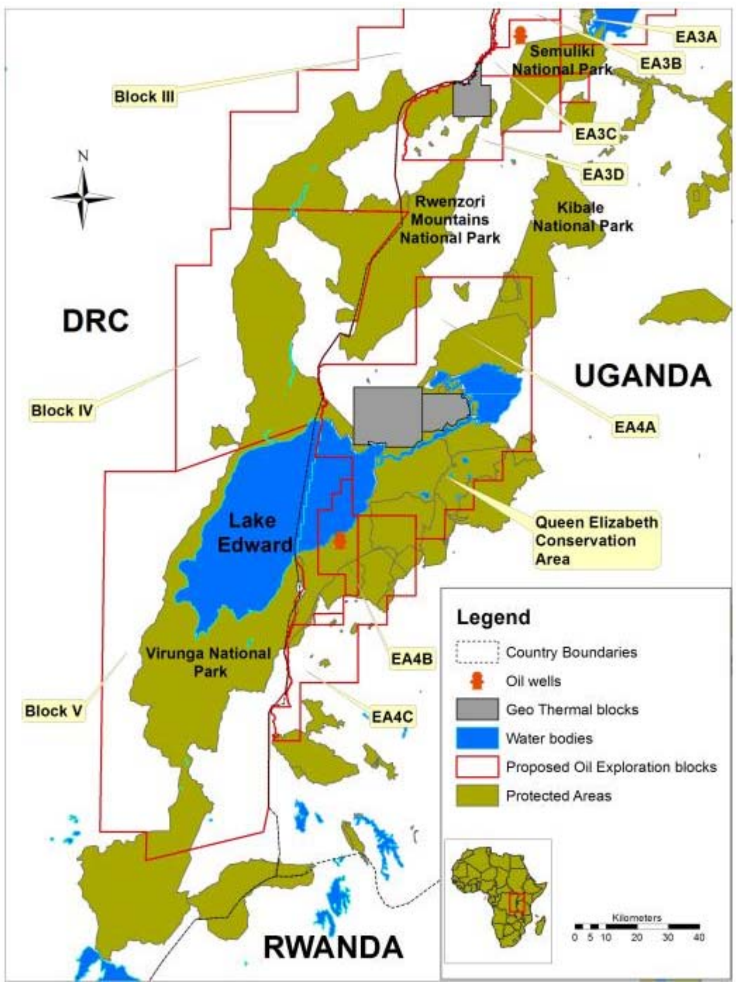

Figure 1 Map showing Oil exploration license areas in Uganda and DRC and major geothermal locations in Uganda (WCS 2015)

This study showed that most of the Greater Virunga Landscape is critical for the conservation of its threatened and endemic species of the Albertine Rift. It also showed that the areas likely to be sensitive to oil and gas exploration as well as geothermal exploration are areas close to rivers, lakes and on steep slopes and areas with high biodiversity, and concentrated in the areas where oil drilling may take place – on Lake Edward. It was also noted that the habitat around Lake Edward, though less biodiverse, particularly for threatened and endemic species, it is more sensitive to impacts because of the lacustrine nature of the area. For example, oil spills, if it occurred here, would travel further because of the flowing water and have more impacts than if there was a spill on land far from a river. Therefore, the lake areas are more sensitive to impacts and potential risks from oil and gas exploration.

The lake shores are also important areas for migratory birds which feed in the wetlands and on the beaches. These are areas where the threatened large mammals (e.g. elephant, hippopotamus, lion, and chimpanzee) and to a lesser extent the threatened savannah and wetland bird species (e.g. vulture species, crowned crane and the shoebill stork) are relatively abundant. In terms of geothermal exploration and production, potential sites so far identified are the crater areas of Queen Elizabeth National Park (QENP) or near the active volcanoes in Virunga Park and around the Volcanoes National park. The crater areas in QENP are important for threatened large mammals and birds while the active volcano areas and Volcanoes Park are important for many of the endemic species and rank highly for all endemic and threatened species (Plumptre et al. 2016). This study revealed that nowhere in the GVL that is not important for an endemic or threatened species. Given this type of information, WCS will prioritize these areas for conducting detailed assessment of the impact of extractive industries on wildlife and attempt to account for the changes in behaviour based on existing information.

