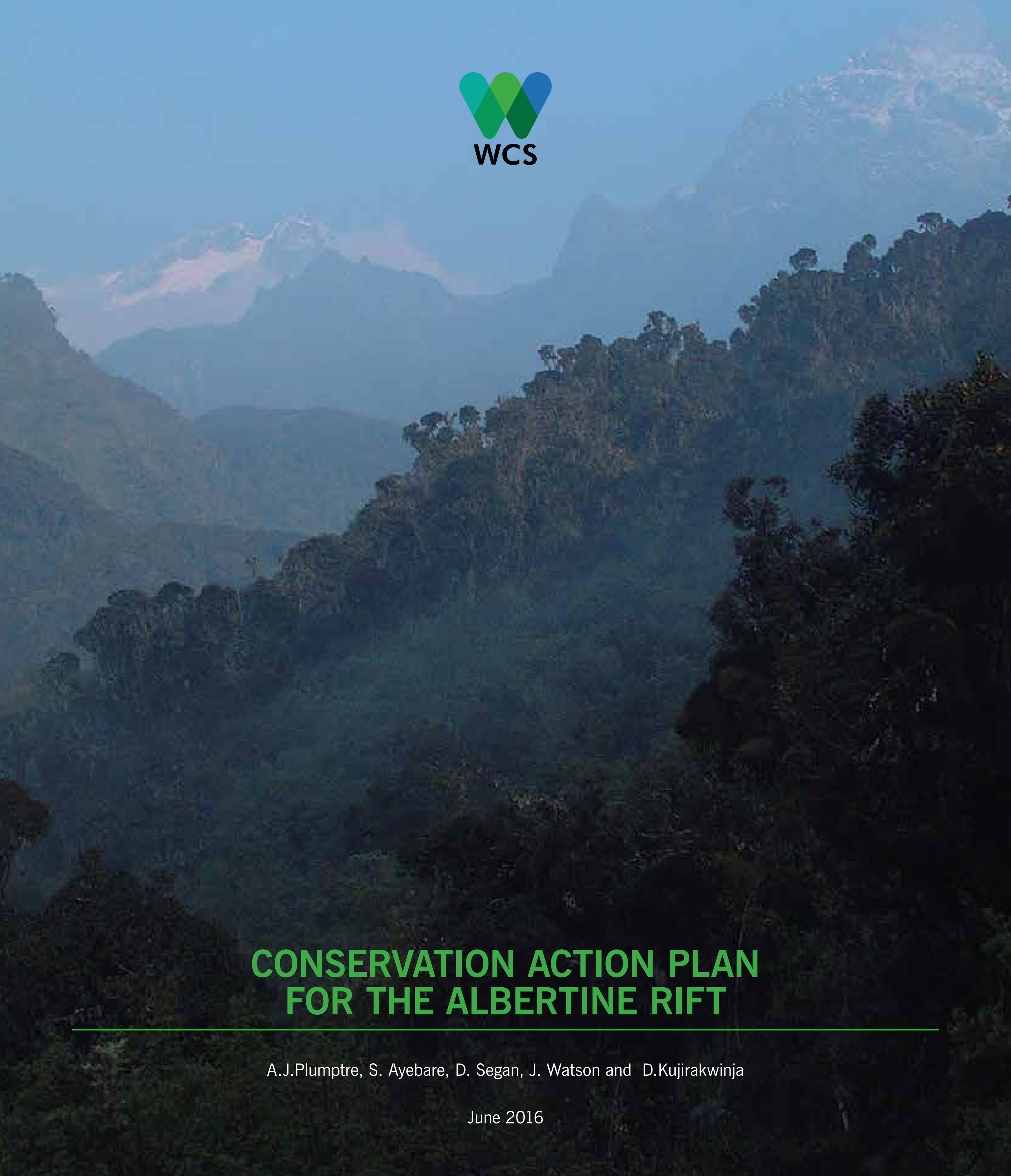

CONSERVATION ACTION PLAN FOR THE ALBERTINE RIFT

A.J.Plumptre, S. Ayebare, D. Segan, J. Watson and D.Kujirakwinja

June 2016




The Wildlife Conservation Society (WCS) saves wildlife and wild places worldwide through science, conservation action, education, and inspiring people to value nature. WCS envisions a world where wildlife thrives in healthy lands and seas, valued by societies that embrace and benefit from the diversity and integrity of life on earth.

In the Albertine Rift region of Africa WCS has supported conservation since 1957 and is the oldest International Conservation NGO working here. Our focus has been on building the capacity of the protected area authorities in the region to better manage their protected areas, and sharing scientific research to better understand the importance of the Albertine Rift and how best to conserve the incredibly rich biodiversity found here. Find more at www.albertinerift.org; www.wcsuganda.org; and www.wcs.org

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Front and back cover photos: A.Plumptre/WCS

FOREWORD

The Albertine Rift region is one of the most biodiverse parts of the World, particularly rich in vertebrates, and forms part of the Eastern Afromontane Hotspot of Biodiversity. It is also a special place for us, as our own history as a species started in Africa's rift valley some 200,000 years ago. I have travelled through this region and had the opportunity to see first hand the stunning scenery and some of the amazing species that are only found here such as the mountain gorilla and golden monkey. I have also seen the rapid changes taking place, and the need to take steps to conserve this region.

The Wildlife Conservation Society (WCS) has been committed to protecting this region for more than 50 years, starting with support to Queen Elizabeth and Murchison Falls National Parks, Uganda in 1957. George Schaller did the first field surveys of Mountain Gorillas in 1959-60, followed by the work by Bill Weber and Amy Vedder. Their research provided the basis for one of the great conservation stories, as the populations of Mountain Gorillas have increased thanks to a partnership between governments, conservation groups and tourism. This provided the foundation for a model that has been replicated across Africa: use science to identify areas important for conservation, establish protected areas and work with governments and local communities to support their management. Examples include the establishment of Nyungwe as Rwanda's third national park, thanks to the work of Michel Masozera and Ian Munanura, and the creation of the Kibale, Rwenzori Mountains, Semuliki and Bwindi Impenetrable National Parks in Uganda, supported by the work of Tom Struhsaker, Tom Butynski and Peter Howard.

Our work in the Albertine Rift region has been led by Andrew Plumptre, who had worked as Assistant Director for our Africa Program, and moved to the region in 2000 to coordinate and expand our work. Over the subsequent 16 years he has undertaken biodiversity surveys to better identify the critical areas for conservation in this region and potential impacts of future climate change and infrastructure development. His work with collaborators in different taxa has increased the number of species known for the region considerably. Using this knowledge he has supported better management of the protected areas and worked with our national staff and local communities to establish new protected areas, notably the recently established Itombwe, Ngandja and Kabobo Reserves in eastern Democratic Republic of Congo (DRC).

The production of this conservation action plan is therefore a result of a long history of investment in the Albertine Rift by WCS. This plan brings together in one place the results of this work and our previous work, together with the results of collaborations with many of our conservation partners, notably the protected area authorities of each country (Uganda Wildlife Authority, Rwanda Development Board, Institute Nationale de l'Environnement et Conservation de la Nature in Burundi, Institute Congolais pour la Conservation de la Nature in DRC and Tanzania National Parks) together with our international partners (Jane Goodall Institute, World Wide Fund for Nature, International Gorilla Conservation Programme, Fauna and Flora International, African Wildlife Foundation) and many national NGOs in each country. These partners were involved in the development of some of each of the landscape plans summarised here and are involved in collaborative projects to implement these plans. The plan identifies priority areas for conservation within these landscapes both now and under future climate change. As the world is changing, so must our conservation strategies and actions on the ground.

WCS is committed to supporting the implementation of this action plan and will be working through each of our Country Programs and with partners in the region to ensure that the amazing diversity of life to be found here is conserved for future generations.

Cristián Samper, CEO Wildlife Conservation Society
New York, December 2016

EXECUTIVE SUMMARY

The Albertine Rift is known to be one of the most biodiverse regions on the African continent, having been designated an endemic bird area (Stattersfield et al.1998), a Global 200 Priority Ecoregion (Olson and Dinerstein, 1998; Burgess et al., 2004) and part of the Eastern Afromontane Hotspot (Brooks et al.,2004). The richness of vertebrate and plant taxa have been documented in the past (Plumptre et al. 2003; 2007a) and in 2003 we estimated that there were about 5,793 plant species and 1,757 terrestrial vertebrate species known for the region. More thorough surveys, identification of new species and the finding of additional records for plants have increased these numbers to 6,568 plants and 1,833 terrestrial vertebrates and more species are being discovered and described every year, particularly amphibians, reptiles and plants. This plan summarises the state of knowledge for terrestrial vertebrates and plants for the Albertine Rift.

The Wildlife Conservation Society (WCS) has had a dedicated program to conserve the Albertine Rift region since December 2000 but had been active in this region at several sites for many years prior to that date, going back to 1957. Conservation planning for the Albertine Rift started in 2001 with MacArthur Foundation support and a strategic framework plan was developed by 2004 which identified six core landscapes. More detailed planning subsequently occurred at each landscape to generate 10 year landscape plans that are all currently being implemented. The conservation targets, threats analysis, visions, goals and objectives are presented here for each landscape. The landscape planning however, looked at the conservation needs at this scale but did not assess the specific requirements of each of the conservation target species known from the Albertine Rift.

This plan builds upon this previous work and assesses what is needed to ensure all the species of conservation concern can be protected both now and in the future. Species distribution models were developed for endemic and globally threatened (IUCN Red List CR, EN and VU) species known from this region. Scenarios were modelled using the software Marxan to assess where best to conserve these species, and these identify conservation action needs to focus outside the existing protected areas. Critical areas identified were the Itombwe and Kabobo Massifs in south eastern Democratic Republic of Congo (DRC), the Tayna-Kisimba-Ikobo region and proposed Oku Community Reserve in eastern DRC, and the Sitebi highlands east of the Mahale Mountains National Park in western Tanzania. Significant conservation activities have already been under way to establish Itombwe Reserve, Ngandja Reserve and Kabobo Reserve in the Itombwe and Kabobo massifs while more needs to be done to conserve the other sites. Mining is a significant emerging threat in the region with many exploration concessions allocated in all five countries, some inside existing protected areas. This plan also found that while costs of conservation may increase, it is necessary to conserve in these mining concessions and there will be a need to stop concessions from becoming operational within protected areas.

The plan also assessed the role existing protected areas will play in the conservation of species under future projected climate change scenarios. The results show that endemic species are predicted to decline significantly in their distributions, losing about 76% of their ranges by 2080 because of the need to move up-slope as climate warms. However, the results also show that the existing protected area network is well placed to conserve under future climate changes, and the recent establishment of the Itombwe Reserve, Ngandja and Kabobo Reserves has ensured important areas for the future are protected.

The costs of implementing the landscape plans totals $21 million USD per year but when calculated per area ($241/$km^2$/yr) or annual support to a species on average ($2,509/yr) the costs are relatively low and show that investing in conservation in the Albertine Rift offers a greater 'bang for the buck' compared with other less biodiverse regions of the World.

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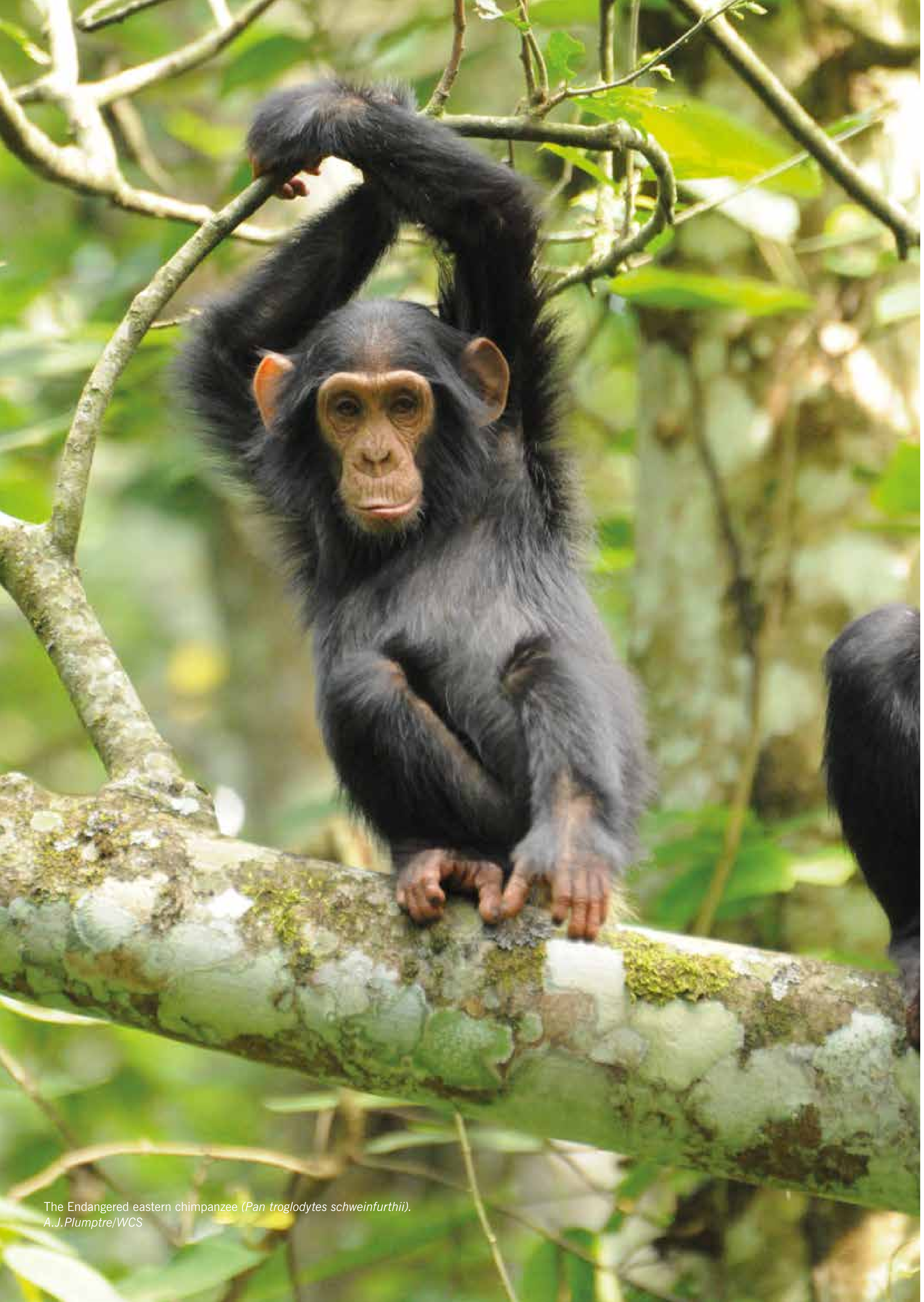


The Endangered eastern chimpanzee *(Pan troglodytes schweinfurthii). A.J.Plumptre/WCS*

THE ALBERTINE RIFT

The Albertine Rift is known to be one of the most biodiverse regions on the African continent, having been designated an endemic bird area (Stattersfield et al.1998), a Global 200 Priority Ecoregion (Olson and Dinerstein, 1998; Burgess et al., 2004) and part of the Eastern Afromontane Hotspot (Brooks et al.,2004). The richness of vertebrate and plant taxa have been documented in the past (Plumptre et al. 2003; 2007a) and in 2003 it was estimated that there were about 5,793 plant species and 1,757 terrestrial vertebrate species known for the region. More thorough surveys by WCS and its partners, identification of new species, and the location of additional records for plants have increased these numbers to 6,658 plants and 1,833 terrestrial vertebrates and more species are being discovered and described every year, particularly amphibians and reptiles.

Running from the northern end of Lake Albert to the southern tip of Lake Tanganyika, the Albertine Rift traverses five key countries: Uganda, Democratic Republic of Congo (DRC), Rwanda, Burundi and Tanzania (figure 1). Northern Zambia, while connected to the southern end of Lake Tanganyika, is not known to contain any terrestrial species known to be endemic to the Albertine Rift or additional species that are confined here and so is not included in this plan. However this region has been poorly explored for its biodiversity. Most of the key sites in the Albertine Rift lie within 100 km of the international boundary of the DRC, on either side, and many protected areas have already been established here because of their biodiversity value (figure 2).

Investing in the conservation of the Albertine Rift region is cost effective because many more species can be conserved for the same amount of funding. More than 50% of Africa's birds and 40% of Africa's mammals are found here. It also contains about 20% of Africa's plants and amphibians with more being described each year, and 14% of Africa's reptiles and 16% of Africa's butterflies. These could also increase with further surveys (Plumptre et al. 2007a). Finally at least 11% of Africa's fish diversity occurs in Lake Tanganyika alone with 89% of the species endemic to this lake (Plumptre et al. 2003). All this diversity is found in 313,000 km^2 or just over 1% of the African continent.

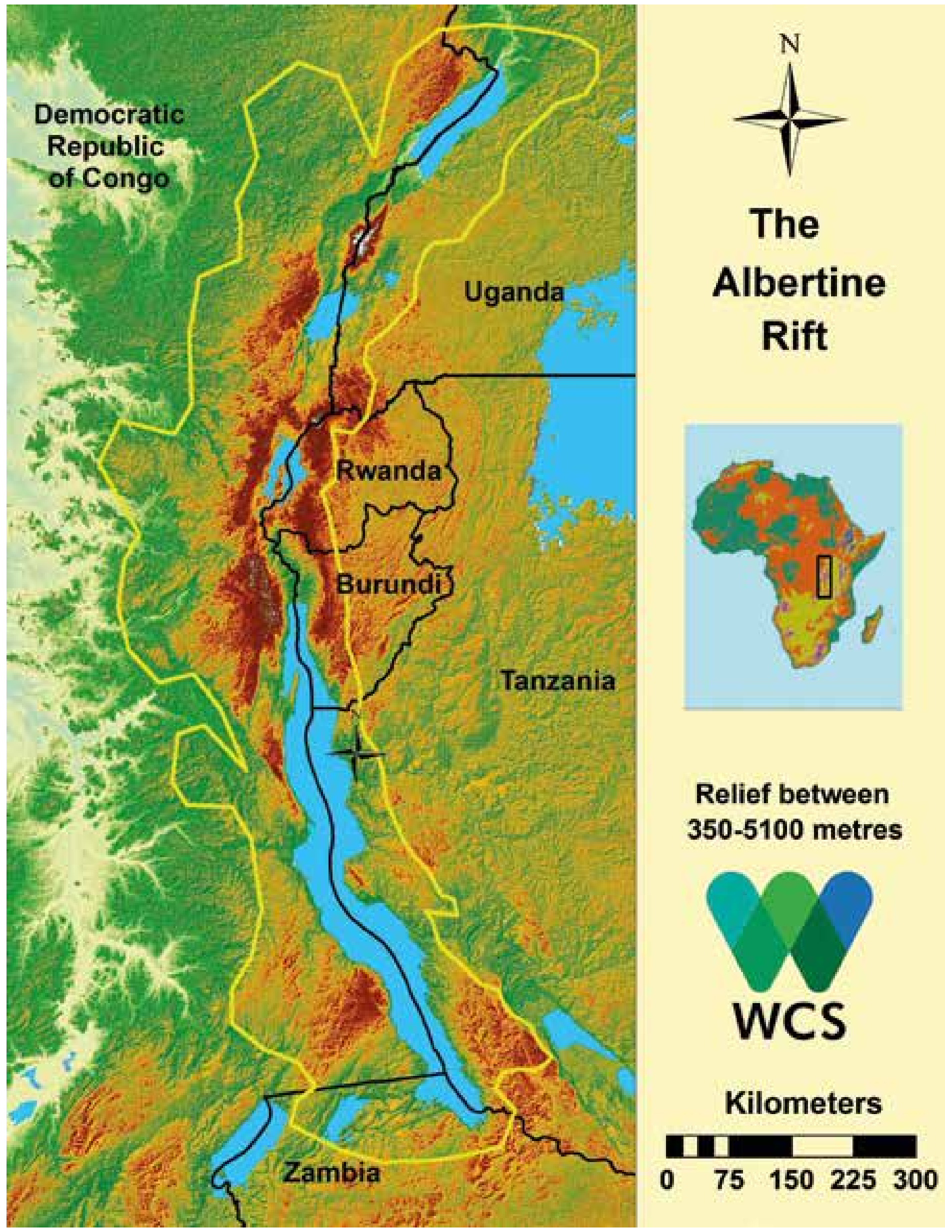


Figure 1. Map of the elevation of the Albertine Rift region (ranging from light green-blue at low altitude to dark brown and white at high altitude). The boundary of the Albertine Rift region of endemism is shown in yellow and follows the 900m contour in DRC.

More importantly the Albertine Rift contains more endemic and globally threatened vertebrates (IUCN 2015) than any other region in Africa (Plumptre et al. 2003; 2007a). The endemic species, those confined to the Albertine Rift only, number at least 980 species (mammals, birds, reptiles, amphibians, fish, butterflies, dragonflies and plants) and would certainly exceed 1000 species if other invertebrate taxa were included. We currently know of 15 Critically Endangered species; 34 Endangered species and 99 Vulnerable species assessed from terrestrial vertebrates and plants (Table 1) but these are likely to underestimate the true number of threatened species and the counts are likely to increase over time.

The numbers of known species have changed significantly from the first assessment for the Albertine Rift (Plumptre et al. 2007a). An additional 851 species have been added to the lists from that time, of which 775 are plant species, through WCS's surveys of the region. Herpetological surveys by WCS, University of Texas at El Paso (Eli Greenbaum) and Trento Science Museum (Michele Menegon) have added 46 species of amphibian and 10 species of reptile by using genetic analyses of various

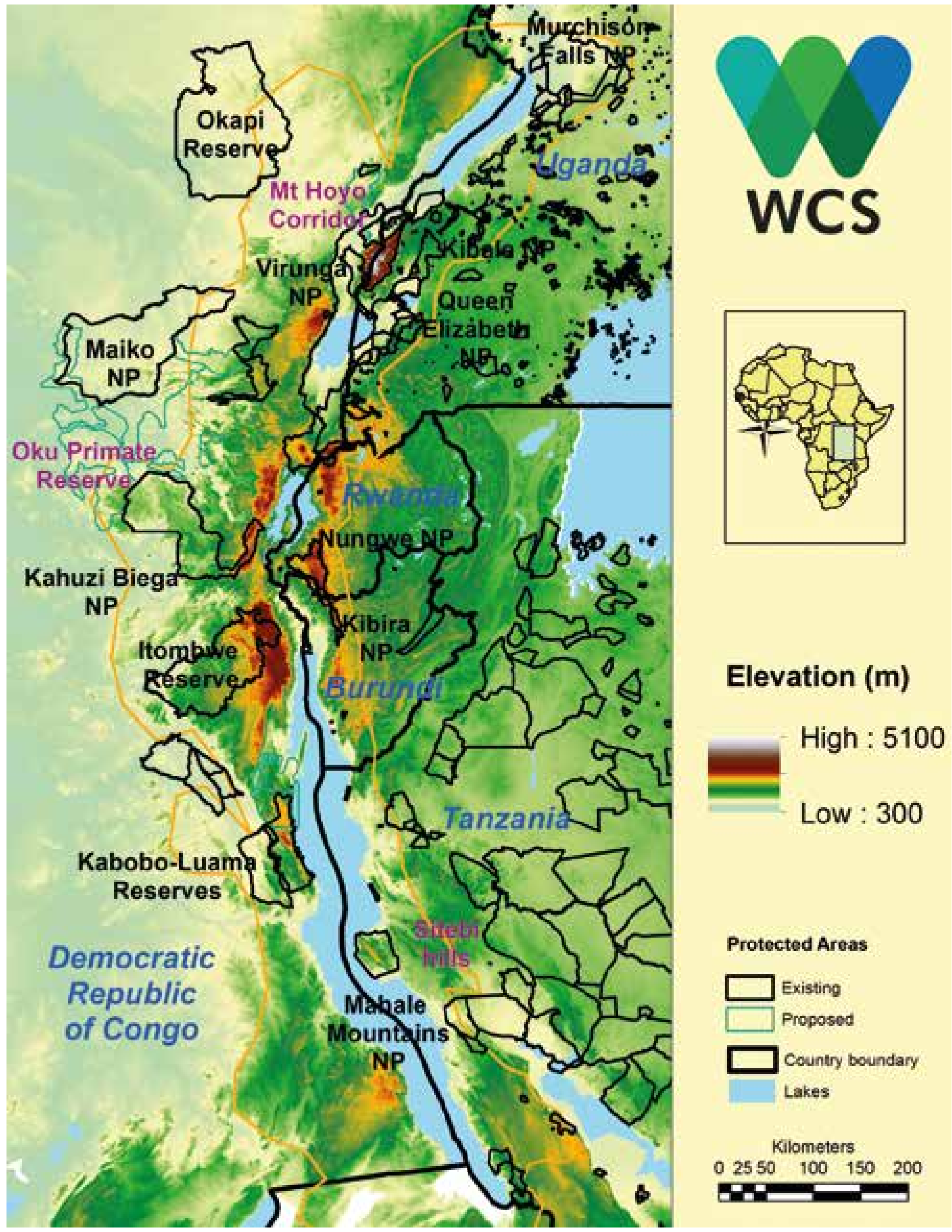


Figure 2. Map of existing and proposed protected areas of the Albertine Rift, including names of some of the larger protected areas. The boundary of the Albertine Rift region is shown in orange.

Table 1. Numbers of species of terrestrial vertebrates and plants in the Albertine Rift. The table gives the number of threatened (CR, EN, VU) species from the IUCN Red List and species that are endemic to the Albertine Rift. These numbers are based on species lists from forests and protected areas but plant species that have been described outside protected areas would increase the number of this taxon in particular.

Species	Mammals	Birds	Reptiles	Amphibians	Plants
Total Richness	420	1,063	185	165	6,568
Endemic	42	42	21	57	350
Threatened	35	33	1	13 (+28 DD)*	66
• CR	5	4	0	1	5
• EN	13	11	0	3	7
• VU	17	18	1	9	54

*Data deficient species are listed for amphibians because many of these are likely to be threatened but have been so rarely sighted that giving an IUCN ranking is not possible.

Genera. Some of these are previously described species (Greenbaum & Kusamba, 2012) while others are new species for the World (Greenbaum et al. 2012a; 2012b; Greenbaum et al. 2013; Greenbaum et al. 2015; Portillo & Greenbaum, 2014a; 2014b; Portillo et al. 2015; Larson et al. 2016). Several new mammal species have also been described following collections made during WCS surveys as well as surveys by Makerere University in Uganda and the Centre National de Recherche en Sciences Naturelles in Lwiro, DRC (Kerbis Peterhans et al. 2013a;2013b) and a total of 18 mammals have been added to the species lists. Finally two additional bird species have been added to the list for the Albertine Rift of which one, Willard's Boubou (Laniarius willardi),is a new endemic species for the Albertine Rift (Voelker et al. 2010).

The plant species list was made by compiling plants from known sites in the Albertine Rift, which tend to be protected areas or sites that may become protected areas, but it is recognised that plant collections have occurred more extensively and that records are contained within herbaria in the region and internationally. Until these collections are fully digitised the complete list of species for the Albertine Rift is likely to be underestimated and it can be seen that surveys over nine years between 2007 and 2016 have added 775 species to the known list of plants for the region, mostly species described in the literature.

Buttresses of forest tree.
A.J.Plumptre/WCS

Endemic species of the Albertine Rift. Clockwise from top left: Image 1: Golden monkey, Image 2: Blue-headed sunbird, Image 3: Johnstone's chamaeleon, Image 4: Giant *Lobelias*, Image 5: *Leptopelis* frog likely to be described as a new species, Image 6: Rwenzori double-collared sunbird. *A,J,Plumptre/WCS*

IUCN MAPPING OF SPECIES RICHNESS ACROSS THE ALBERTINE RIFT

Carr et al. (2013) combined the IUCN Red List (IUCN 2015) species range maps of all species known from the Albertine rift for mammals, birds and amphibians as these three taxa had been most completely assessed for the IUCN Red List and range maps were available for most species. These layers were re-mapped with the protected areas shown by WCS (figure 3).

The results show that for each of the three vertebrate taxa the richest area for species tends to be in the central section of the Albertine Rift, north of Lake Edward, particularly in eastern DRC. The most species rich areas of the Albertine Rift occur in the northern part of Virunga Park and westwards in the lowland forest towards the northern part of Maiko National Park and the Okapi Reserve. These maps show the total species richness at a relatively coarse scale because the maps of the extent of occurrence were developed by drawing polygons around all known sightings of a species (as mapped for the IUCN Red List). This likely includes areas that are unsuitable for the species and are not as accurate as the area of occupancy. Later in this plan we map the area of occupancy for endemic and threatened species using species distribution models.

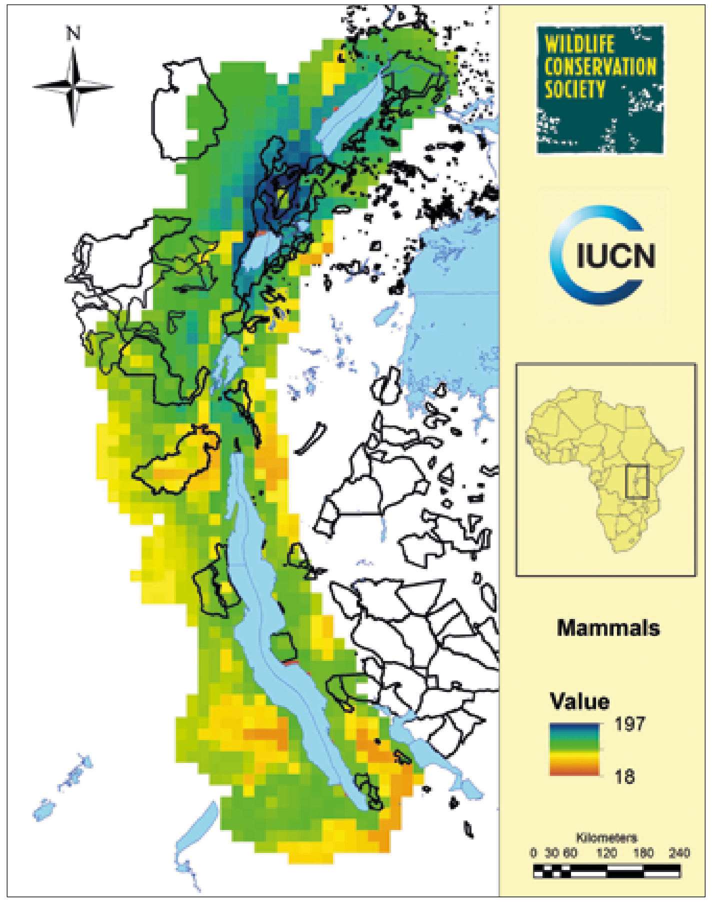
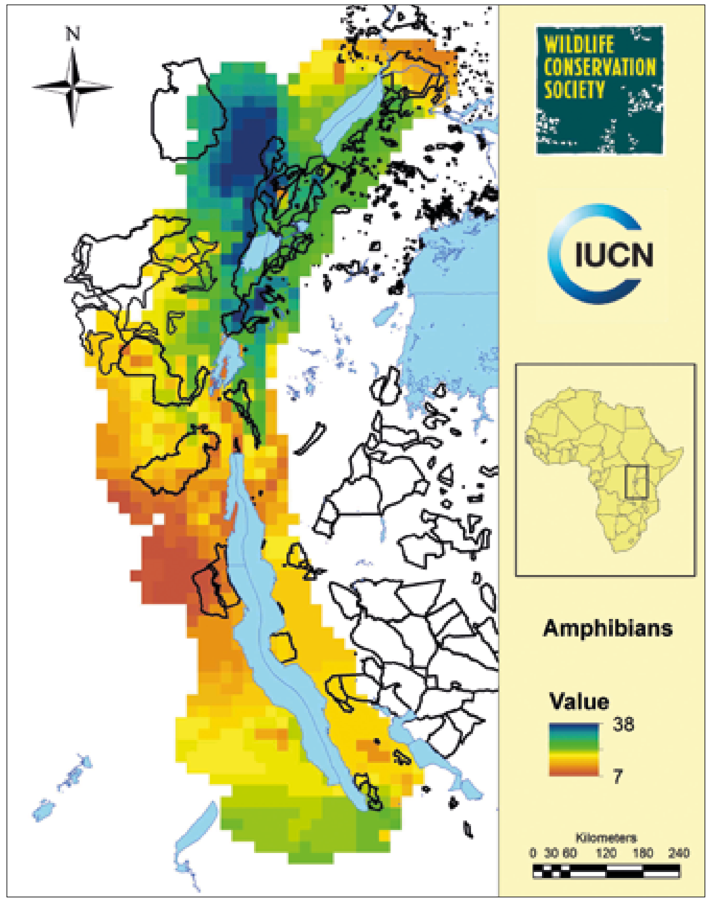
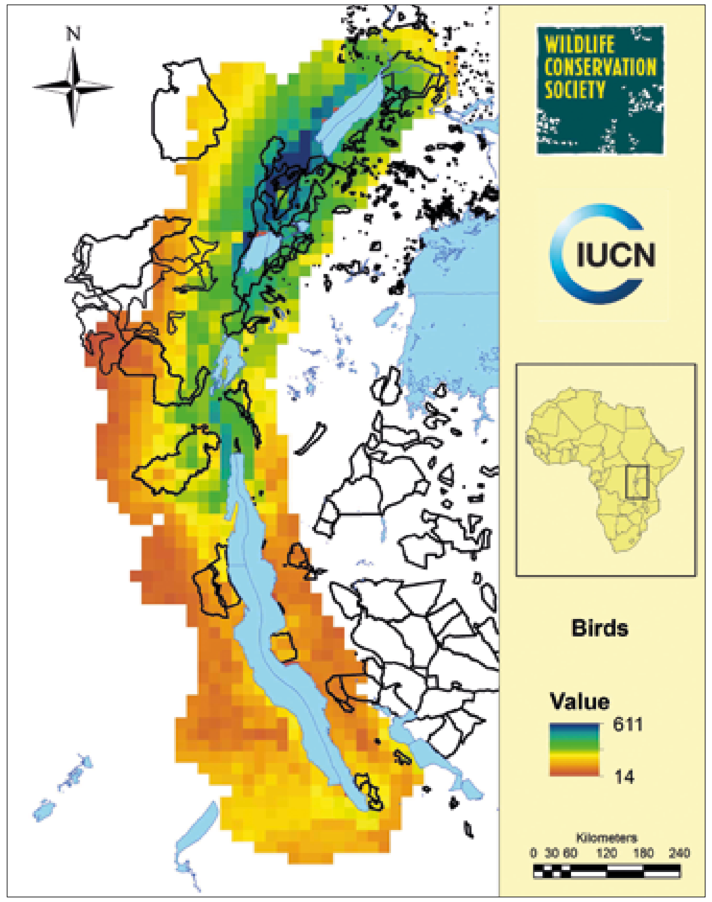


Figure 3. Map of relative species richness (value) across the Albertine Rift region for mammals (top), birds (bottom right) and amphibians (bottom left). Data are from IUCN (Carr et al. 2013).





Lions, a Vulnerable species, are noted for their tree-climbing abilities in the Queen Elizabeth Park, Uganda.
A.J.Plumptre/WCS

LANDSCAPES OF THE ALBERTINE RIFT

Strategic Framework Plan

Between 2001 and 2004 a process was supported by the MacArthur Foundation to develop a Strategic Framework Plan (SFP) for the Albertine Rift (ARCOS 2004). Involving International and National NGOs, Universities, local communities and Protected Area Authorities this process identified six key landscapes of importance for conservation that would protect many of the endemic and threatened species. These six landscapes (figure 4) included:

1. Murchison-Semliki Landscape - western Uganda
2. Greater Virunga Landscape - Straddling the borders of south-west Uganda, northern Rwanda and eastern DRC.
3. Maiko-Itombwe Landscape - Eastern DRC
4. Congo-Nile Divide Landscape - Straddling the border of southern Rwanda and northern Burundi
5. Greater Mahale Landscape - western Tanzania
6. Marungu-Kabobo Landscape - South east DRC

The SFP proposed the development of more detailed landscape plans for each of the six landscapes that would identify the key conservation targets, the direct and indirect threats to these targets, and strategies and actions that would be used to tackle the threats. Between 2004 and 2015 detailed landscape plans were developed for each landscape focusing on ten year periods. Plans were based around conceptual models of the threats to conservation targets using the Miradi software (www.miradi.org). Each landscape has complex conceptual models with many direct and indirect threats which are presented in this plan but not examined in detail. More detail can be found in the individual landscape plans. Several have also been updated and revised since they were first developed. Each landscape plan is summarised in this Conservation Action Plan and the following section describes how this plan builds upon these landscape plans and also the original SFP. WCS is the only institution that has been involved with the development and implementation of all of these plans.

Development of Albertine Rift Conservation Action Plan

This plan builds upon the original SFP and the more detailed landscape plans by compiling all known information about the biodiversity of the Albertine Rift, particularly of the endemic and threatened species, and its distribution. We then use this information to identify conservation priority areas within the Albertine Rift to protect viable populations of all the species of conservation concern. This assessment is made within and outside the six landscapes to identify which parts of the landscapes are critical for the conservation and also where else must be conserved outside the landscapes to ensure the survival of these species both now and under predicted climate change.