Approach to achieve objective two

WCS understands that there are no studies that were conducted in the past to determine how animal behaviour has changed in GVTC as a result of oil exploration since there were no behavioural studies made when the oil exploration was happening except for the lion monitoring conducted by WCS in Ishasha sector of Queen Elizabeth Protected Area (QEPA) and lion tracking was nowhere near the oil exploration sites. This is also partly because the exploration has been minimal on the Uganda side of the GVL and limited baseline data on the DR Congo side since most of the exploration was on Lake Edward. In our opinion, it makes sense to focus on assessing potential behaviour should significant oil and gas/geothermal production happen in the landscape. As such, WCS will draw lessons from lion and elephant monitoring in Murchison Falls National Park (MFNP) where oil and gas exploration happened at the time we were monitoring these two species. WCS is also aware that no oil and geothermal exploration and exploitation are taking place now in GVL. WCS will conduct a desktop analysis of its own studies and also review two Master's theses written by Sam Ayebare, and Paul Mulondo who studied animal response to oil and gas exploration, particularly drilling and seismic exploration in MFNP. This will be supplemented by reviewing studies done elsewhere to get a general understanding of how oil and gas exploration impacts wildlife behaviour. In selecting the reports, published articles and print media articles, targeted searches on the internet will be focused on areas with similar climatic and biodiversity characteristics e.g. Tanzania, Gabon in Africa, partly South Africa and South American countries. For purposes of capturing the best practices and experiences, Europe (particularly Norway) and North America (USA) will be targeted for this type of review. We will also use radiotracking data of elephants from 2006/7 and lion radio tracking data, map Kob leks and salt licks in QENP, and use SMART data from Virunga and QENP to assess concentrations of species in the landscape to identify areas that are potentially sensitive for these species currently. The assumption is that any oil/gas and geothermal exploration in future will focus on these two parks. We will explore data collected by Nature Uganda for bird counts along Kazinga channel and combine it with

WCS's internally collected bird data from Lake Edward to map critical bird congregation areas that might be affected by extractive industries.

Objective 3: To assess the potential impacts of water industries on long-term wildlife behaviour

There is a large requirement for water in oil and gas production processes. Most of this water needs are for drilling and construction and demand increases during production, particularly when the oil refinery construction is completed and functional. Refineries are normally constructed near coastlines due to the efficiencies of transport and also the plentiful supply of water. The other water needs include domestic water use in camps and for cleaning and medical, vehicle washing, washing out salt water from oil during refining process. It is estimated that at its peak nearly 5000 bbl per day equivalent to 1 bbl = 42 gallon will be needed. The most obvious and reliable water sources will be from lakes, although groundwater aquifers can be used if available with a sufficient reliable quantity of water. The impacts of water abstraction from both sources were documented (Plumptre et al. 2016). This is a great opportunity for us to assess in details and understand better the consequences of abstraction of subterranean water resource, use of aquifers to wildlife and communities as well as water availability in reservoirs such as lakes and dams.

Approach to achieve objective three

For this particular objective, in case of plants, we will assess the impact of Mpanga falls dam before and after its construction by assessing the changes in Mpanga Falls with specific reference to the endemic Cycad, *Encepholartos whitelockii* population density using old photographs taken in the region. During the mapping of QENP in 2006, we were able to detect clearly the cycads on the imagery we took in 2006 and those taken in 1954. We will use Google earth or freely available high resolution satellite imagery to implement this analysis. WCS also mapped habitat change in the GVL savannas from 1954, 1990 and 2006 using aerial photography and has documented an increase in woody habitat as a result of the poaching of large herbivores in the 1970s and 1980s. We will update these maps. Virunga Park has some fixed images which show vegetation changes over time and some of these were published in the Virunga book so will refer to this during the analysis. We will explore the opportunity to assess the impacts of pollutant and waste disposal from Kasese Cobalt pollution dn Kilembe Mines on QENP vegetation, in terms of extent of damage to the habitat using old and recent imagery. UWA assess the potential impacts of limestone mining in Dura sector, QENP by Hima cement factory. UWA's report produced under this work will be reviewed to identify the impacts and use this knowledge to inform further analysis.