Given the growth in exploration for oil and gas, and in the granting of mining concessions in this region WCS felt it was necessary to identify the key areas that are required to protect species of conservation concern and

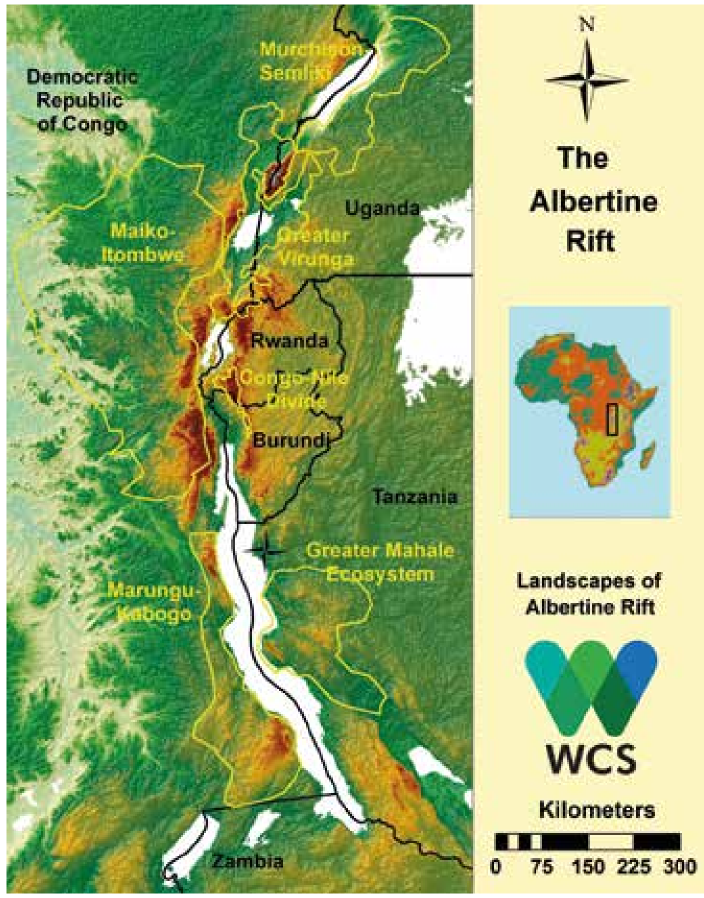


Figure 4. Map of the six key landscapes of the Albertine Rift as originally defined in the Strategic Framework Plan (ARCOS 2004).

particularly which areas are the most important parts of each landscape. Not all of each landscape is under protection, as many of the landscapes include areas of human habitation and even agriculture production. Across all six landscapes 60% is under some form of protection (Table 2) although this has increased from 49% through the conservation efforts made since 2000.

Redtail monkey.
A.J.Plumptre/WCS

Landscape	Landscape Area (km^2)	Area Protected (km^2)	Percentage protected
Murchison-Semliki	10,500	7,350	70.0
Greater Virunga	15,700	13,800	87.9
Maiko-Itombwe	40,300	22,250	55.2
Congo Nile Divide	1,450	1,450	100.0
Greater Mahale	14,700	1,600	10.9
Kabobo-Luama	6,950	6,950	100.0
All Landscapes combined	89,600	53,400	59.6

Table 2. Areas of the six landscapes and area protected as park, forest reserve or wildlife/hunting reserve. Areas are rounded to the nearest 50 km^2 because of inaccuracies in area measurement on the ground for many sites in DRC.

Detailed species models calculating the area of occupancy were made for endemic and threatened (Critically Endangered (CR); Endangered (EN) and Vulnerable (VU) from the IUCN Global Red List) species for five taxa (mammals, birds, reptiles, amphibians and plants) and target areas established for each species to conserve enough of the species to remain viable. A Marxan analysis is then used to identify where all these species can be conserved at minimal cost under different scenarios which adjusts the cost at different sites and factors in the impacts of potential mining concessions.

Papyrus gonolek, found in papyrus swamps around the Lake Victoria region. *A.J.Plumptre/WCS*

Little egret.
A.J.Plumptre/WCS

LANDSCAPE 1: MURCHISON-SEMLIKI LANDSCAPE

Description of Landscape

The most northerly landscape, the Murchison-Semliki Landscape, encompasses the natural and human modified habitats from the Murchison Falls National Park (NP) in the north of the landscape down along the eastern shores of Lake Albert to the Semliki Wildlife Reserve in the south (figure 5). It encompasses the Budongo and Bugoma Forest Reserves (FR), together with several smaller Central Forest Reserves, the Bugungu, Karuma and Kabwoya Wildlife Reserves (WR), and the Kaiso-Tonya Community Wildlife Area (CWA). Natural habitat, notably grassland and bushland, occurs outside protected areas along the escarpment above Lake Albert and south west of the Bugungu WR in the Butiaba-Buliisa region. Lions appeared in Kabwoya WR briefly around 2008 (B. Martin pers. comm.) which indicates that this grassland corridor along the escarpment is occasionally used by such species. The altitude ranges between 610 along the Nile River flowing from Lake Albert to 1500 metres a.s.l. on the escarpment above the lake in the south of the landscape and at the base of the Rwenzori Mountains (figure 5b).

Key habitats include the moist Acacia-Combretum woodland savannas (including *Borassus* palm woodland) in Murchison Falls NP and the wildlife reserves; medium altitude tropical high forest in the forest reserves, particularly *Cynometra* dominated forest; and Papyrus and *Carex* wetlands around the Nile River and lake shores. Many of the forests have been harvested quite intensively for timber, charcoal and fuelwood, particularly the smaller reserves. Budongo FR was the main research forest in Uganda during colonial times where sustainable timber harvesting methods were trialled and implemented including the intensive use of arboricides (Plumptre, 1996). The impacts of these interventions were studied by the Budongo Conservation Field Station which was established in 1991 (Plumptre & Reynolds, 1999; Owiunji & Plumptre, 1998; Babweteera et al. 2012). Murchison Falls NP and the surrounding Wildlife Reserves and historical hunting areas used to contain over 14,000 elephants (*Loxodonta africana*) which had major impacts on the woody vegetation of the park (Laws, Parker and Johnstone, 1975) but heavy poaching in the 1970s and 1980s reduced their numbers to only 250 individuals and in the most recent survey these have only recovered to 1,300 individuals (Wanyama et al. 2014). As a result, the vegetation of the park and the reserves has become increasingly wooded again since the 1980s. Elephants used to be abundant in the landscape, but have not been seen in Budongo for 20 years, a few are left in Bugoma FR or Semliki WR, and are now extinct in Kagombe forest, where they were observed as recently as 1999. Their loss is likely having an impact on the species composition of the vegetation and its associated fauna.

Biodiversity

While not as rich in species as other landscapes in the Albertine Rift, the Murchison-Semliki Landscape still contains large numbers of vertebrates and plants compared with other sites in Africa (Table 3). Some key species of conservation concern in this landscape include the Rothschild giraffe (*Giraffa camelopardalis rothschildi*), (Uganda Mangabey (*Lophocebus ugandae*), and Nahan's Francolin (*Francolinus nahani*), as this landscape holds significant global percentages of these three species. It is also an important landscape for the conservation of elephants, chimpanzees (*Pan troglodytes*), lions (*Panthera leo*), and spotted hyaenas (*Crocuta crocuta*) nationally in Uganda. The number of endemic species relative to other landscapes in the Albertine Rift is also low; including 10 terrestrial vertebrates and 38 plants primarily because much of the habitat is medium-altitude semi-deciduous forests and savannas rather than the montane forests where many of the endemic species occur. Globally threatened species include elephant, chimpanzee, lion, Rothschild giraffe and several vulture species and total 26 terrestrial vertebrates and 31 plants (Table 3).

Table 3. The total number of terrestrial vertebrates and plants, together with the number of globally threatened species and species endemic to the Albertine Rift, in the Murchison-Semliki Landscape.

	Mammals	Birds	Reptiles	Amphibians	Plants
Endemic	2	0	3	5	38
Threatened	8	14	1	3	31
Species	189	706	90	53	2,115

Rothschild's giraffe is an Endangered sub-species and Murchison Falls holds the largest population. *A.J.Plumptre/WCS*

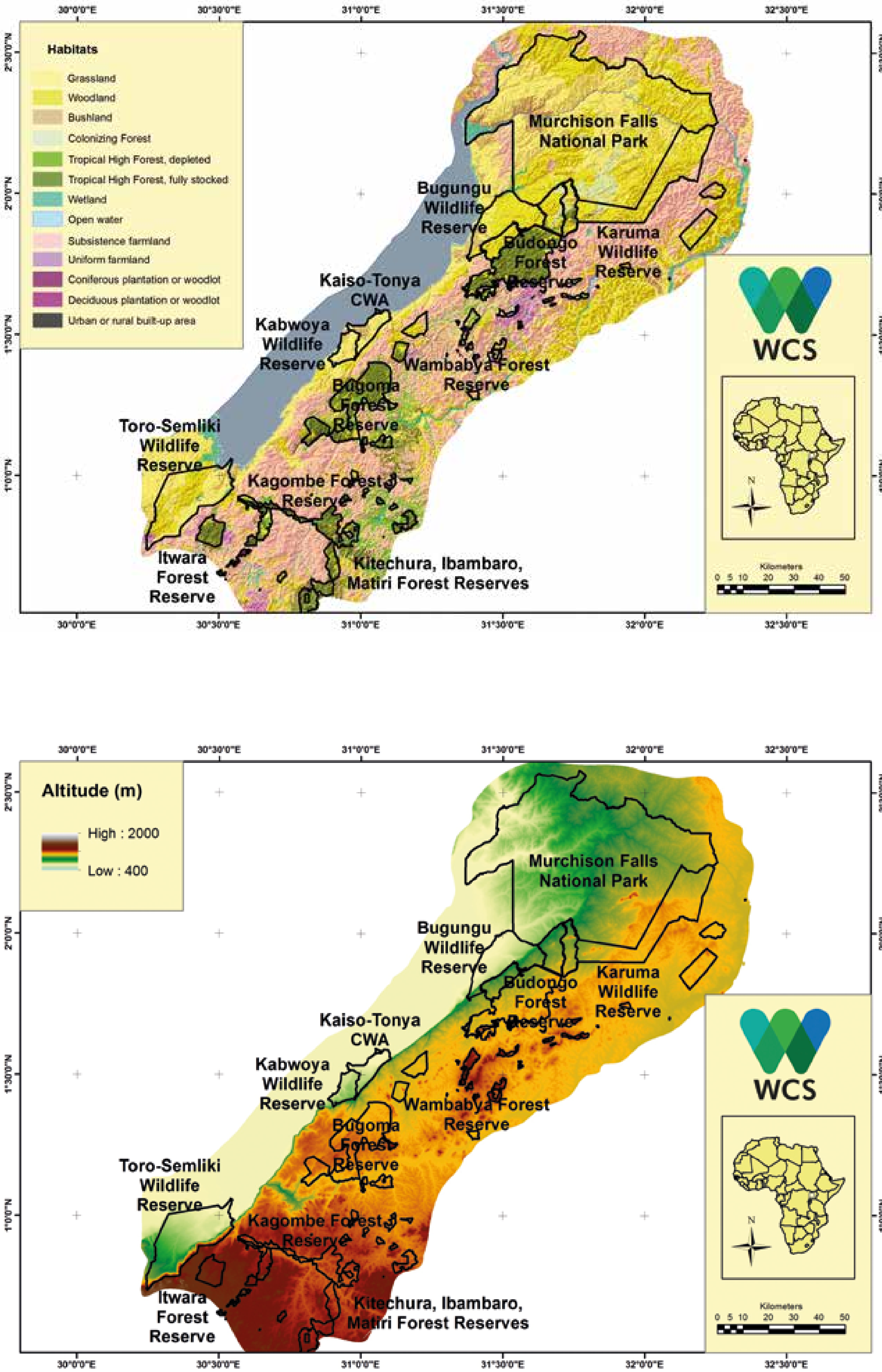


Figure 5. Map of the vegetation of the Murchison-Semliki Landscape (top) and elevation (m) (below).

Photo 1: Images of the Murchison-Semliki Landscape. Clockwise from top left: Image 1: Murchison Falls in Murchison Falls National park; Image 2: Borassus open woodland in Murchison Falls National Park; Image 3: Oil exploration pad in Murchison Falls National Park; Image 4: Forest clearing at edge of Budongo Forest Reserve; Image 5: Kabwoya Wildlife Reserve with rift escarpment in background; Image 6: Lake Albert is an important source of fish for people. *A.J.Plumptre/WCS*

Threats to Landscape

The Murchison-Semliki Landscape is under some of the greatest threats of any of the landscapes in the Albertine Rift. Rampant deforestation is occurring in natural forests on private land and also in the smaller forest reserves in the landscape with an estimated 8,000 hectares being lost every year between 2000 and 2010 (Leal et al. 2011). Priority forest corridors have been identified in this landscape to preserve the connectivity between the main forest blocks and conservation actions need to focus on preserving these corridors (Nangendo, Plumptre and Akweteireho, 2010).

The discovery of medium-sized reserves of oil in the Landscape is leading to local impacts on wildlife from oil exploration activities (Prinsloo et al. 2012; Plumptre, Ayebare & Mudumba, 2015a), and the in-migration of people seeking work. The population boom has resulted in increased demand for fuel wood, water and demand for land for cultivation (Treweek Environmental Consultants, 2015). Plans for a refinery, access roads and pipelines will also increase the impacts associated with the oil production. Natural resource extraction for timber, fuelwood, charcoal and fisheries are all having a major impact on the degradation and loss of habitat in the landscape (Treweek Environmental Consultants, 2015).

Hunting of large mammals for bushmeat is also very common in the Murchison Falls Protected Area (MFPA - Murchison Falls NP together with Bugungu and Karuma WRs) and estimates have been made of up to 40-50% of households admitting to hunting for bushmeat in communities adjacent to MFPA (H. Travers pers. comm.).

Conservation plan for landscape

In 2012 the Ministry of Water and Environment in Uganda published a Strategic Plan for the conservation of the Murchison-Semliki Landscape (MWE 2012). This was developed over a three year period with an extensive consultation process and series of studies led by WWF Uganda with UNDP/GEF support. WCS was closely involved in developing the plan and undertaking several of the studies, particularly focusing on corridor identification, sustainable financing of the plan and development of a REDD+ project to incentivise private forest owners to conserve natural forest on their lands. During the planning process a conceptual model was developed that identified conservation targets for the landscape, direct and indirect threats to these targets and strategies to tackle the threats. The conceptual model and Goal and objectives of the plan are summarised here.

Conceptual model

The conceptual model (figure 6) identified 14 conservation targets. These included six species targets (chimpanzees (*Pan troglodytes*), forest raptors, shoebill (*Balaeniceps rex*), crocodile (*Crocodylus niloticus*), timber species, and elephants/giraffes/lions in MFPA); four habitat targets (Forests and woodlands, savanna grasslands, Hydrological systems (lakes, rivers, catchments) and wetlands); and four ecosystem processes (Connectivity of habitat, biomass productivity, migration of species, and pollination and seed dispersal). Seven direct threats to these targets were identified:


African elephants are Vulnerable and Murchison Falls used to support the largest population in the Albertine Rift. *A.J.Plumptre/WCS*

1. Habitat loss: clearance, encroachment, conversion (land use change)
2. Unsustainable use of forest products: timber, fuel wood for brick making,
3. Poaching and over-fishing
4. Industrial development impacts: oil and gas, HEP, pollutants
5. Invasive species
6. Grazing, transmission of disease between wild and domestic animals
7. Climate change

Six key strategies were identified to tackle these threats:
1. Improve natural resources governance
2. Support restoration of degraded habitats on public and private land
3. Support integrated and coordinated natural resources management and sustainable livelihoods
4. Reduce illegal activities impacting on natural resources
5. Improve corporate responsibility to mitigate threats and realize benefits from industrial or other private sector development
6. Climate change mitigation, adaptation and monitoring

A vision and objectives were developed based upon the conceptual model as follows:
Vision: *The landscape of the northern Albertine Rift is conserved effectively by a partnership between Government, communities and other stakeholders to ensure protection of biodiversity, functional habitat connectivity and contribution to sustainable livelihoods*

Thirty objectives were identified under the six strategies many of which are in the process of being implemented by a Northern Albertine Rift Conservation Group (NARCG) which was formed following the planning process and includes WCS, other national and international NGOs, together with the Uganda Wildlife Authority and National Forest Authority.


The Shoebill (Vulnerable) is one of the landscape conservation targets. *A.J.Plumptre/WCS*


Murchison Falls is the last site where Nile crocodiles are still abundant in the Albertine Rift. *A.J.Plumptre/WCS*

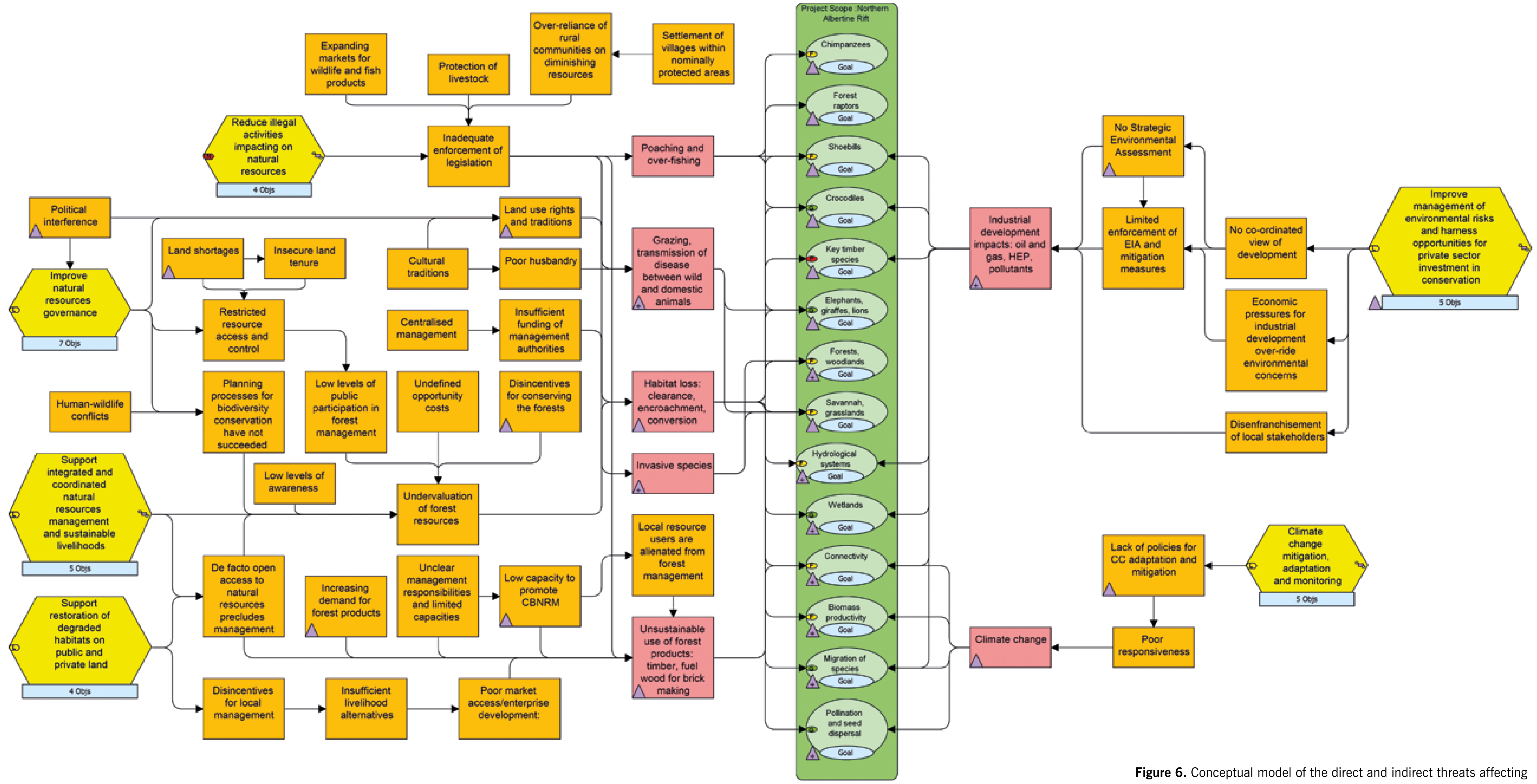


Figure 6. Conceptual model of the direct and indirect threats affecting 14 conservation targets in the Murchison-Semliki Landscape

Key strategies and objectives

Objectives for Strategy 1. Improve natural resources governance

1.1 National and locally-based institutions able to conduct advocacy and lobbying for improved governance identified and advocacy programmes in place by 2014
1.2 Government structures, Kingdom structures and faith based organizations are aware and informed of ENR laws and policies by 2013
1.3 Mechanisms for coordination and cooperation between key players in the environment and natural resources sector in place by 2015
1.4 Participatory structures for environment and natural resources management in place in all key target areas by 2015
1.5 Law enforcement agencies working collaboratively to enforce natural resources laws by 2017
1.6 Gaps in existing natural resources laws identified and filled by 2016
1.7 Natural resources governance systems in place and functioning effectively by 2020

Objectives for Strategy 2. Support restoration of degraded habitats on public and private land

2.1 By 2015, 20% of degraded habitats in key target areas of public and private land restored
2.2 Institutional management capacity of public and private sector institutions for targeted habitats improved by 2015
2.3 Mechanisms in place for the control and management of invasive species on both public and private land by 2015
2.4 By 2020, 40% of degraded habitats in key target areas of public and private land restored

Objectives for Strategy 3. Support integrated and coordinated natural resources management and sustainable livelihoods

3.1 District Environment Action Plans prepared for eight target districts, taking into account all natural resources issues at all levels of planning, and in place by 2012
3.2 Empower 40% of communities in the northern Albertine rift to participate in natural resources management by 2015
3.3 Build capacity and enable 40% of the households in target areas of the northern Albertine rift actively to practise sustainable management of natural resources by 2018
3.4 Build awareness programmes for the sustainable management of natural resources in the northern Albertine rift landscape that reach 80% of communities by 2015
3.5 Enhanced integration and coordination of natural resources management and sustainable livelihoods within Local Government planning processes by 2020

Objectives for Strategy 4. Reduce illegal activities impacting on natural resources

4.1 Levels of prosecution and fines raised to act as sufficient deterrents to carrying out of environmental crimes by 2015
4.2 Build capacity of regulatory authorities and other stakeholders to monitor and respond to environmental crimes by 2015
4.3 Mechanisms in place to report corruption issues to relevant authorities for effective redress by 2016
4.4 By 2020, 80% reduction in illegal activities impacting on natural resources through an improved enabling environment for law enforcement and improved capacity of regulatory authorities

Objectives for Strategy 5. Improve management of environmental risks and harness opportunities for private sector investment in conservation

5.1 Involve developers/investors in planning and monitoring processes for environmental management by 2015
5.2 Ensure compliance with General Environmental Assessments through regular joint compliance reporting by the industrial developers and other private stakeholders from 2015
5.3 Engage key developers/investors in the northern Albertine rift in off-setting their negative environmental impacts through payment of ecosystem services or similar private-public partnerships by 2015
5.4 Major investment opportunities in biodiversity conservation by private sector harnessed by 2018
5.5 Social and environmental risks from private sector investment mitigated by 2020

Objectives for Strategy 6. Climate change (CC) adaptation, mitigation and monitoring

6.1 Develop a monitoring system at national and local level to document climate change impacts within the landscape by 2013
6.2 Promote CC adaptation measures reaching 50% of communities in the landscape by 2015
6.3 Promote CC mitigation measures reaching 50% of communities in target areas by 2015
6.4 CC adaptation mechanisms in place for 80% of communities in the landscape by 2020
6.5 CC mitigation mechanisms in place for 80% of communities in target areas by 2020

LANDSCAPE 2: GREATER VIRUNGA LANDSCAPE

Description of Landscape

The Greater Virunga Landscape (GVL) is sometimes referred to as the Central Albertine Rift although under this name it mainly includes the transboundary protected areas only, not the adjacent forest reserves and Kibale National Park which are contiguous with the landscape (figure 7). This landscape straddles the international boundaries of the DRC, Rwanda and Uganda and includes three World Heritage Sites (Rwenzori Mountains NP, Bwindi Impenetrable NP and Virunga NP), a Man and Biosphere Reserve (Queen Elizabeth NP), and a Ramsar Site (Lake George and Kazinga Channel). Virunga NP is Africa's oldest park, gazetted in 1925, and this landscape is one of the most biodiverse landscapes in the World. Kibale National Park is recorded as having the largest biomass of primates per hectare of any forest in the World (Struhsaker 1997) and the Virunga-Queen Elizabeth NP savannas also supported the largest biomass of wild ungulates recorded in the World in the 1960s (Bourliére, 1965; Plumptre et al. 2012) at 31.2 tonnes per km^2.

The high biodiversity is a result of diverse habitats which are determined by the elevation range (600-5,100 metres a.s.l.) and climate patterns in the landscape. Forming Africa's third highest peak, Margherita at 5,100 metres is in the centre of a glacier that is steadily receding as climate is warming in the region. Below the ice and rock at the summit is alpine habitat that gives way to peat bogs and giant *Lobelia*/giant *Senecio* habitat. Below that is giant heather, bamboo and montane forest which then gives way to medium-altitude forest in wetter areas or savanna woodland and grassland in drier areas. Finally at the lowest altitudes lowland rainforest is found. Wetlands and swamps add to the habitats around lakes Edward and George and along the Semliki River that drains Lake Edward to Lake Albert, Kazinga channel that links Lake George to Lake Edward and the Ishasha River that brings water from Bwindi Impenetrable NP to Lake Edward.

The history of this landscape over the past 100 years saw the increase in large mammal numbers following an outbreak of rinderpest and sleeping sickness at the beginning of the 20th Century which led to a decline in wild animal and cattle numbers and people moving out of the savanna areas (Plumptre et al., 2012). However, by the 1960s wild ungulate numbers were so high that culling operations were trialled of hippopotamuses (*Hippopotamus amphibious*) which numbered 30,000 individuals in Lakes George and Edward at that time (Africa's largest hippopotamus population). Following culling, marked improvements in the vegetation leading to an increase in large mammal biomass occurred but the hippopotamus numbers rebuilt very quickly (Eltringham, 1999). With the military coup in 1971 and the leadership of Idi Amin in Uganda, poaching of large mammals escalated in Queen Elizabeth NP and by the early 1980s after Amin's overthrow numbers were at their lowest recorded levels. Numbers have rebuilt, notably with immigration from Virunga NP as security has improved in Uganda but worsened in DRC. With the insecurity in Virunga NP since the civil war in 1996, species such as elephants have taken refuge in Queen Elizabeth NP, highlighting the importance of maintaining the transboundary linkages in this landscape (Plumptre et al.2007b). As a result of these changes in large mammal numbers the vegetation has also been changing, becoming more wooded since the 1970s (Plumptre et al. 2010; 2012).

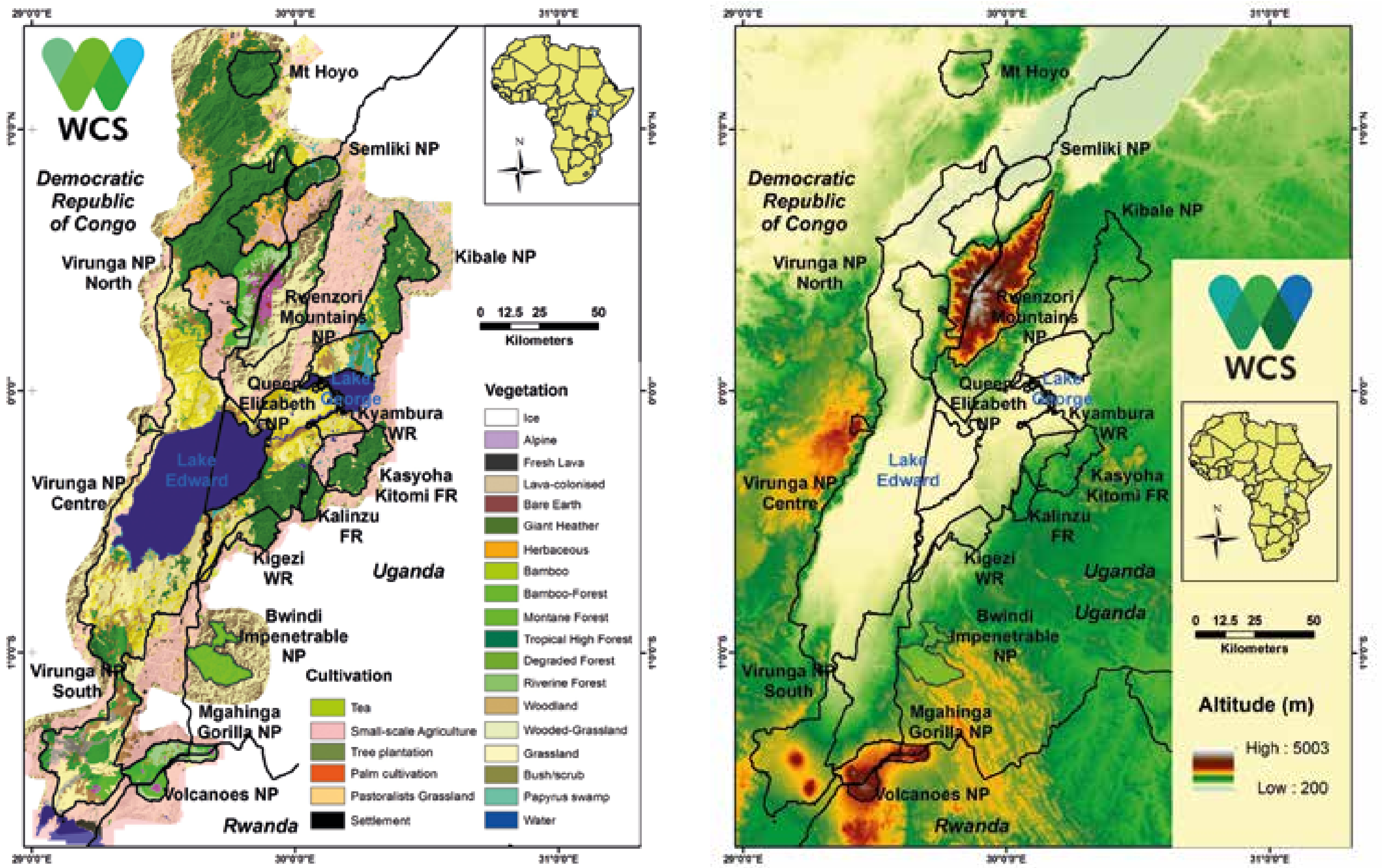


Figure 7. Map of the vegetation of the Greater Virunga Landscape (left) and elevation (m) (right).

Biodiversity

This landscape is one of the most diverse landscapes in the World and contains 1,462 terrestrial vertebrate species and 3,105 plant species (Table 4). Some key species which are only found in this landscape include the mountain gorilla (*Gorilla beringei beringei*); golden monkey (*Cercopithecus kandti*), Rwenzori duiker (*Cephalophus rubidus*), Matthew's or Virunga buffalo (*Syncerus mathewsi*) (Groves and Grubb, 2011), Strange-nosed chamaeleon (*Kinyongia xenhorrina*) and Carpenter's chamaeleon (*Kinyongia carpenteri*). Several plant and amphibian species are also confined to this landscape. Endemic species number 107 terrestrial vertebrates and 145 plant species; and 74 terrestrial vertebrates together with 41 plant species are globally threatened.

Table 4. The total number of terrestrial vertebrates and plants, together with the number of globally threatened species and species endemic to the Albertine Rift, in the GVL

	Mammals	Birds	Reptiles	Amphibians	Plants
Endemic	29	38	16	24	145
Threatened	27	27	1	19	41
Species	289	941	137	95	3,105

Photo 2: Images of the Greater Virunga Landscape. Clockwise from top left: Image 1: Queen Elizabeth National Park with Rwenzori Mountains in background; Image 2: Lake Kitandara in Rwenzori Mountains National Park; Image 3: Mubwindi Swamp in Bwindi Impenetrable National Park; Image 4: Glaciers on the Rwenzori Mountain peaks, Rwenzori Mountains National Park; Image 5: Katwe Crater lake with Salt pans in Queen Elizabeth National Park; Image 6: Virunga Volcanoes range on the border of Uganda, Rwanda and DRC. *A.J.Plumptre/WCS*

Threats to Landscape

The main direct threats to the landscape include poaching of wildlife for bushmeat and ivory in the case of elephants and hippopotamuses; harvesting of timber, fuelwood, thatch and charcoal; oil exploration; geothermal exploration; habitat degradation and loss, including loss of habitat connectivity which is important for maintaining viable populations of landscape species. Grazing of livestock in the landscape creates conflict between pastoralists and large carnivores and is the main cause of mortality of adult lions and hyaenas in the landscape. Agricultural encroachment is a major problem in Virunga NP and has led to the loss of 9% of this park since 1996 (WCS unpublished data). Changes in large mammal numbers and climate are also causing changes in vegetation of the savanna areas with increasing cover of woody vegetation and loss of open grasslands. Some naturally occurring species appear to be becoming invasive as a result of these changes and spear grass (*Imperata cylindrical*) and *Dichrostachys* are spreading across large areas of Queen Elizabeth NP. Exotic plant species such as *Lantana* and *Parthenium* are also taking over parts of the landscape.

Conservation plan for landscape

A Transboundary Strategic Plan was developed for the landscape in 2006 for a ten year period and this was revisited in 2010 and revised in 2013. The process was led initially by the International Gorilla Conservation Programme (IGCP) and in each case extensive consultations were made with different stakeholder groups. The establishment of the Greater Virunga Transboundary Conservation Secretariat (GVTC) under the first plan led to their management of the revision of the plan in 2013.

Conceptual model

In 2010 a conceptual model was developed for the landscape as part of the planning process (figure 8) which identified six conservation targets and their direct and indirect threats together with the strategies to tackle these threats. Three species targets were identified: Large predators, great apes and large herbivores as these were all species affected by man. Three habitat targets were also identified: Aquatic habitats, Forest habitats and Savanna (grassland and woodland) habitats. The threats in this landscape are many and varied and nineteen strategies were identified to tackle them (figure 8).

A 30 year vision and ten year goal was developed for the plans:

Vision: *The Greater Virunga landscape Transfrontier Protected Area Network together with the surrounding Landscape conserved sustainably.*

Goal: Sustainable Conservation of the Greater Virunga landscape Biodiversity for Long Term Socio-Economic Development through Strategic Transboundary Collaborative Management

Six key results areas were identified for the 2013 plan:

1. Landscape Management
2. Effective and Efficient Management Capacity
3. Transboundary Collaboration
4. Communication and Information Management
5. Natural Resource-based Socio-economic Development
6. Financial Sustainability

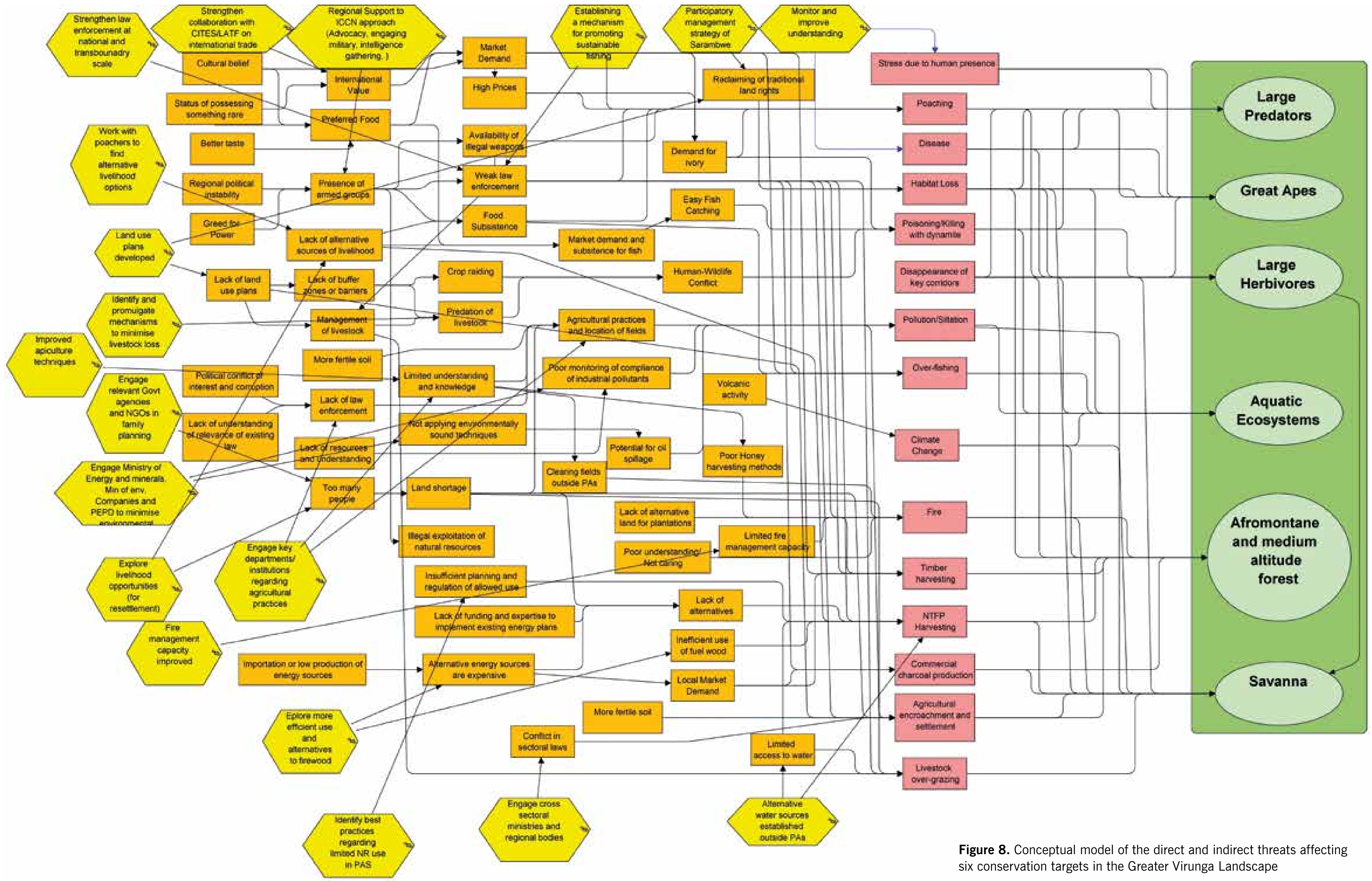


Figure 8. Conceptual model of the direct and indirect threats affecting six conservation targets in the Greater Virunga Landscape

Strategic objectives under each key results area

Key Results Area 1: *Landscape management*

SO 1.1 Integrity of protected areas preserved

SO 1.2 A regional research and monitoring plan in place

SO 1.3 The GVL PA network effectively managed

SO 1.4 GVL global environmental benefits enhanced

SO 1.5. Animal Health for sustainable management of GVL enhanced

Key Results Area 2: *Effective and Efficient Management Capacity*

SO 2.1: Institutional and individual capacity improved

Key Results Area 3: *Transboundary Collaboration*

SO 3.1 Appropriate political, institutional and legal framework established

Key Results Area 4: *Communication and Information Management*

SO4.1 Relevant information within the landscape shared and disseminated locally, regionally and internationally

SO 4.2 GVTC visibility enhanced

Key Results Area 5: *Natural Resource-based Socio-economic Development*

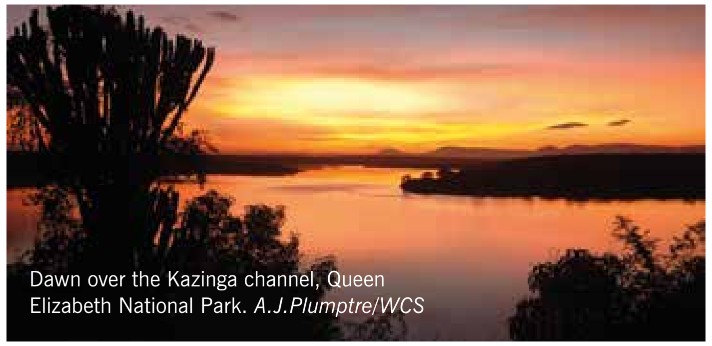
SO5.1 Contribution of ecosystem services towards socio- economic development increased

SO5.2 The value of the Greater Virunga Landscape enhanced through tourism

SO5.3 Dependence of the population on protected area based natural resources is reduced

Key Results Area 6: *Financial sustainability*

SO6.1 Financial capacity to implement the Transboundary Strategic Plan enhanced



Dawn over the Kazinga channel, Queen Elizabeth National Park. *A.J.Plumptre/WCS*

LANDSCAPE 3: MAIKO-ITOMBWE LANDSCAPE

Description of Landscape

The Maiko-Itombwe Landscape is the largest of the six landscapes and encompasses the Maiko and Kahuzi Biega National Parks, Tayna, Kisimba-Ikobo and Itombwe Natural Reserves, and proposed community reserves (Oku Community Reserve (RCO), REGOMUKI, REGOUWA, Lobutu, Usala amongst others). Ranging from 3,400 m down to about 600 metres a.s.l. the landscape encompasses an altitude range of natural habitat that has been lost elsewhere in the Albertine Rift. In the past this region was recognised as having two contiguous endemic bird areas (Albertine Rift and Eastern Zairean Lowlands - Stattersfield et al. 1998) although Plumptre et al.(2007a) suggested that these should be combined as there was much overlap in range of the endemic birds in each region. However, these intermediate elevations that have been converted to farmland elsewhere in the Albertine Rift are clearly important for several endemic birds and other species. Whilst some of the least surveyed areas occur in this landscape it is known to be very rich in species and new species continue to be identified regularly (Greenbaum & Kusamba 2012).