In case of birds, we also conduct surveys of birds and plants from plots we established in 2009 and will repeat the measurements at the same plots (as we recorded the GPS location of the plots) to assess changes that have occurred in the past eight years. Many of the plant plots were established at sites estimated to be close to plots that were measured in 1990 and drawn on maps, but with no Georeferenced locations. We will explore the possibility of estimating changes over the past 27 years at these particular sites and relate these changes to the vegetation maps we produced. During field data collection, we will take georeferenced photographs at each plot in a N, E, S, and W direction to be able to visually compare changes over time in future. Professor Derek Pomeroy, National Biodiversity Databank, Makerere University has monitoring data for birds from transects in QENP. We will request Derek to share this data so we can use it to assess changes and in bird community over time and overlay it on the habitat change map and correlatively make some inferences to wildlife behavioural change.

In terms of mammal assessments, WCS mapped historical data on elephant and buffalo distributions in the park from the 1970s and will compare these with distributions from aerial total counts in 2006 and 2014 to assess how their use of the Queen Elizabeth National Park (QENP) has changed as a result of habitat changes. The same will be done for documented lion ranges in QENP's Ishasha sector comparing the 1970s and current lion ranges. WCS is aware that there are other sites with behavioural data such as gorillas GPS data in Bwindi (Max Planck Institute) and Mgahinga, chimp ranging in Kibale, ITFC/TEAM data on plants and large mammal camera trapping data, golden monkey ranging data in Mgahinga collected by Dennis Twinomugisha, data for species likely not to be affected by climate change greatly or by developments. WCS plans to assess the usefulness of this data to this project. In his study, Simon Nampindo modelled the effect of climate change on elephant population dynamics in GVL, Simon also accounted for the available water resources in the landscape, particularly the surface runoff, glacier melt from the Rwenzori Mountain contribution to river flows and water in reservoirs mainly lakes and river. The results of this study will be considered in attempting to achieve this objective. In future, the modelling could be repeated using recent data on glacier melt and water inventory in reservoirs, elephant movement data from Virunga National Park and incorporate the results of the hydrological modelling for Virunga, Echuya, and Mgahinga which was conducted by ITFC with funding from GVTC.

Objective 4: To analyse other factors that could lead to long term changes in wildlife behaviour

Achievement of this objective will be done through a number of approaches. First, after all analyses planned for under objectives 1-3, and 5 is completed, the results will be carefully interpreted and discussed with respect to the overall goal of this study. Second, during the project life, an extensive review of reports, peer-reviewed publications in the region and elsewhere, where a similar study or subject has been conducted will be done. Third, with permission from GVTC, the draft report will be circulated to scientists and other experts in this field to provide comments and generate candidate explanations for the observed trends. In doing so, WCS will rely on its professional networks, including the academia, researchers to generate a list of other factors that could contribute to long term changes in wildlife behaviour with specific reference to oil and gas, geothermal activities and climate change; and Forth, WCS will ask the validation workshop participants to provide a list of factors that they consider or are aware of, that could lead to the wildlife behavioural change. This analysis will be included in the report as part of the results discussion.

Objective 5: To map the land use land cover changes in GVL for the period between 2000 to data at an appropriate temporal mapping scale

The savannas of Queen Elizabeth National Park (QENP) in western Uganda have been studied since the 1950s. The Nuffield Unit of Tropical Animal Ecology was established at Mweya Peninsula in QENP in 1961 and this later became the Uganda Institute of Ecology which continued operating until the early 1990s. Individual researchers, however, have continued undertaking research here to the present day and the published literature from this site is extensive (Olupot et al., 2010). The long term vegetation change mapping for Virunga National Park and Queen Elizabeth National Park (Figure 2) by Wildlife Conservation Society

(Plumptre et al. 2010a), showed that between the 1950s and 2006, there have been changes in woody cover in GVL (Table 2). In general, there has been more increase in woody cover of 1,579 km^2 compared to a decrease of 334 km^2. They attributed the net gain in woody vegetation cover (1245 km^2) to a decrease in large mammals in the landscape from the 1970s as demonstrated by the observed elephant population trend, where elephant numbers reduced from 3000 between 1950 - 1960s to less than 400 in 1980s. Other candidate causes of vegetation change are continued recovery of the vegetation from the human resettlement away since the late 1880s (Spinage 1970), increasing rainfall, climatic variability, and changes in fire frequency.