Key habitats in the landscape include montane, medium altitude and lowland forest types including monodominant *Gilbertiodendron dewevrei* forest. Montane grasslands in the Itombwe massif are also important for some of the endemic species (figure 9). This landscape encompasses most of the global range of Grauer's gorilla (*Gorilla beringei graueri*), apart from a small population in Tshiaberimu in the GVL. Maiko National Park includes important habitat for okapis (*Okapia johnstonii*), Congo peacock (*Afropavo congensis*), elephants and Grauer's gorilla, while Kahuzi Biega National Park was identified as a critical site for Grauer's gorillas, containing an estimated 59% of the global population of this gorilla (Hall et al. 1998a; 1998b). The Itombwe Reserve has been identified as a site of great importance for the conservation of threatened and endemic birds (Wilson and Catsis 1990; Doumenge 1998; Omari et al. 1999) and amphibians (Laurent 1954; Greenbaum & Kusamba 2012). It is the only site where Schouteden's swift (*Schoutedenapus schoutedeni*) and Itombwe or Prigogine's Nightjar (*Caprimulgus prigoginei*) are known to occur together with several frog species, some of which are being described at present. In an assessment of the Albertine Rift Region of Africa, Plumptre et al. (2007a) showed that this region contained more endemic and threatened species than any other region in Africa.

While still relatively intact in comparison to other parts of the Albertine Rift, this region has been affected by a prolonged civil war from 1996 to 2003 and since then continuing insecurity due to the presence of many armed militias and rebel groups. These groups have been engaging in

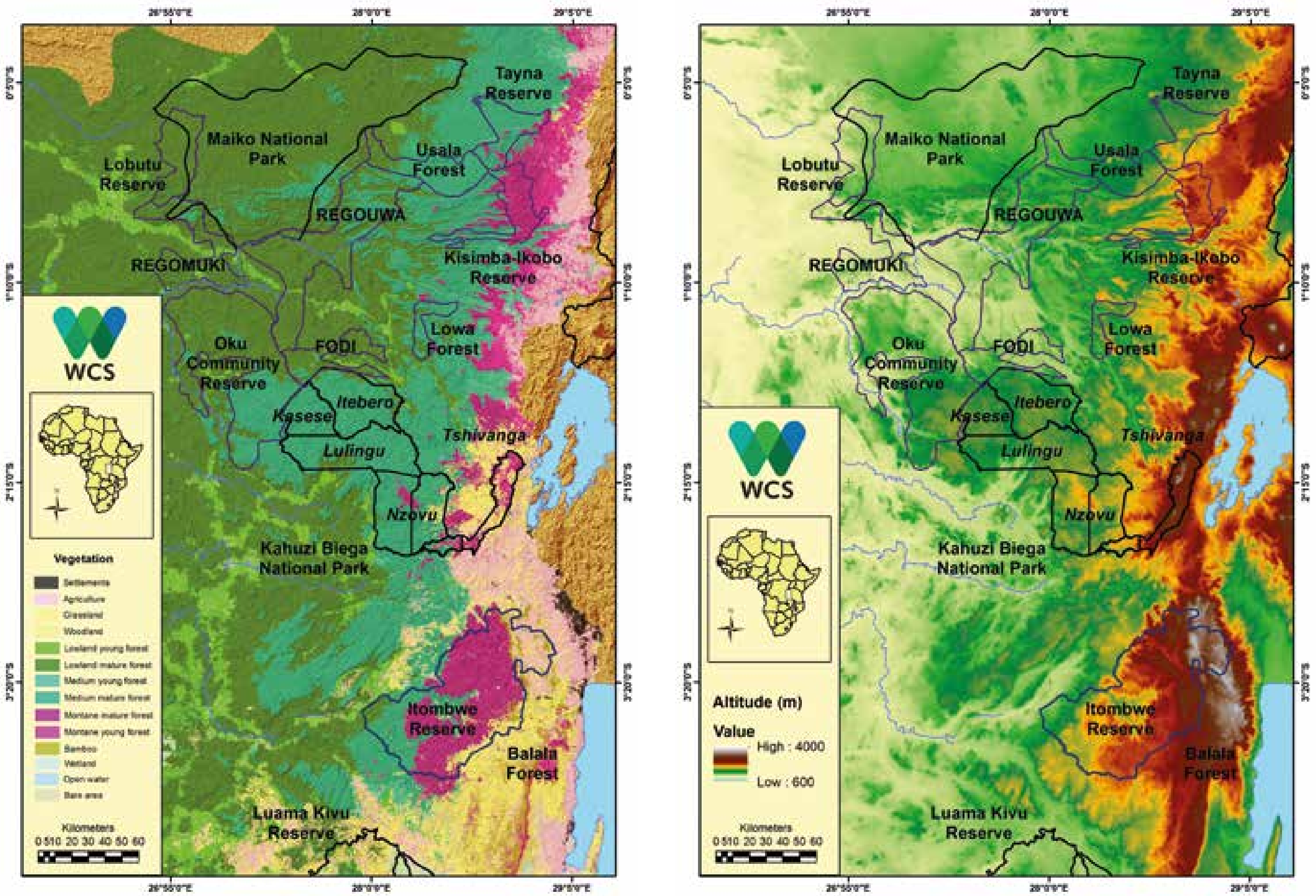


Figure 9. Map of the vegetation of the Maiko-Itombwe Landscape (left) and elevation (m) (right).

Montane forest canopy with tree ferns. *A.J.Plumptre/WCS*

small scale artisanal mining for gold, columbo-tantalite, and wolfram in particular, using the sale of these minerals to finance themselves. Given their need to hide in the forest and move around they have used bushmeat as their main source of provision. As a result many large mammals have been decimated in number through hunting for bushmeat and elephants and Grauer's gorillas in particular have been almost completely lost (Plumptre et al. 2016). While much of the forest remains intact it has lost many of the large mammals and their functional roles. Bushmeat hunting is currently targeting smaller species such as rats and birds in many sites in the landscape because of the decline in large and medium mammals. The recent establishment of the Itombwe Natural Reserve in June 2016 was a result of the conservation efforts by partners working in this landscape because of the recognition of the importance of the Itombwe massif and the threats to this region.

Biodiversity

The landscape contains 1,041 vertebrates and 2,499 plant species, of which 105 vertebrates and 150 plants are endemic to the Albertine Rift and 56 vertebrates and 30 plants are globally threatened (table 5). The biodiversity of the Maiko-Itombwe Landscape is therefore rich and particularly rich in the numbers of endemic species. Several species are only found in this landscape such as Grauer's cuckoo shrike (*Coracina graueri*), the Itombwe nightjar (*Caprimulgus prigoginei*), and Itombwe golden frog (*Chrysobatrachus cupreonitens*) as well as mostly confined to the landscape such as Grauer's gorilla (*Gorilla beringei graueri*). It is an area that has been relatively poorly surveyed and it is likely that many new species of plant and amphibian remain to be identified here (eg. Greenbaum & Kusamba 2012). Table 5 gives the number of species and numbers of endemic and threatened species for the four vertebrate and plant taxa.

Table 5. The total number of terrestrial vertebrates and plants, together with the number of globally threatened species and species endemic to the Albertine Rift, in the Maiko-Itombwe Landscape.

	Mammals	Birds	Reptiles	Amphibians	Plants
Endemic	24	38	12	31	150
Threatened	17	19	0	20	30
Species	171	697	89	84	2,499

Chrysobatrachs cupreonitens, endemic to the Itombwe massif. *E.Greenbaum/UTEP*

Kivu Ground Thrush, endemic to the Albertne Rift. *A.J.Plumptre*

Photo 3: Images of the Maiko-Itombwe Landscape. Clockwise from top left: Image 1: Montane forest in Kahuzi Biega National Park; Image 2: Mt Kahuzi near the summit; Image 3: ICCN rangers on patrol in highland forest; Image 4: Juvenile Grauer's gorilla; Image 5: Montane forest in Itombwe Reserve; Image 6: The endemic Bururi long-fingered frog (Cardioglossa cyaneospila) from Kahuzi Biega. *A.J.Plumptre/WCS*

Threats to Landscape

The level of threat in this landscape is not as great as the Greater Virunga or Murchison-Semliki Landscapes but people are still having a major impact. Bushmeat hunting is particularly severe and in several sites the large mammals have been mostly hunted to extinction and hunters are targeting large birds (turacos, hornbills, owls) as well as rats and squirrels. In the Itombwe massif we have observed specific traps for different birds and even mist nets that were made locally to trap small birds. Artisanal mining camps occur throughout the landscape and attract armed militias/ rebel groups. These groups support hunting around the mines to feed the miners (Kirkby et al. 2015). Loss and degradation of habitat for farming is also a major threat and is expanding along roads through the forest as the roads are rehabilitated following the civil war. In the east several high altitude forest areas have been lost completely (some with Grauer's gorilla populations) to clearance for agriculture. These highland areas are the most important areas for the endemic species.

Conservation plan for landscape

A conservation action plan was developed for the landscape under the USAID/CARPE program but it didn't develop a conceptual model of the targets and threats and is currently in the process of being revised. Jane Goodall Institute led a process to develop a conceptual model and action plan for great apes and their habitat in eastern DRC which was recently updated (Maldonado & Fourrier, 2015). This action plan was more logical in the approach it took and is similar to the other landscape plans for the Albertine Rift. We therefore based the action plan and model on the Great Ape plan and added in broader conservation targets and threats for the landscape for this plan.

Conceptual model

We based our conceptual model on the model developed for the Great Apes Action Plan for eastern DRC and added in two additional conservation targets: 1) Large mammals which are hunted by man and 2) the unique biodiversity of the landscape. We also combined chimpanzees and gorillas into one target of great apes as the threats to each are similar (figure 10). There were therefore four key conservation targets: 1) Large mammals hunted by man; 2) Ecological and Cultural Diversity of Great Apes; 3) Intact habitat with connectivity; and 4) Unique and Rich Biodiversity.

Seven direct threats were identified that affect these targets:

1. Bushmeat hunting
2. Hunting for cultural reasons
3. Sale of infants for pet trade
4. Disease
5. Habitat fragmentation
6. Habitat degradation
7. Deforestation

The action plan identified key strategies for each target which were combined as follows:

1. Assessment of the priority populations of great apes in the landscape
2. Public awareness campaign strategy and involvement of the local people in conservation
3. Strategy for the consolidation of territorial management
4. Strategy to reinforce the protected areas, community forests, and the sanctuaries
5. Strategy for implementation of the law in the landscape

A long term vision and objectives for the 10 year great apes conservation plan (CAP) were developed which we present here and also present our suggested changes given the two additional conservation targets:

Vision Great Ape CAP: Viable populations of Grauer's Gorilla, endemic species, and of the Eastern Chimpanzee of the DRC, their ecological diversity and the integrity and viability of their habitat, are ensured through the involvement of communities and authorities at all levels, and this is a source of national pride.

Vision Maiko-Itombwe Landscape Plan: Populations of large mammals and the unique biodiversity of the Maiko-Itombwe Landscape conserved, together with intact and connected habitat, ensuring the viability of each species and supported by the local communities and authorities at all

Silverback Grauer's gorilla, an endemic to the Albertine Rift *A.J.Plumptre/WCS* levels, generating national pride in the region.

Key objectives for each strategy

Objectives were identified for each of the five key strategies in the great ape CAP and these are given here together with additional objectives (in bold) where these have been added for the new conservation targets.

Strategy 1. *Assessment strategy of the priority populations of great apes and other large mammals in the landscape*

Objective 1. For 2014, priority populations of great apes and other large mammals are known and baselines for abundance, distribution, and threats are established in consultation with local authorities.

Objective 2. Starting in 2013, tracking techniques (inventory and health) are standardized and work in priority zones is under way.

Objective 3. From 2013, health status of great apes is tracked.

Strategy 2. *Strategy for promoting awareness and involvement of local people in conservation*

Objective 1. For 2016, the rate of respect for the law on conservation protection among target populations has increased by 60%.

Objective 2. For 2016, target population consumption of meat from Great Apes and other large mammals has diminished by 51%.

Objective 3. For 2015, at least one micro-project per identified Great Ape priority zone is put in place.

Strategy 3. *Strategy for consolidation of territory management*

Objective 1. By 2016, pilot plans for land use are worked out and implemented in 3 administrative territories of the landscape, identified as priorities.

Objective 2. For 2021, 30% of land in the landscape will be managed rationally with the land use plans

Objective 3. For 2014, the zones of concentration and impact of human communities next to and in the Great Ape habitats are identified

Strategy 4. *Strategy to reinforce the protected areas, the community forests and the sanctuaries*

Objective 1. By 2016, at least 50% of the surface area of the Protected Areas undergo regular surveillance.

Objective 2. For 2016, the sanctuaries will be able to welcome all the Great Apes caught and will bring together the conditions allowing their reintroduction into the natural environment.

Objective 3. For 2021, the extent of the protected areas and community forests will increase by more than 20%, with an improvement in the management of the protected areas.

Objective 4. For 2014, the identified tourist sites are able to receive tourists.

Objective 5. For 2014, veterinary care for the populations of habituated great apes is ensured.

Strategy 5. *Strategy for the implemention of the laws in the protected areas as well as in the entire intervention zone.*

Objective 1. For 2012, the politico- administrative, judiciary, police, and traditional authorities and ANR are sensitized to the protection of the great apes and a continued training program is in progress.

Objective 2. One advisory panel by province for the protection of forests is put in place and is operational by the start of 2012.

Objective 3. For 2013, 100% of mining, forest, and farming title deeds in the protected areas and 50% in the sensitive zones for the great apes are reconsidered.

Objective 4. For June 2015, 60% reduction of negative impact of mining, forest, and farming operations is reached.

Objective 5. For 2021, no illegal mining activity in the entire protection zone.

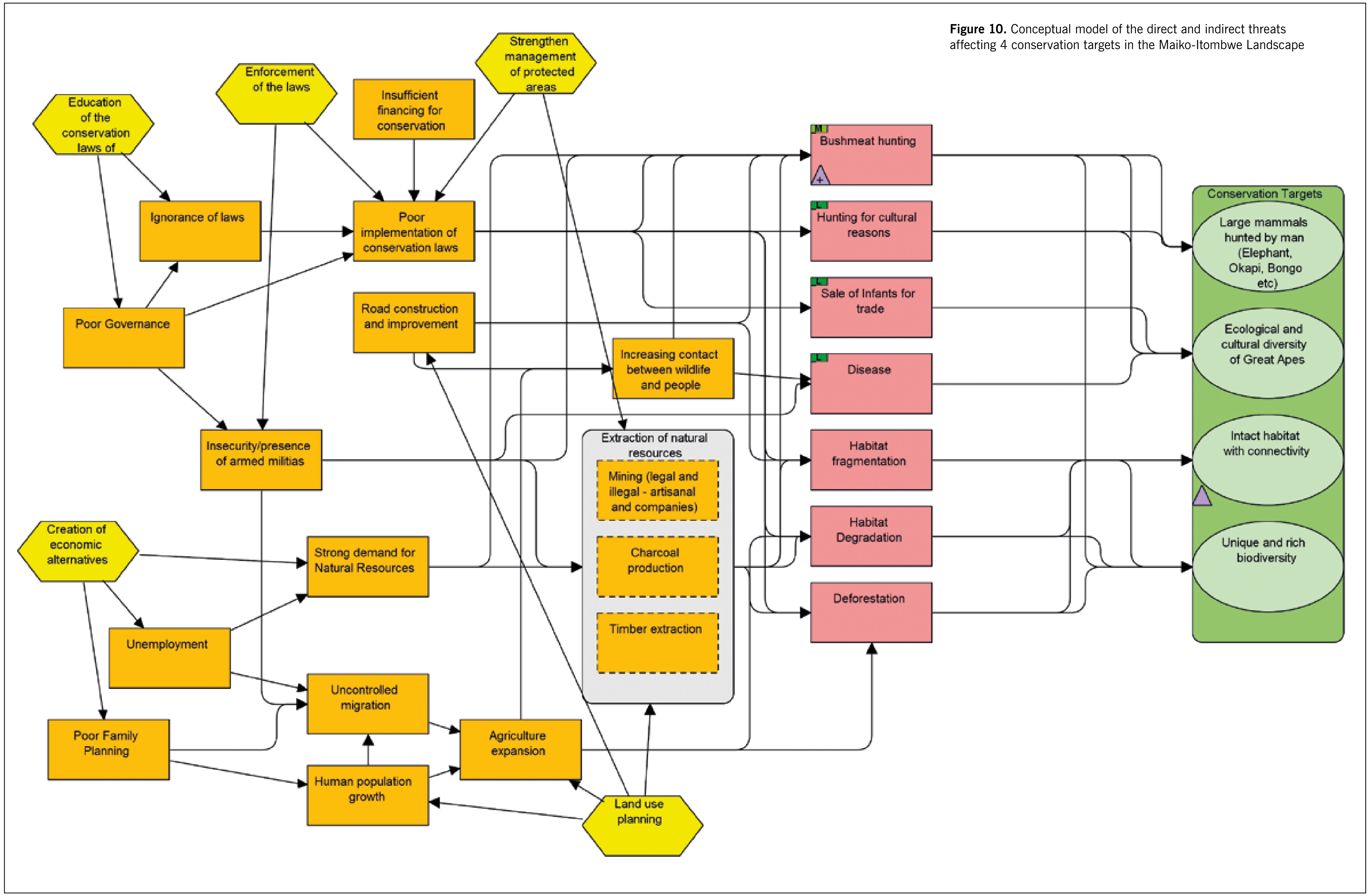


Figure 10. Conceptual model of the direct and indirect threats affecting 4 conservation targets in the Maiko-Itombwe Landscape

Strange Weaver, endemic to the Albertine Rift.
A.J.Plumptre/WCS

LANDSCAPE 4: CONGO-NILE DIVIDE LANDSCAPE

Description of Landscape

The Congo-Nile Divide primarily encompasses the Nyungwe and Kibira National parks in Rwanda and Burundi respectively. The small remnant forest reserves of Gishwati and Mukura in Rwanda, and Bururi and Rumonge-Vyanda in Burundi are also included as part of the landscape but are not connected to each other (Figure 11). Cyamudongo Forest is an isolated forest which is part of Nyungwe National Park but captures some of the lower altitude habitat that is not found in the main block of forest.