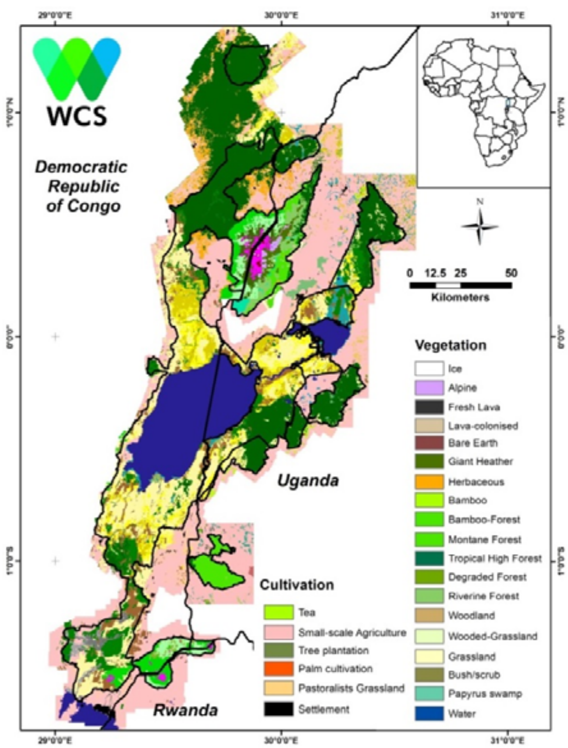

Figure 2 Land cover/use of the Greater Virunga Landscape (source: WCS 2006)

The GVL land cover proportions disaggregated by four broad categories in 2006 were forest (7721.95 sq.km), savanna (8859.56 sq.km), wetland (3539.22 km^2), human settlement/agriculture (5569.98 sq.km), and the total woody cover percentage of 65% (WCS 2006). The overall impression is that the vegetation of the landscape has become more wooded/forested. Another clear difference is agriculture expansion. Whereas in the 1950s there was very little agriculture around the parks, now farms are up to the park boundary. In Virunga National park alone, 98.2 km^2 were encroached upon by humans and the number of settlements within two (2) km of QENP estimated 179,200 people living within this distance of the park (Plumptre et al. 2007).

Table 2 Woody vegetation cover change in QENP and Virunga NP in GVL (1950s – 2006)

National Park	Area (km^2)	increase in woody cover (km^2) in some areas	Change (%)	decrease in woody cover (km^2) in some areas	Change (%)	Net change in woody cover (km2) from
QENP	2080	1021	28%	260	7%	761
Virunga	8090	558	40.5%	74	5%	484
Total	10,170	1579		334	1245	1245

Source: Plumptre et al. 2006, 2010a

Vegetation plots measured in 1991 (Lenzi-Grillini,Viscanic and Mapesa 1996) were revisited and re-measured by WCS in 2009. The results of the assessment of habitat types showed that burn frequency as measured from the satellite images (above) at a site is strongly related to the percentage cover of herbs and grasses and negatively related to the cover of trees and shrubs (Plumptre et al. 2010a). It is also known that as hippopotamus abundance increases the cover of grasses and herbs decreases and shrubs increase in cover, and inversely, with increases in elephant abundance the vegetation tends to decrease in tree and shrub cover and increase in grass cover (Lock, 1972; 1993; Eltringham, 1980; Olupot et al. 2010). Therefore, the changes in abundance of these animal species overtime in this landscape has probably affected where fires burn. Unfortunately, we don't have enough images from the early decades when animal numbers were high to assess where this effect may have occurred. Updating the maps from 2006 to the present with the known animal numbers across Queen Elizabeth and Virunga parks from censuses in 2006, 2010 and 2014 will enable us to get at the effects of fire on the distribution of these animals.