Most of the landscape includes small scale cultivation and plantation forests outside protected areas and there is virtually no natural habitat remaining outside these protected areas (figure 11). Inside the protected areas the habitat is rich in plant species, many of which are endemic to the Albertine Rift region. Most of the habitat is montane forest, with some bamboo on the border with Rwanda and Burundi (figure 12), and open areas dominated by bracken ferns (*Pteridium aquilinum*) where forest fires have destroyed the forest in recent years.

The landscape is rich in species and contains some species which are only found here within the Albertine Rift, notably Fisher's caecilian (*Boulengerula fisheri*) which has only been recorded from Cyamudongo Forest and several amphibian species (eg. *Hyperolius Jackie* (Dehling 2012)). Nyungwe National Park is the only site outside the Rwenzori massif (Kerbis-Peterhans & Ntare, 2009) that has been found to protect the Rwenzori Otter Shrew (*Micropotamogale ruwenzorii*). Several Albertine Rift endemic plant species have been discovered in Nyungwe National Park and are only known from here such as *Impatiens nyungwensis* (Fischer & Killmann, 2008).

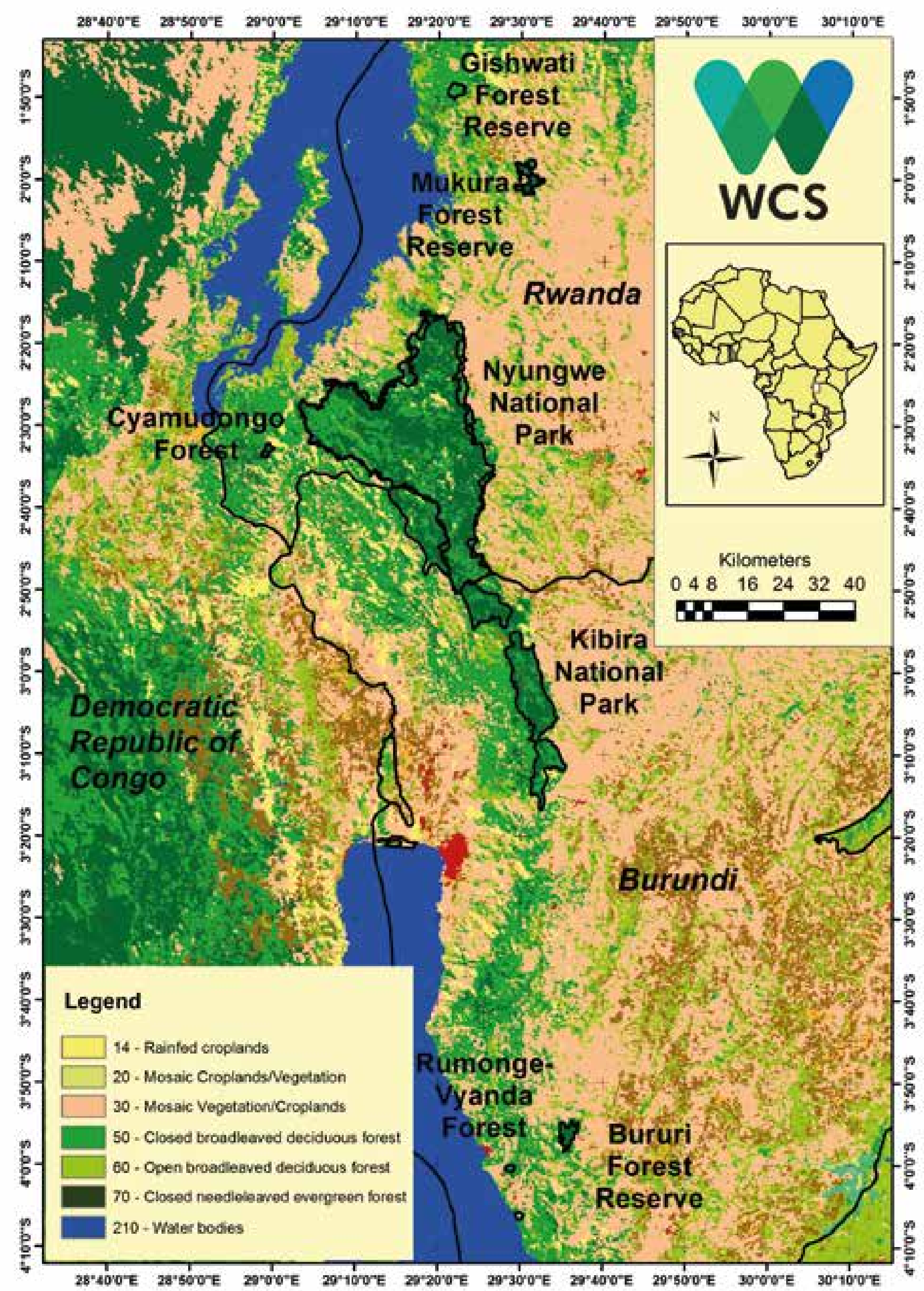


Figure 11. Map of the Congo-Nile divide landscape showing the broad vegetation types in the landscape. Most natural forest lies within protected areas while forest outside is in plantations. Vegetation from Global 2000 landcover map.

The landscape is highly threatened by pressure from people living around the forests. Human population density is highest in this part of the Albertine Rift reaching over 1000 people per km^2. Human use of the forests to collect forest products (fuel wood, lianas, rattan, bamboo etc.) and slow encroachment of the boundaries of the forests are leading to a gradual degradation of the forests. The burning of 12% of Nyungwe National Park in the early 2000s was also a result of people's use of the forest in the dry seasons (De Gryze et al. 2008; Chao et al. 2012) and has led to large areas of bracken fern replacing the forest which is taking a long time to recover.

Boulengerula fisheri, only found in and around Cyamudongo Forest. *F.Pupin/Trento Science Museum*

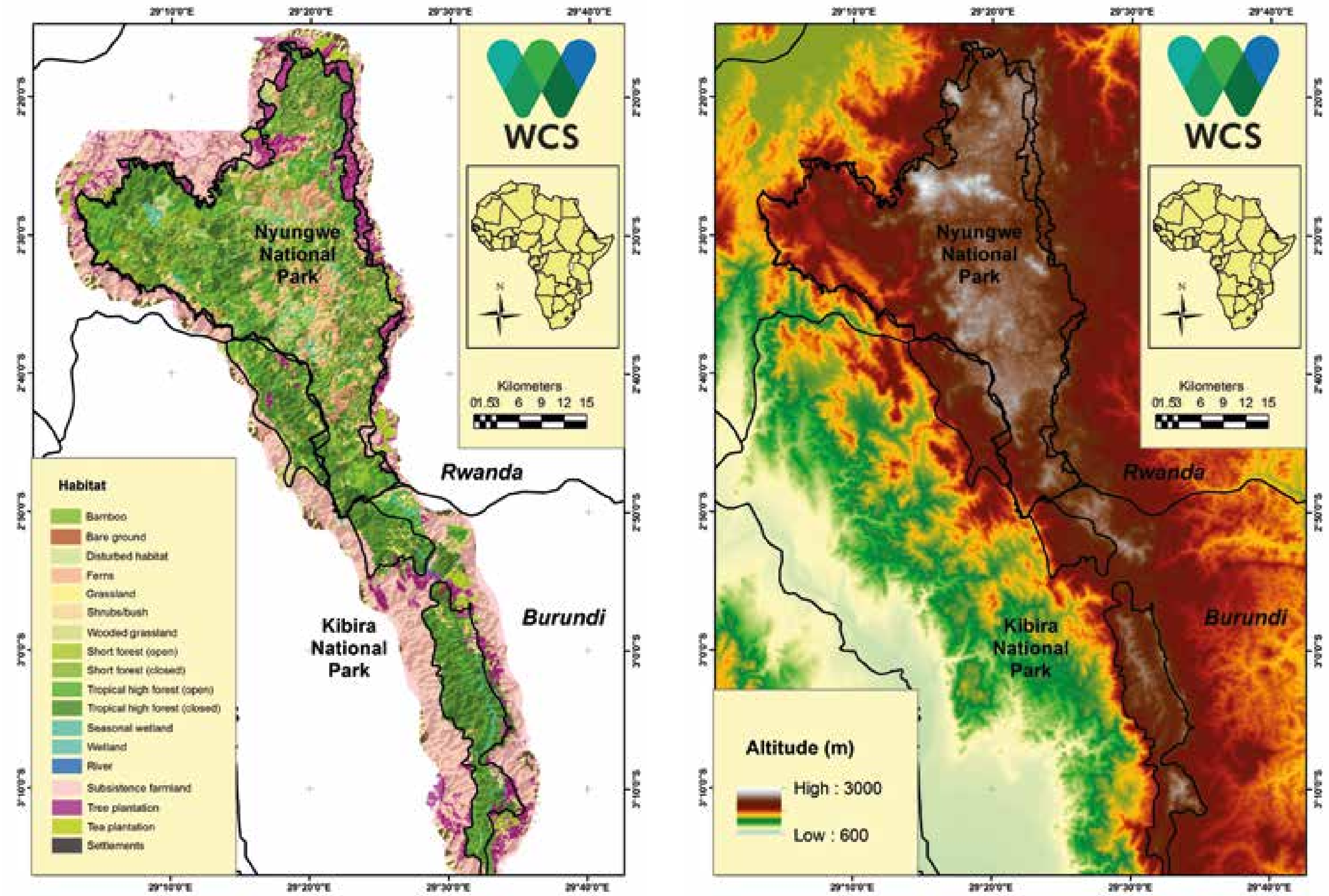


Figure 12. More detailed map of the vegetation of the main Congo-Nile Divide Landscape (left) and elevation (m) (right) in Nyungwe and Kibira National Parks mapped from satellite imagery (WCS).

L'Hoest's or mountain monkey, mostly confined to the Albertine Rift. *A.J.Plumptre/WCS*

Photo 4: Images of the Congo-Nile Divide Landscape. Clockwise from top left: Image 1: Nyungwe National Park bordered by Tea plantation; Image 2: Forest canopy in Nyungwe National park; Image 3: Angolan colobus monkeys that form troops of more than 400 individuals (Credit: M. Wieland/WCS); Image 4: Forest burnt by fires and colonised by bracken fern; Image 5: Flowering *Sericostachys* smothering a tree; Image 6: Bururi Forest Reserve. *A.J.Plumptre/WCS*

Biodiversity

Species richness is high with 580 terrestrial vertebrates and 1,340 plant species of which 79 vertebrates are endemic and 39 threatened (Table 6). There are a particularly large number of endemic species of plants in this landscape (174 species), despite its relatively small area of natural habitat (about 1,500 km^2), more than any other landscape in the Albertine Rift (Table 5). Given that many invertebrate species can be specific to plant species this may mean that invertebrate diversity is particularly high in these forests. While not as rich as the Greater Virunga Landscape or Maiko-Itombwe Landscape for terrestrial vertebrate species, the percentage of species in each taxon that are endemic to the Albertine Rift is higher than at any of the other landscapes, particularly birds, reptiles and plants. Species that are only known from this landscape include Fischer's Caecilian, *Hyperolius jackie* (Dehling, 2012), and several plant species (Fischer & Killmann, 2008). More species continue to be found as researchers explore Nyungwe, Kibira and Bururi forests and these are only likely to increase with time. Nyungwe and Kibira Parks have unique groups of Angolan colobus monkeys which form groups of more than 400 individuals (Fashing et al. 2007), some of the largest primate groups in the World.

Table 6. The total number of terrestrial vertebrates and plants, together with the number of globally threatened species and species endemic to the Albertine Rift, in the Congo-Nile Divide Landscape.

	Mammals	Birds	Reptiles	Amphibians	Plants
Endemic	19	29	9	22	174
Threatened	14	11	0	14	7
Species	124	365	43	48	1,340

Threats to Landscape

Key threats to the landscape result from the very high human population pressure around the forests, some of the highest in rural Africa with over 1000 people per km^2 in some areas. There is extensive use of the forests to supply fuel wood and non-timber forest products such as rattan, bamboo, honey, lianas, and medicinal plants. There is also extensive hunting of large and medium mammals with the result that elephants and buffalos have been extirpated from Nyungwe and Kibira National Parks (Chao et al. 2012), and duikers and bushbucks are at very low density. Some hunters resort to catching Gambian rats or cane rats for meat, and recently some have started hunting primates. Encroachment for farming is a constant threat to the boundaries of the protected areas and illegal farming of crops such as marijuana within the forest leads to the degradation of the forest. Gold mining was a major threat in the 1980s but is rarer now than it used to be. Easy access to the forest by people leads to other threats such as the outbreak of fires. Recent El Nino years have led to a drastic drying of parts of Nyungwe National Park with the result that between 2001 and 2004 12 % of the forest was destroyed by fire (Chao et al. 2012). Active fire fighting by protected area staff and local communities is now an annual occurrence to protect the remaining forest. Where these fires occurred bracken has taken over and it has taken over 10 years for the first saplings to start to appear above the ferns. Studies by WCS scientists have shown that once the saplings get above the fern layer then regeneration proceeds more quickly.

Other threats include natural factors such as the smothering of trees and regenerating forest by a climber, *Sericostachys scandens*. This plant flowers once and dies after about 10-15 years of growth but as it grows it can affect the growth and survival of even large trees because it smothers canopies of host trees. This leads to greater tree mortality and a slowing of forest regeneration. It was once thought that an increase in *Sericostachys* abundance was due to the loss of large herbivores, such as elephants, but this is not thought to be the case now and it is more likely that any spread in distribution is due to opening of the canopy of the forest through anthropogenic activities.

Conservation plan for landscape

A transboundary conservation plan for the Nyungwe-Kibira Part of the Congo-Nile Divide was developed by WCS with the national park authorities RDB and INECN in 2009.

Conceptual model

The conceptual model of the Congo Nile divide identified three key conservation targets:1) Biodiversity and endemic species in the Albertine Rift; 2) Ecosystem services and functions; and 3) ecological integrity and health of ecosystems. Ecological integrity and health was selected because this landscape has been greatly affected by anthropogenic pressures, particularly fire, and participants in the planning process wanted to highlight the importance of conserving this within the landscape.

Eight main direct threats to these targets were identified and included:

1. Hunting Bushmeat
2. Encroachment resulting in habitat loss and degradation
3. Fires resulting in habitat loss and degradation
4. Mining resulting in degradation and siltation in riparian areas in particular
5. Unplanned infrastructure development resulting in environmental degradation and pollution
6. Invasive species resulting in degraded habitats
7. Disease resulting in biodiversity loss
8. Climate change resulting in changed ecosystem functions and biodiversity

A vision and goal were formulated for the transboundary action plan as follows:

Vision: *The integrity of Nyungwe-Kibira Ecosystem is restored, its ecological, economic and social values are recognised and accessible for the sustainable development at local, national and global levels*

Goal: *The transboundary collaboration mechanisms are established, and operational for an integrated management of the Nyungwe-Kibira Ecosystem*

Several *Impatiens* are endemic to the Albertine Rift. *A.J.Plumptre/WCS*

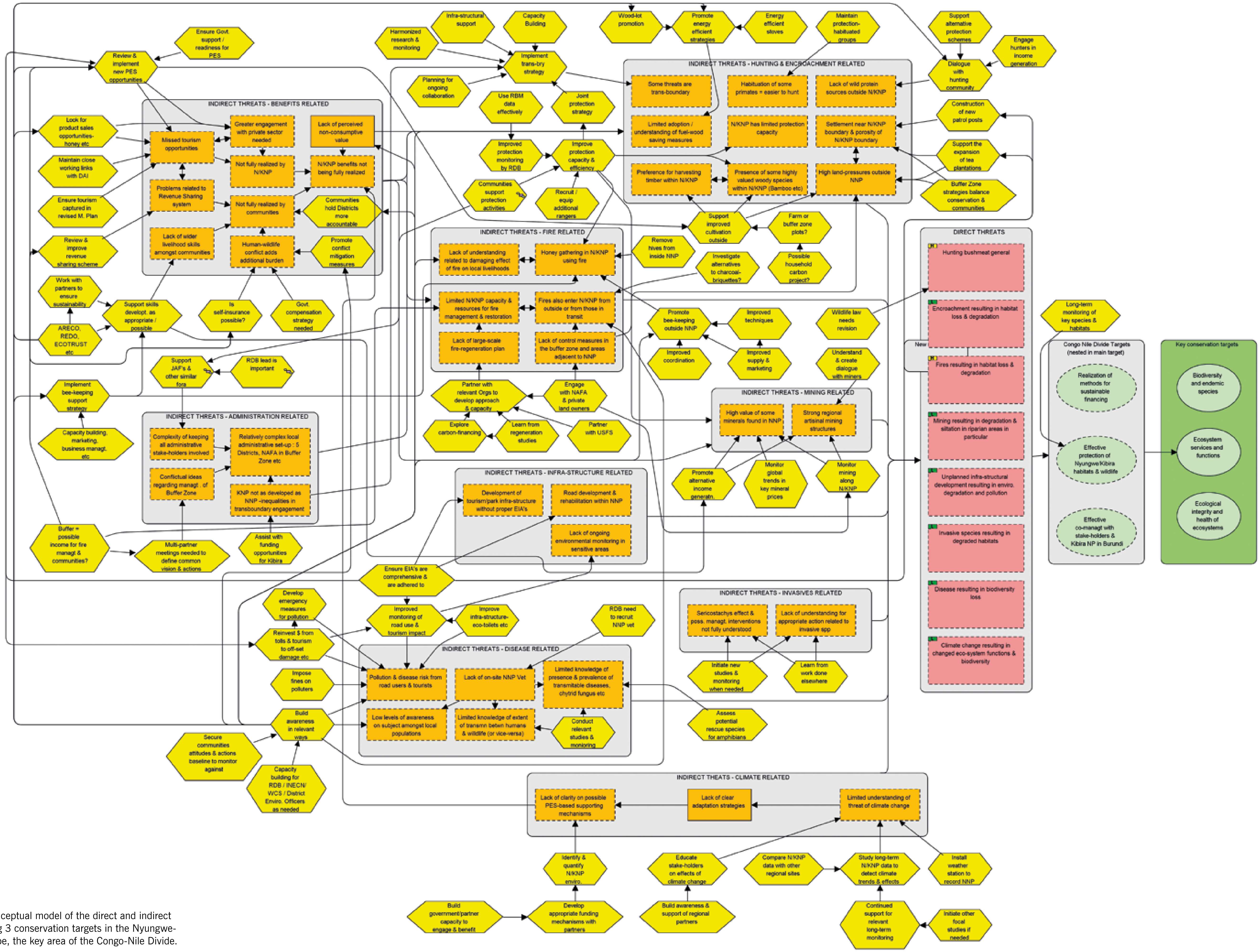


Figure 13. Conceptual model of the direct and indirect threats affecting 3 conservation targets in the Nyungwe-Kibira Landscape, the key area of the Congo-Nile Divide.