Habitat changes in Bwindi National Park

Before Bwindi was gazetted as a National Park in 1991, widespread human activities, such as logging and encroachment for agriculture, resulted in habitat modification over a large scale. The range of habitats in Bwindi is unique due to its altitudinal range and in many ways is more similar to what is found in Nyungwe Forest in Rwanda than the nearby Virunga Volcanoes. Nkurunungi et al. (2004) described the major vegetation types and habitats at two sites of different elevation: Buhoma (lower altitude) and Ruhija (high altitude). The major vegetation types are open forest, mixed forest, mature forest, swamp forest, riverine forest, and regenerating forest. Plant community composition is related to altitude (Ganas et al., 2008) and there are significant differences in plants available for large mammals such as mountain gorillas depending on location, but little temporal variation (Ganas et al., 2008). Olupot et al. (2009) assessed the major anthropogenic threats to the park-people interface around Bwindi, and reported that wood and pole harvesting was the major threat to the integrity of the edge. Other threats included occurrence of exotic species, degradation of adjacent habitat fragments and the high impact of problem animals on some of the neighboring communities. They concluded that, since the threats were mostly associated with the edges of the Park when previously they were widespread throughout the Park, illegal resource harvesting had been reduced since the forest was upgraded to a national park (Olupot et al.2009). We hope to examine the vegetation map for Bwindi that Dennis Babaasa of ITFC developed at a coarse scale.

In order to conserve the fauna and flora that occur in this landscape, it is important that land cover/use changes are closely monitored since they are often an indicator of the human pressure being exerted on a landscape and a good indicator of management effort as well as ecosystem health. Given the transboundary nature of the landscape, there is varied mapping effort over the landscape. Mapping carried out so far has either been done at a course scale or in a piecemeal format focusing on Bwindi NP (Nkurunungi et al., 2004; Ganas et al., 2008), QENP (Lock, 1992, 1993; Plumptre et al. 2010a) and Virunga NP (Plumptre et al. 2010a). For GVTC to carry out informed management decisions, there is need for a map produced at the same scale and covering the entire landscape. From such a map, information about how the different land cover types have changed over time would be invaluable. This will then be linked to how well the species populations in GVL are performing as a measure of effective GVTC stakeholder's management interventions and support to the protected area authorities.

Approach to achieve objective four

In order to achieve this objective, the following activities will be conducted.

1. Generate a 2015 full land cover/land use map of the Greater Virunga Landscape
2. Conduct a land cover change analysis for GVL between 2006 to 2014/5and relate it to animal distributions.
3. Identify the invasive plant species (e.g. Parthenium hysterophorus, Lantana camara) in QENP and Bwindi from field surveys and mapping

First, to generate the current land cover map, several steps will be carried out. Initially, it had been indicated that the entire area would be mapped starting with acquiring satellite images covering the area Effort has been made to search for high resolution and quality satellite images, but some of the areas such as Rwenzori National Park were consistently covered by clouds. We also note that the 2006 GVL vegetation cover map was prepared using mainly high resolution images (i.e. aerial photographs taken by WCS, and Aster images). To overcome these challenges, a variety of datasets will be used to produce an updated land cover/land use map.

The following steps will be followed:

1. The existing (2006) GVL map will be examined against other course scale land cover maps e.g. NFA land cover map for Uganda (2015) to identify areas that have significantly changed. Coordinates of such areas will be recorded and converted into a point map that will be used as a guide in the subsequent steps
2. The point map and the 2006 map will then be overlaid on the online image datasets (google earth and world Imagery) to allow for identification of actual vegetation cover types' boundaries
3. Onscreen digitization of the areas that have changed will then be carried out.
4. The digitized polygons will be used to update the 2006 map so as to generate an updated map
5. Data for ground truthing the map will be collected during the revisit vegetation plots that were established and measured in 1991 (Lenzi-Grillini,Viscanic and Mapesa 1996) and later revisited in 2009 and re-measured by WCS botanists using the same methods, the survey of Bwindi for invasive species and visit to areas of high vegetation mapping uncertainty identified during the development of the updated land cover/land use. Also old data WCS collected from across GVL between 2000 and 2010 will be used to validate the generated

6. Part of the field data obtained during the ground truthing exercise will be used to carry out an accuracy assessment of the classified map.