Eight strategic objectives were identified in the transboundary plan:

1. Policies and laws are in place and harmonized for the sustainable development and conservation of the Nyungwe-Kibira landscape
2. Capacity to manage the Nyungwe-Kibira Transboundary border by institutions and other stakeholders is enhanced
3. The ecological, economic and social values of the Nyungwe-Kibira landscape are well understood
4. Attitude and behaviour of stakeholders have changed because of a good understanding of the value and importance of the Nyungwe-Kibira landscape
5. Conservation of the Nyungwe-Kibira landscape contributes to the human welfare at local, regional and international levels
6. Nyungwe -Kibira landscape is restored and well protected
7. Functioning regional collaborative mechanisms are in place
8. Long -term sustainable financing mechanisms established

Key strategies within each strategic objective

Within the eight strategic objectives key strategies were identified during the planning and these are summarised here.

Strategic Objective 1: *Policies and laws are in place and harmonized for the sustainable development and conservation of the Nyungwe-Kibira Landscape*
Strategy 1.1: Harmonise policies and laws between the two countries and work to implement recommendations for transboundary legislation

Strategic Objective 2: *Capacity to manage the Nyungwe-Kibira transboundary landscape by institutions and others stakeholders is enhanced*
Strategy 2.1: Align the Institutional structures of INECN and RDB to facilitate the Transboundary collaboration.
Strategy 2.2: Coordinated planning and monitoring of the Nyungwe-Kibira landscape
Strategy 2.3: Capacity of PA staff and others stakeholders is enhanced
Strategy 2.4: Management oriented research aimed at sustainable conservation of biodiversity in the Nyungwe-Kibira landscape undertaken

Strategic Objective 3: *The ecological, economic and social values of the Nyungwe-Kibira landscape are well understood*
Strategy 3.1: Assessment and marketing of the ecological, economic and social values of Nyungwe-Kibira Landscape

Strategic Objective 4: *Attitude and behaviour of stakeholders have changed because of the good understanding of the value and importance of the Nyungwe-Kibira landscape*
Strategy 4.1: Positive attitude towards Nyungwe-Kibira Landscape encouraged.
Strategy.4.2: Acceptance of the PA as an important resource to be managed by different partners including local community

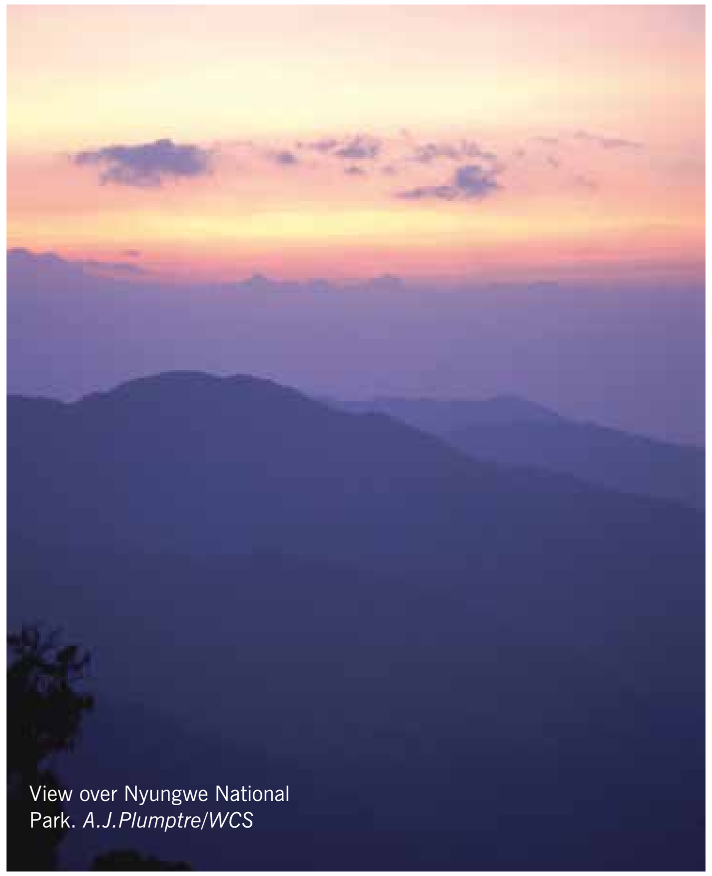
Strategic Objective 5: *Conservation of the Nyungwe-Kibira landscape contributes to the human welfare at local, regional and international levels*
Strategy 5.1: Natural resource based economic development promoted to support conservation efforts and contribute to the welfare of local, regional and international community
Strategy.5.2: Sustainable economic development of the natural resource based tourism enhanced
Strategy 5.3: Required infrastructure for tourism and PA management identified and developed
Strategy 5.4: Local communities participating in and benefiting from natural resource management and other development initiatives

Strategic Objective 6: *Nyungwe -Kibira landscape is restored and well protected*
Strategy 6.1: Formal transboundary collaborative law enforcement mechanisms to control illegal activities established in the Nyungwe-Kibira landscape.
Strategy 6.2: Connectivity and integrity of core wildlife protected areas in the Nyungwe-Kibira Landscape ensured
Strategy 6.3: Degraded areas are well protected and restored in the Nyungwe-Kibira Landscape
Strategy.6.4: Integrity of protected areas assured through development of mechanisms for natural disaster management

Strategic Objective 7: *Functioning regional collaborative mechanisms are in place*
Strategy.7.1: Coordination mechanisms enhanced to contribute towards avoiding conflicts, duplication and wastage of existing resources.
Strategy 7.2: Effective communication mechanisms between protected area authorities and other stakeholders established

Strategic Objective 8: *Long -term sustainable financing mechanisms established*
Strategy 8.1: Explore sustainable financial mechanisms and their applicability

The implementation of this transboundary plan encouraged the development of an MOU between Rwanda and Burundi and the formalisation of this eventually with a treaty between the two countries. It was planned to establish a Core Secretariat that would take over the management of the transboundary engagement but to date the funding for this has not been available.



View over Nyungwe National Park. *A.J.Plumptre/WCS*

LANDSCAPE 5: GREATER MAHALE LANDSCAPE

Description of Landscape

The Greater Mahale Landscape in western Tanzania encompasses the Mahale Mountains National Park (MMNP) together with the Masito-Ugalla region south of Uvinza, the Sitebi Highlands and the Wansisi Hills west of Mupanda town. A larger landscape was initially identified that included Gombe National Park and south of MMNP up to the southern end of Lake Tanganyika and Mbizi forest but for planning and management purposes it was decided to separate these areas and planning focused around the Gombe National Park and Greater Mahale Landscape (figure 14). Albertine Rift endemic species are mostly confined to the Greater Mahale Landscape and this is summarised here. The Greater Mahale Landscape (GML) is also known as the Greater Mahale Ecosystem. Other protected areas within the GML include the Ugalla Forest Reserve and to the south east at the edge of the landscape the Katavi National Park.

The Mahale Mountains and the area around it are recognized as being an outlier of the Albertine Rift mountains in the western Uganda-Kivu-Burundi highlands. Many of the species found here come from central Africa or are similar to those found in the forests in Uganda, Rwanda, Burundi and eastern Democratic Republic of Congo. A study of the birds of this region led Moreau (1943) to suggest that in geological history there had been a barrier to movements of animals from south of Karema (just south of Mahale) and that the Malagarasi river that borders the northern part of the Ugalla-Masito region is a relatively recent barrier. As a result species in the past were able to migrate from the north to this region but not from the south. The postulated barrier was an ancient Rift valley that predated the formation of Lake Tanganyika - the Karema Gap (Moreau, 1943, Nishida, 1990).

The Ugalla-Masito area is characterized by a very interesting topography of eroded canyons, cliffs and flat-topped hills. This area is the driest part of chimpanzee range and is dominated by Miombo woodland with *Brachystegia* trees (together with *Isoberlinia* and *Julbernadia*). In the dry season Miombo woodland loses its leaves and trees become bare until the leaves flush after, or sometimes just prior to, the first rains. In the valleys along streams are gallery forests which remain green throughout the year. These forests are where the chimpanzees find much of their food although Miombo woodland is also a source of food but it is often more seasonal in nature. On the flat-topped hills bare rocks are often found, grassland or sclerophyllous vegetation that is adapted to low moisture availability. Further south the Ntakata-Sitebi highlands and the region around Wansisi hills and towards Mpanda is dominated by higher elevation hills and mountains. Below about 1800 metres the vegetation is Miombo woodland

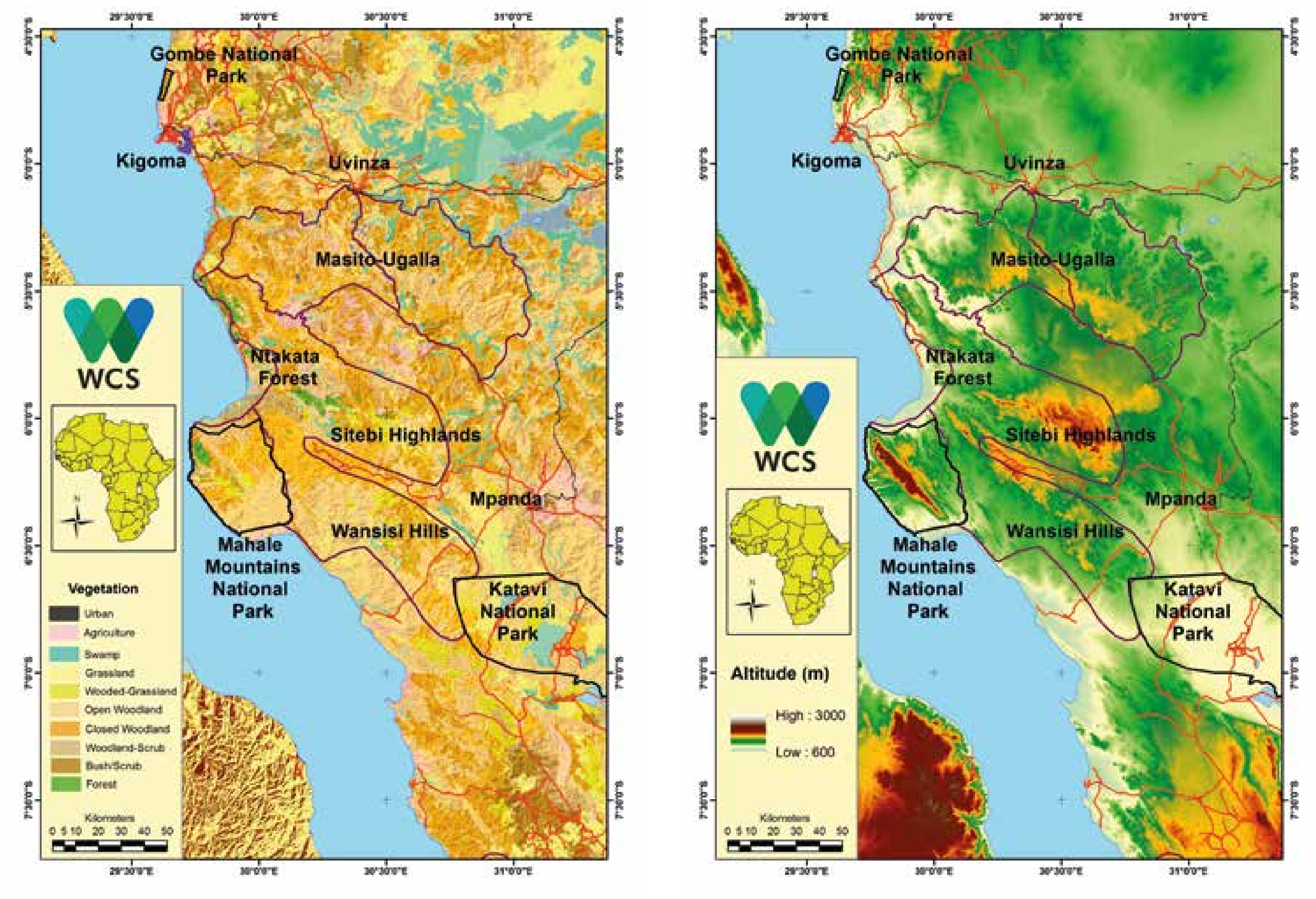


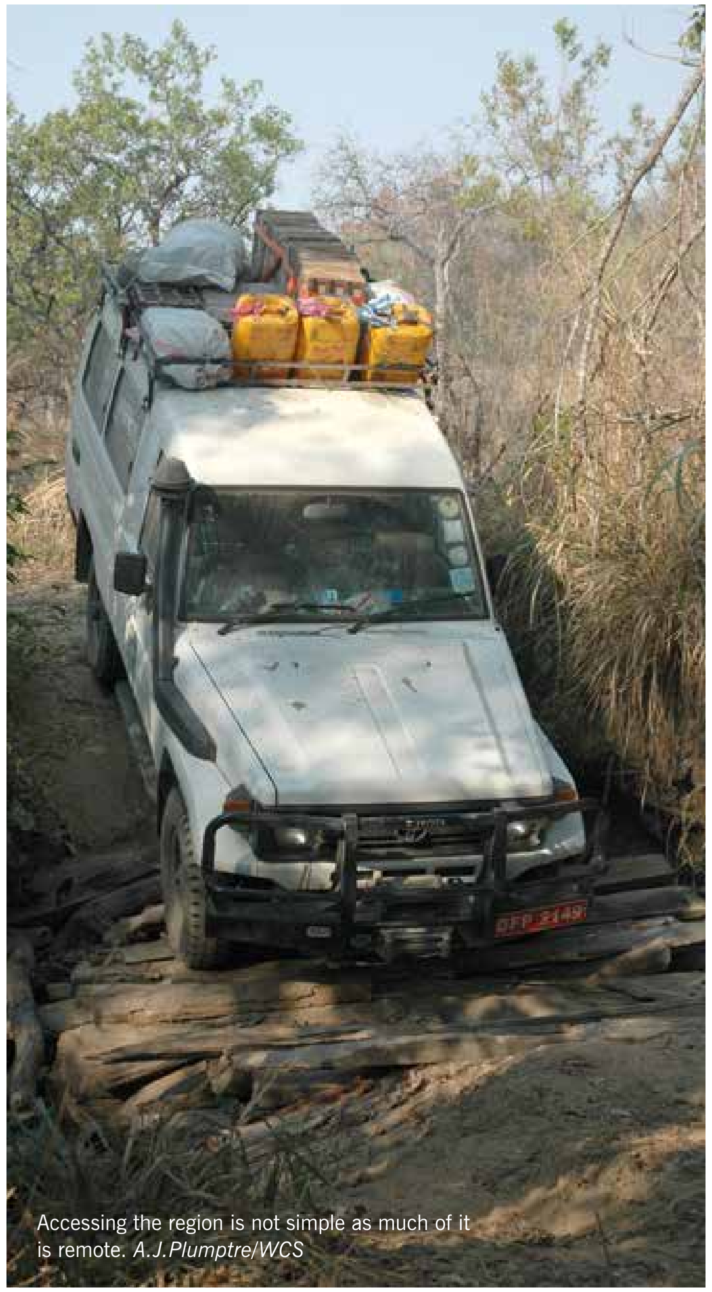
Figure 14. Map of the vegetation of the Greater Mahale Landscape (left) and elevation (m) (right).

and gallery forest as found in the Ugalla-Masito area but there are also large areas of lowland bamboo (*Oxytenanthera abyssinica*) to the east of MMNP towards and beyond Mwese to Mpanda. Above 1800 metres altitude the Miombo woodland gives way to high altitude grasslands with montane plants such as *Proteas*, and gallery forest. A few small swampy areas occur in the valley bottoms and people have started cultivating in the recent past along the Mpanda-Mwese-Lubalisi road. A larger block of forest occurs in and around the Ntakata Forest Reserve (figure 14). In the area south of Mahale from Wansisi Hills to Loazi there is extensive cultivation along the lake shore with gallery forest following the steeper rivers. Further inland there is an escarpment which leads up to highland grassland and gallery forest with patches of Miombo at lower altitude.

Biodiversity

This area is characterized by a species rich vegetation (Plumptre et al. 2007a) which is in part due to the varied topography. The altitudes in this region range from 780 metres to 2,460 metres a.s.l. (Nishida, 1990). A total of 683 terrestrial vertebrates and 1,890 plant species have been recorded, with seven vertebrates and 36 plants endemic to the Albertine Rift region, and 16 vertebrates and 13 with globally threatened status. Five hundred and fifty seven bird species have been recorded for this region (Table 7) yet the region has been poorly surveyed for birds (N. Baker pers. comm.).

The Sitebi highlands contain open grasslands and patches of forest and several new species of plant have been discovered here (K. Vollesen unpublished reports; Vollesen and Bidgood, 1994, 1997). Their 1994 plant surveys found that 7% of plants in this region were new to science and an additional 7% were new in their 1997 expedition. This region also includes most of the global range of the Kungwe Apalis (*Apalis argentea*) described by Moreau and Hall (1970), currently (Urban et. al. 1997) thought to be a subspecies of buff-throated apalis (*Apalis rufogularis*). WCS ornithologists suspect that it may deserve species status however, and keep it distinct for the moment based on the call from surveys in GML compared with surveys elsewhere of buff-throated apalis in the Albertine Rift and because it is a poorly known in Tanzania. This region also has 13 endemic butterflies (Kielland, 1990). MMNP is famous for its long term research on chimpanzees which has been ongoing since 1965 established by Professor Toshisada Nishida (Nishida, 1990). It is therefore a region that is rich in species despite there being little forest in the landscape (table 7).



Accessing the region is not simple as much of it is remote. *A.J.Plumptre/WCS*

The Miombo woodland is botanically diverse. *A.J.Plumptre/WCS*

Photos 5: Images from the GML. From top left in a clockwise direction: Images 1 and 2 - Rocky canyon lands typical of the Ugalla-Masito region; Image 3 - montane grassland and gallery forest in the Sitebi highlands; Image 4 - Mahale National Park and mt Kungwe, the highest peak; Image 5 - gallery forest in lowland bamboo; image 6 - Miombo woodland with young leaves (red). *A.J.Plumptre/WCS*

Table 7. The total number of terrestrial vertebrates and plants, together with the number of globally threatened species and species endemic to the Albertine Rift, in the Greater Mahale Landscape.

	Mammals	Birds	Reptiles	Amphibians	Plants
Endemic	0	3	1	3	36
Threatened	5	9	0	2	13
Species	71	557	31	24	1,890

Threats to Landscape

Human population density is still relatively low compared to other parts of the Albertine Rift but it is increasing and this is leading to more agricultural land and increasingly larger projects for farming rice and other crops in the region. There is little forest in this landscape but it is targeted for agricultural production because it is fertile and tends to be in valley bottoms where the soil is moist and water is available. Associated with the increasing human population are increased bush fires that are set by hunters or people clearing their fields and this also leads to forest loss as trees at the forest margins are killed by repeated fires. Another major threat in the landscape is the large Mishamo refugee camp between Masito-Ugalla and the Sitebi Highlands, which houses refugees from Burundi, who are involved in hunting (Piel et al. 2015) and these have a major impact on the woody vegetation as they source fuel wood from around the camp. Mining interests in the region have led to mining companies moving in and prospecting for gold, copper, nickel and other minerals, and many exploration concessions in the landscape have been taken up by companies.