Vegetation change analysis

After the above analysis, vegetation change analysis will be implemented in the GIS laboratory as follows; The generated (current) map will be crossed with the historical map (Figure 2) to generate a vegetation change map. Matrix tables indicating percentage and area change of each land cover class will then be generated.

Invasive species mapping

WCS is already working closely with UWA management in QENP who identified Lantana camara, Parthenium hysterophorus and Dichrostachys cinerea as the top three invasive species dominating the park. We will study the spectral signature of the areas where we already have GPS coordinate locations of these species and use it to digitize the invasive species in QENP and to a limited extent Bwindi National Park. Other data for image training will be acquired from ITFC TEAM data collected in Bwindi Impenetrable NP over the past seven years. We will also make us of data that Margaret Driciru, QENP monitoring and research warden, has been collecting with respect to these invasive species as well as the mapping that was done by WCS in 2010 under the lion monitoring project. The resultant map will be a differentiation between areas where invasive species occur and where they do not. The final report will include results of the mapped vegetation changes resulting from large mammal increases since early 1990s to 2014/, vegetation plot changes since 2009 with updated fire maps and changes in bird distributions also across QENP park, changes in distributions of large mammals as a result of these changes in habitat; and projected impacts of climate change on key species in GVL.

Objective Six: Propose appropriate recommendations for managing and mitigation of adverse changes in wildlife behaviour to be included in the transboundary General Management Plan

Based on the results of the data collection and analysis, we will make recommendations for a) mitigating likely effects of climate change on wildlife; b) identifying areas of avoidance for any oil/gas and geothermal developments and c) mitigating impacts of changes in habitat that are taking place, particularly with invasive species.

Expected deliverables

The expected deliverables as per the terms of reference are:

1. Inception report
2. Brief progress reports
3. Final report submitted both in English and French

Timeline

	Activities	Time in months (Year 2017)					
		April	May	June	July	August	September
1	Analysis of impacts of climate change and other factor that could lead to long-term wildlife behaviour change						
2	Modelling of potential and actual impacts of oil, natural gas, and geothermal exploration/exploitation on long-term wildlife behaviour						
3	Modelling of potential impacts of water industries on long-term wildlife behaviour						
4	Develop a land use land cover change for GVL for the period between 2000 to date at an appropriate temporal mapping scale.						
	a) Image acquisition						
	b) Classification of images, segmentation and base map production						
	c) Invasive species mapping						
	d) Revisiting of vegetation plots in QENP						
	e) Birds survey in QENP						
5	Reporting writing, including recommendations on how to manage and mitigate negative changes in wildlife behaviour to be included in the Transboundary General Management Plan						
7	Participate in dissemination of results meeting/workshop						
8	Inception report						
9	Progress report						
10	Final Report						

In-depth studies to examine the long-term changes in wildlife behaviour in protected areas as a result of oil and water industries development, climate change and habitat change in the Greater Virunga Landscape (GVL)

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In-depth studies to examine the long-term changes in wildlife behaviour in protected areas as a result of oil and water industries development, climate change and habitat change in the Greater Virunga Landscape (GVL)

Selected species for modelling

Taxa	Species	Status
Birds	Archers ground Robin	Endemic
Birds	Blue headed sunbird	Endemic
Birds	Collared Apalis	Endemic
Birds	Grauers Warbler	Endemic
Birds	Grauers Rush Warbler	Endemic
Birds	Montane masked apalis	Endemic
Birds	short tailed warbler	Endemic
Birds	Purple-breasted_Sunbird	Endemic
Birds	Red-faced_Woodland_Warbler	Endemic
Birds	Red-throated_Alethe	Endemic
Birds	Regal_Sunbird	Endemic
Birds	Ruwenzori_Double-collared_Sunbird	Endemic
Birds	Ruwenzori_Turaco	Endemic
Birds	Rwenzori batis	Endemic
Birds	Strange_Weaver	Endemic
Birds	Handsome Francolin	Endemic
Birds	Dusky Crimson wing	Endemic
Birds	Kivu Ground Thrush	Endemic
Birds	Yellow eyed Black Flycatcher	Endemic
Birds	Stripe-breasted_Tit	Endemic
Birds	African Green Broadbill	Endemic
Birds	Chapin's Flycatcher	Endemic
Birds	Dwarf_honey_guide	Endemic
Birds	Rockefellers Sunbird	Endemic
Birds	Ruwenzori Nightjar	Endemic
Birds	Shelleys Crimson-wing	Endemic
Birds	Yellow-crested Helmet Shrike	Endemic
Birds	Prigogines greenbul	Endemic
Birds	Forest ground thrush	Endemic
Birds	Golden naped weaver	Endemic
Birds	Yellow legged weaver	Endemic
Birds	Graures cuckoo shrike	Endemic
Birds	Chapin's Mountain-babbler	Endemic
Amphibians	Afrixalus_orophilus	Endemic
Amphibians	Amietia_desaegeri	Endemic
Amphibians	Artholeptis_adolfifriederici	Endemic
Amphibians	Arthroleptis_pyrrhoscelis	Endemic
Amphibians	Callixalus_pictus	Endemic
Amphibians	Cardioglossa_cyaneospila	Endemic
Amphibians	Hyperolius_castaneus	Endemic
Amphibians	Hyperolius_chrysogaster	Endemic

Amphibians	Hyperolius_discodactylus	Endemic
Amphibians	Hyperolius_frontalis	Endemic
Amphibians	Leptopelis_karissimbensis	Endemic
Amphibians	Leptopelis_kivuenis	Endemic
Amphibians	Phrynobatrachus_bequaerti	Endemic
Amphibians	Phrynobatrachus_versicolor	Endemic
Amphibians	Ptychadena_christyi	Endemic
Amphibians	Xenopus_vestitus	Endemic
Amphibians	Xenopus_wittei	Endemic
Reptiles	ADOLFUS_vauereselli	Endemic
Reptiles	Atheris_nitschei	Endemic
Reptiles	Kinyongia_adolfifriderici	Endemic
Reptiles	Kinyongia_carpenteri	Endemic
Reptiles	Kinyongia_xenorhina	Endemic
Reptiles	Leptosiaphos_blochmanni	Endemic
Reptiles	Leptosiaphos_graueri	Endemic
Reptiles	Leptosiaphos_hackarsi	Endemic
Reptiles	Trioceros_johnstoni	Endemic
Reptiles	Trioceros_rudis	Endemic
Reptiles	Trioceros_schoutedeni	Endemic
Small mammals	Crocidura_lanosa	Endemic
Small mammals	Crocidura_maurisca	Endemic
Small mammals	Crocidura_niobe	Endemic
Small mammals	Crocidura_stenocephala	Endemic
Small mammals	Dasymys_montanus	Endemic
Small mammals	Delanymys_brooksi	Endemic
Small mammals	Funisciurus_carruthersi	Endemic
Small mammals	Heliosciurus_ruwenzorii	Endemic
Small mammals	Hylomyscus_denniae	Endemic
Small mammals	Hylomyscus_vulcanorum	Endemic
Small mammals	Lophuromys_medicaudatus	Endemic
Small mammals	Lophuromys_rahmi	Endemic
Small mammals	Lophuromys_woosnami	Endemic
Small mammals	Mus_bufo	Endemic
Small mammals	Myosorex_babaulti	Endemic
Small mammals	Myosorex_blarina	Endemic
Small mammals	Otomys_denti	Endemic
Small mammals	Paracrocidura_maxima	Endemic
Small mammals	Praomys_degraaffi	Endemic
Small mammals	Rhinolophus_ruwenzorii	Endemic
Small mammals	Ruwenzorisorex_suncoides	Endemic
Small mammals	Scutisorex_somereni	Endemic
Small mammals	Sylvisorex_granti	Endemic
Small mammals	Sylvisorex_lunaris	Endemic

Small mammals	Sylvisorex_vulcanorum	Endemic
Small mammals	Thamnomys_venustus	Endemic
Plants	Allanblackia_kimbiliensis	Endemic
Plants	Balsamocitrus dawei	Endemic
Plants	Chassalia_subochreata	Endemic
Plants	Cincinnobotrys_speciosa	Endemic
Plants	Coccinia_mildbraedii	Endemic
Plants	Crassocephalum_ducis-aprutii_	Endemic
Plants	Diplazium_humbertii	Endemic
Plants	Embelia_libeniana	Endemic
Plants	Erica_johnstoniana	Endemic
Plants	Grewia_mildbraedii_	Endemic
Plants	Harungana_montana	Endemic
Plants	Helichrysum_stuhlmannii	Endemic
Plants	Impatiens_gesneroidea	Endemic
Plants	Impatiens_keilii	Endemic
Plants	Impatiens_mildbraedii	Endemic
Plants	Impatiens_purpureo_violacea	Endemic
Plants	Isoglossa_laxiflora	Endemic
Plants	Isoglossa_vulcanicola	Endemic
Plants	Ixora_burundiensis	Endemic
Plants	Lobelia_mildbraedii	Endemic
Plants	Lobelia_stuhlmannii	Endemic
Plants	Melchiora_schliebenii	Endemic
Plants	Mimulopsis_excellens	Endemic
Plants	Monanthotaxis_orophila	Endemic
Plants	Musanga_leo-errerae	Endemic
Plants	Oxyanthus_troupinii	Endemic
Plants	Pavetta_pierlotii	Endemic
Plants	Peddiea_rapaneoides	Endemic
Plants	Peucedanum_runssoricum	Endemic
Plants	Pilea_bambuseti	Endemic
Plants	Pseudosabicea_arborea	Endemic
Plants	Pycnostachys_goetzenii	Endemic
Plants	Rubus_kirungensis	Endemic
Plants	Rubus_runssorensis	Endemic
Plants	Rytigynia_bridsoniae	Endemic
Plants	Rytigynia_kigeziensis	Endemic
Plants	Senecio_johnstonii	Endemic
Plants	Sericanthe_leonardii	Endemic
Plants	Stapfiella_lucida	Endemic
Plants	Tabernaemontana_odoratissima	Endemic
Plants	Thunbergia_mildbraediana	Endemic
Plants	Uebelinia_kiwuensis	Endemic

Plants	Vernonia_kirungae	Endemic
Large mammals	Golden_monkey	Endemic
Large mammals	Gorilla beringei	Endemic
Large mammals	mathews_buffalo	Endemic
Large mammals	Rwenzori duiker	Endemic

Taxa	**Species**	**IUCN Category**
Mammals	Chimpanzee	Threatened
Mammals	Elephants	Threatened
Mammals	Hippopotamus	Threatened
Mammals	Lion	Threatened
Mammals	Spotted_Hyaena	Threatened
Mammals	Okapi	Threatened
Mammals	Buffalo	Threatened
Mammals	Topi	Threatened
Mammals	Mangebay	Threatened
Mammals	Giant forest hog	Threatened
Mammals	Rwenzori duiker	Threatened
Mammals	leopard	Threatened
Plants	Beilschmiedia_ugandensis	Threatened
Plants	Carex_runssoroensis	Threatened
Plants	Casearia_engleri	Threatened
Plants	Entandrophragma_angolense	Threatened
Plants	Entandrophragma_cylindricum	Threatened
Plants	Entandrophragma_excelsum	Threatened
Plants	Entandrophragma_utile	Threatened
Plants	Guarea_cedrata	Threatened
Plants	Hallea_stipulosa	Threatened
Plants	Helichrysum_formosissimum	Threatened
Plants	Khaya_anthotheca	Threatened
Plants	Lovoa_swynnertonii	Threatened
Plants	Lovoa_trichilioides	Threatened
Plants	Ocotea_kenyensis	Threatened
Plants	Prunus_africana	Threatened
Plants	Psilotrichum_axilliflorum	Threatened
Plants	Turraeanthus_africanus	Threatened