Poaching for bushmeat has been fairly extensive in the past although the number of snares found in recent years is not high (Piel et al. 2015). Most large mammal species are rarely observed and species such as elephants and other large ungulates are at low numbers. Chimpanzees, however, were estimated at about 2,600 in 2006 (Moyer et al. 2006).

Conservation plan for landscape

A conservation action plan was developed for the Greater Mahale Landscape in a process led by the Jane Goodall Institute (JGI), between 2007-2008. Three planning meetings were held to develop the inputs to the plan and included extensive GIS analysis made by Lilian Pintea of JGI.

Conceptual model

The planning process identified six conservation targets: 1) Chimpanzees; 2) elephants; 3) Montane ecosystems; 4) Miombo woodland and evergreen forest; 5) Bamboo Forest and 6) the fish diversity of Lake Tanganyika. The fish diversity was included because parts of MMNP include the lake and the human activities on the land have impacts on the lake also. The conceptual model developed at the meetings was complex and has been simplified in figure 15.

Five key threats were identified:

1. Bushmeat hunting
2. Disease impacts on wildlife
3. Habitat conversion to agriculture
4. Habitat degradation from human activities
5. Incompatible fishing methods

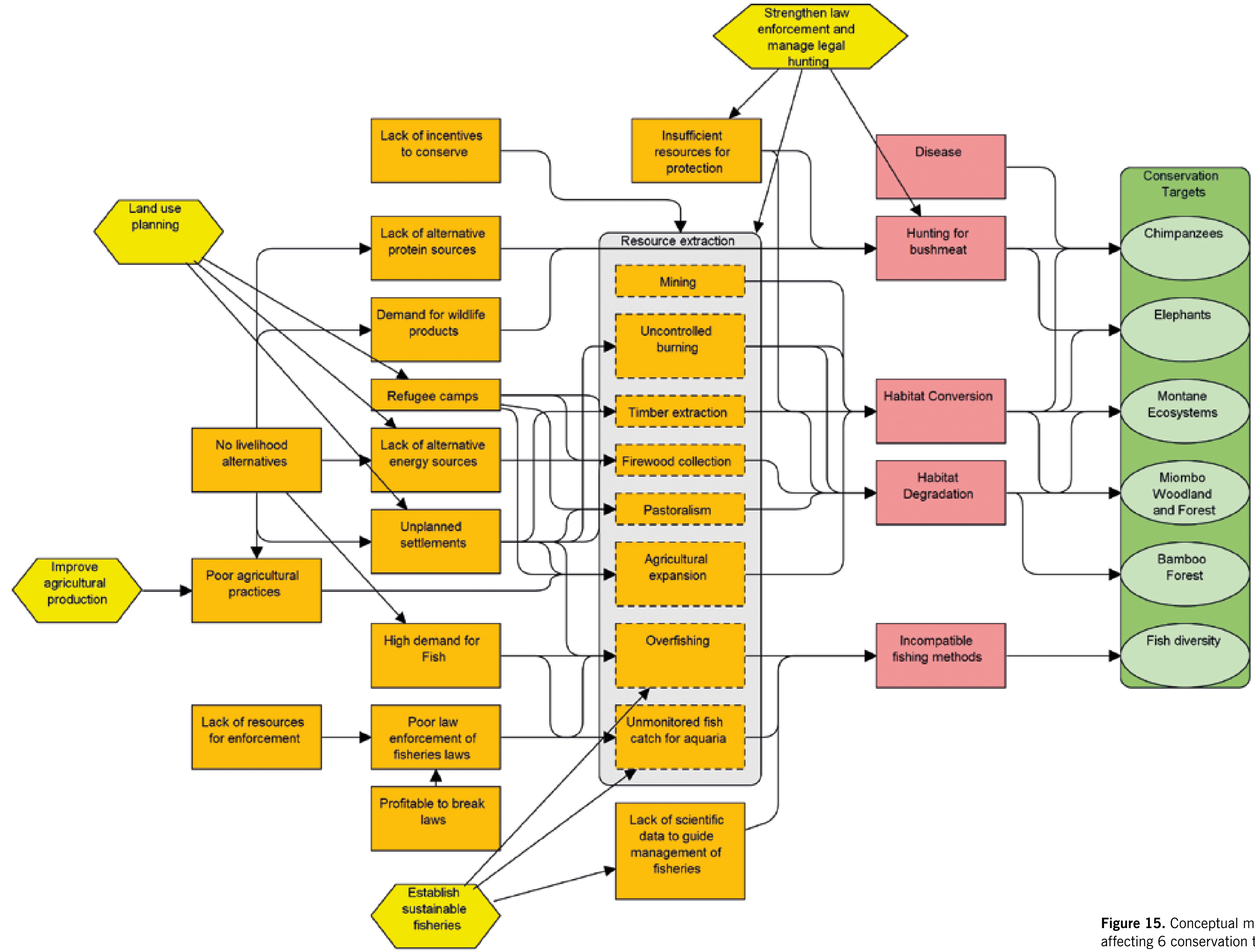


Figure 15. Conceptual model of the direct and indirect threats affecting 6 conservation targets in the Greater Mahale Landscape

Key objectives and activities

Thirteen strategic objectives were developed during the planning and specific activities identified for each of these objectives.

Objective 1: *By 2013, resources and capacity for Village Land Use Planning (which are in accordance with the Greater Mahale Conservation Plan) have been provided and used to develop VLUMPs; by 2018, LUPs are fully implemented in all GML villages.*

Activity 1.1: GML Priority Areas are endorsed by key stakeholders (i.e., create Map and get endorsement).

Activity 1.2: Ensure GML conservation priorities are incorporated into existing District Development Plans (5 year plans and annual plans).

Activity 1.3: Support land-use planning activities and implementation.

Objective 2: *By 2009, relationships are established with refugee agencies and NGOs to ensure that the most appropriate land use is implemented within areas that are currently designated as refugee settlements and past negative natural resource impacts are addressed or offset.*

Activity 2.1: Support land-use planning activities and implementation.

Objective 3: *By 2018 the total deforestation rate (of evergreen forests and woodlands) is reduced.*

Activity 3.1: Establish and implement sustainable resources use programme for communities which focuses on improving NR management, efficient use of fuel resources and enforcement of environmental laws, harvesting and management plans.

Activity 3.2: Increase capacity of responsible authorities to ensure sustainable management of timber extraction and use (e.g. enforcement of quota's and harvesting plans).

Activity 3.3: Strengthen existing and new Forest Reserves management (for example by demarcating boundaries and enforcing associated laws).

Activity 3.4: Pursue appropriate higher level protection status/type for areas of especially high conservation priority.

Activity 3.5: Investigate and, if appropriate, implement financial support mechanisms for community based natural resource management (e.g., carbon credit schemes, fair trade, and forest certification).

Activity 3.6: Investigate potential regeneration programmes for areas where natural forest has been cleared and implement those strategies found to be appropriate.

Objective 4: *By 2012 fisheries management is improved, the use of illegal fishing methods is progressively declining and the rate of extraction of fish is at a sustainable level.*

Activity 4.1: Strengthen the enforcement and awareness of fishing regulations.

Activity 4.2: Establish a programme to demonstrate best fishing techniques and provide incentives to facilitate their use

Objective 5: *By 2012 the rate of chimpanzee mortality from diseases transmitted by humans is reduced by 90% within Protected Areas, and is zero in all new chimp habituation projects.*
Activity 5.1: Develop and enforce employees' health programme for chimp trackers and guides within the PA and enforce regulations concerning cleanliness in and around tourist camps.
Activity 5.2: Decrease pressure on habituated chimps by diversifying tourist activities within the PA.
Activity 5.3: Provide assistance and advice to Wildlife Division concerning protocols that should be followed by projects habituating chimps outside the PA
Objective 6: *By 2015, more than 75% of agricultural activities (including livestock keeping) take place in designated areas (as laid out in the Greater Mahale Conservation Plan) and agricultural production in increasing.*
Activity 6.1: Facilitate/improve enforcement of environmental laws in relation to agriculture.
Activity 6.2: Establish microfinance groups to facilitate acquisition of capital equipment/materials for farmers (e.g., fertilisers, tractors, seeds, livestock etc).
Activity 6.3: Strengthen the capacity and delivery of current agricultural extension services to ensure that farmers use best practices.

Objective 7: *By 2018, poaching is reduced by 50% overall and by 75% in newly designated Protected Areas within 5 years of their establishment; appropriate legal hunting is sustainable with benefit sharing (communities and wildlife protect).*
Activity 7.1: Pursue appropriate higher level protection status for areas of especially high conservation priority.
Activity 7.2: Gather information / conduct research to determine wildlife population baselines and establish population monitoring programmes, to ensure sustainable wildlife management and use.
Activity 7.3: Strengthen the ability of responsible authorities (District Councils, WMA management committees) to sustainable management of wildlife resources (monitoring, enforcement, quota setting, licensing, and anti-poaching measures).
Activity 7.4: Improve benefit sharing to local communities, to provide compensation for reduced access to natural resources, e.g., support enterprise development, shares in revenues from hunting incomes.

Objective 8: *By 2018, connectivity of key areas within the ecosystem is maintained and/or restored.*
Activity 8.1: Support land-use planning activities and implementation.
Activity 8.2: Pursue appropriate higher level protection status for areas of especially high conservation priority.
Activity 8.3: Gather information / research and identify areas of key importance in terms of structural and functional habitat connectivity.
Activity 8.4: Ensure no new settlements are developed and existing settlements are voluntary removed in priority conservation areas and corridors.
Activity 8.5: Engage with discussions regarding new legislation for corridor areas and implement if appropriate

Objective 9: *From 2013 onwards all infrastructure development within the GML is compatible with land-use plans and the conservation of key priority conservation areas (as laid out in the GML Priority Areas Map).*
Activity 9.1: Build the capacity of appropriate local institutions to adopt environmentally sensitive infrastructure development procedures.
Activity 9.2: Work with wards to ensure ward development plans are compatible with GME conservation priorities.
Activity 9.3: Monitor all infrastructure development to ensure compliance with Tanzania law and highest global standards through independent "watchdog" and ensure independent EIAs are undertaken when necessary.

Objective 10: *By 2018 there is no burning within evergreen forest and the frequency and extent of uncontrolled fire is reduced to acceptable levels in all other habitats.*
Activity 10.1: Develop an adaptive fire management plan for the GME, using definitions of acceptable levels of burning that are based on sound scientific data concerning the effects of burning on different habitat types.
Activity 10.1: Strengthen the capacity of VECs and VCs to enforce by-laws through discussion forums and training.

Objective 11: *By 2012 ensure relationships with relevant partner organisations are in place to achieve a reduction in population growth from 2007 baseline levels to 2.6% (the national average) by 2030.*
Activity 11.1: Develop partnerships with donors/development/health organizations that have experience implementing strategies to reduce population growth and support their implementation
Activity 11.2: Investigate strategies to manage, limit or discourage immigration into the area and implement.

Objective 12: *By the end of 2008, sufficient financial resources are acquired to implement CAP strategies, and by mid-2009, human resources and political buy-in are acquired.*
Activity 12.1: Publicise GML conservation priorities to key decision makers.

Objective 13: *All current and future exploration and mining activities use the most environmentally and socially sensitive methods available and are subject to rigorous EIA processes according to the highest global standards.*
Activity 13.1: Develop GML-specific conservation guidelines for mining and exploration operations and see them formally adopted by mining companies and government.
Activity 13.2: Monitor mining and exploration activities to ensure compliance with Tanzania law and highest global standards through independent "watchdog" and ensure independent EIAs are undertaken when necessary (see also Objective 9 for infrastructure development).

Miombo woodland dominates the lower altitudes in this landscape. *A.J.Plumptre/WCS*

LANDSCAPE 6: KABOBO-LUAMA LANDSCAPE

Description of Landscape

In the ARCOS (2004) strategic framework plan this landscape encompassed the Marungu highlands and the Kabobo massif. Following aerial surveys made by WCS in 2006 which showed that there was little remaining forest in the Marungu highlands the focus of conservation in this region turned to Kabobo massif and the adjacent Luama Reserve. The Kabobo-Luama Landscape is situated in south eastern Democratic Republic of Congo (DRC) on the western shores of Lake Tanganyika. It encompasses the largest block of intact forest remaining on the lake and the only place around the lake where forest ranges from the lake shore at 770m a.s.l to montane forest at 2,700m a.s.l. The landscape includes the existing Luama Katanga Reserve and the recently established Kabobo and Ngandja Natural Reserves (figure 16). The terrain is very rugged in the forest block with steep slopes down to river valleys which flow into Lake Tanganyika. The ridges between the valleys orient east-west up to an escarpment that then drops about 700 metres to a plateau of undulating land which extends west into the Luama Katanga Reserve.

The habitat includes a block of medium altitude and montane forest and this then becomes montane grassland on the escarpment before it drops down to the plateau where Miombo woodland and gallery forest dominate. This gradually becomes more dominated by Miombo woodland as you move west. In the north of the landscape is a large wetland, the Elombwe Marsh (190 km²), which is potentially of conservation value but has not been surveyed greatly and is now part of the Ngandja Reserve. Part of the Kabobo Natural Reserve includes the lake shore and up to 200 metres into the lake with the aim that it will protect some of the rich fish diversity of the lake, recognised for its high numbers of endemic cichlid species (Snoeks,2000; Patterson & Makin, 1998). Similarly the recently established Ngandja Reserve conserves 277 km² of the lake along the shore south of the Bay of Burton.

Despite few surveys of the region, this landscape is biologically rich and is similar in composition to the Itombwe massif but also containing some species which are unique to the landscape (Kerbis-Peterhans et al. 2013a; 2013b). A sizeable population of chimpanzees has been estimated for the landscape of 2,500 individuals (Plumptre et al. 2007c) and a few other large mammals still occur in the landscape such as hippopotamus, elephant, buffalo and bongo, although in very small numbers. Following surveys of the biodiversity of the region made by WCS in 2006 and 2007 and a socioeconomic survey of people living in the landscape in 2008 (Plumptre et al. 2009) a process was started to establish a protected area in the region to ensure the conservation of the rich biodiversity of the forest. Every village in the landscape around the forest block was consulted about their views and the traditional chiefs representing the villages voted in two meetings to establish a new national park, the Misotshi-Kabogo National Park. A participatory mapping approach was

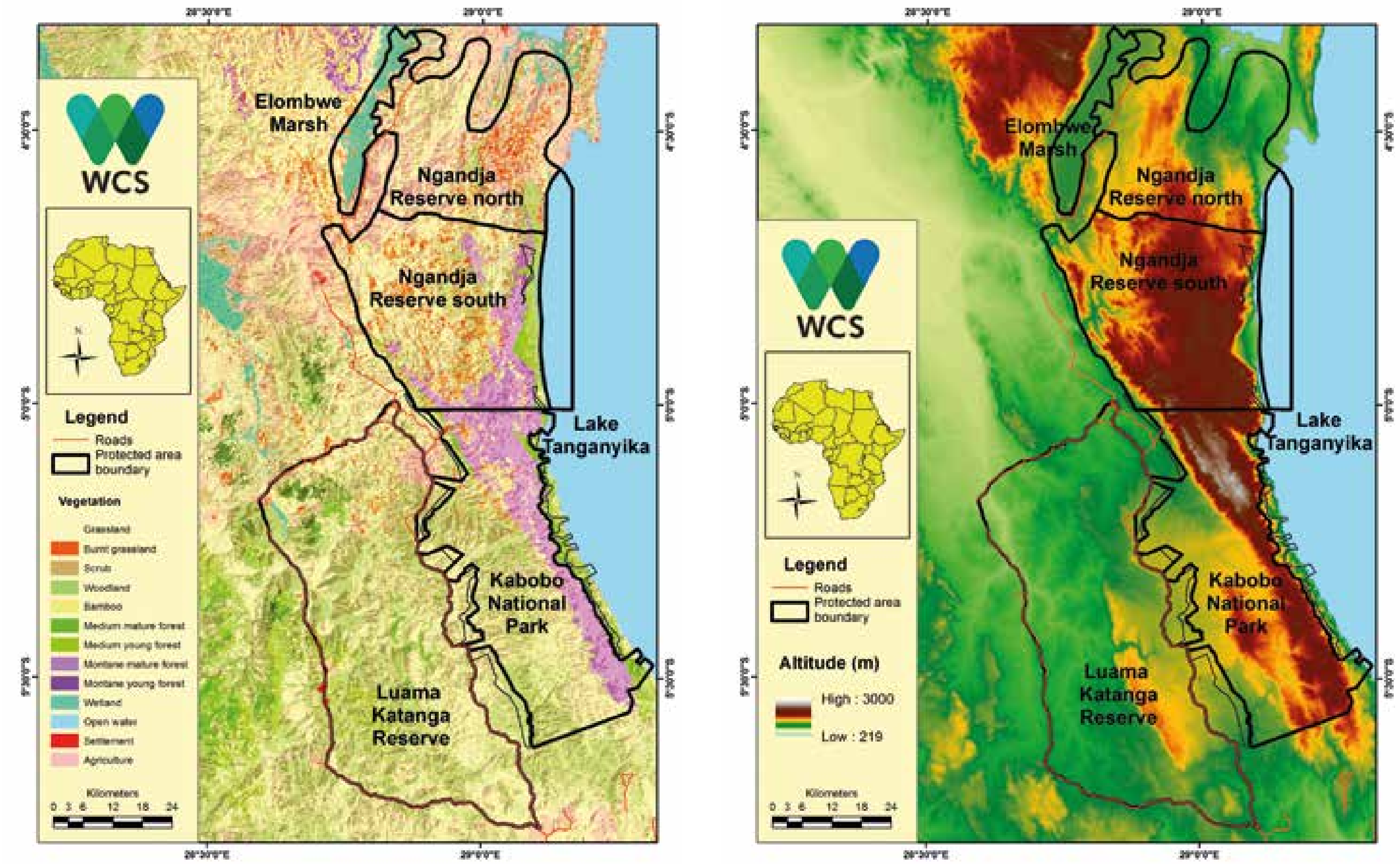


Figure 16. Map of the vegetation of the Kabobo-Luama Landscape (left) and elevation (m) (right).

Photo 6: Images of the Kabobo-Luama Landscape. Clockwise from top left: Image 1: Kabobo forest and montane grassland; Image 2: Kabobo escarpment dropping to woodland and gallery forest; Image 3: Field team in miombo woodland approaching Kabobo escarpment; Image 4: Mountain masked Apalis, an endemic bird to the Albertine Rift; Image 5: *Rhinolophus willardi* a new bat species only known from Kabobo massif; Image 6: Artisanal mining site in Kabobo Massif. *A.J.Plumptre/WCS*

then used to map the boundaries of the proposed park. In 2015 the opportunity to establish an extended reserve to the north of the main forest block and also to conserve the Elombwe Marsh occurred and ICCN's executive Director moved quickly to establish the Ngandja Natural Reserve in June 2016 in the Province of South Kivu, which included the northern part of the planned Misotshi-Kabogo National Park. It was therefore proposed to establish a separate protected area in the newly created Tanganyika Province (formerly part of Katanga Province), the Kabobo Natural Reserve. The Ngandja, Misotshi and Kabobo mountains and the Kabogo River are sites of cultural significance for the Babembe people living in this landscape which gave their names to the proposed protected areas.

Biodiversity

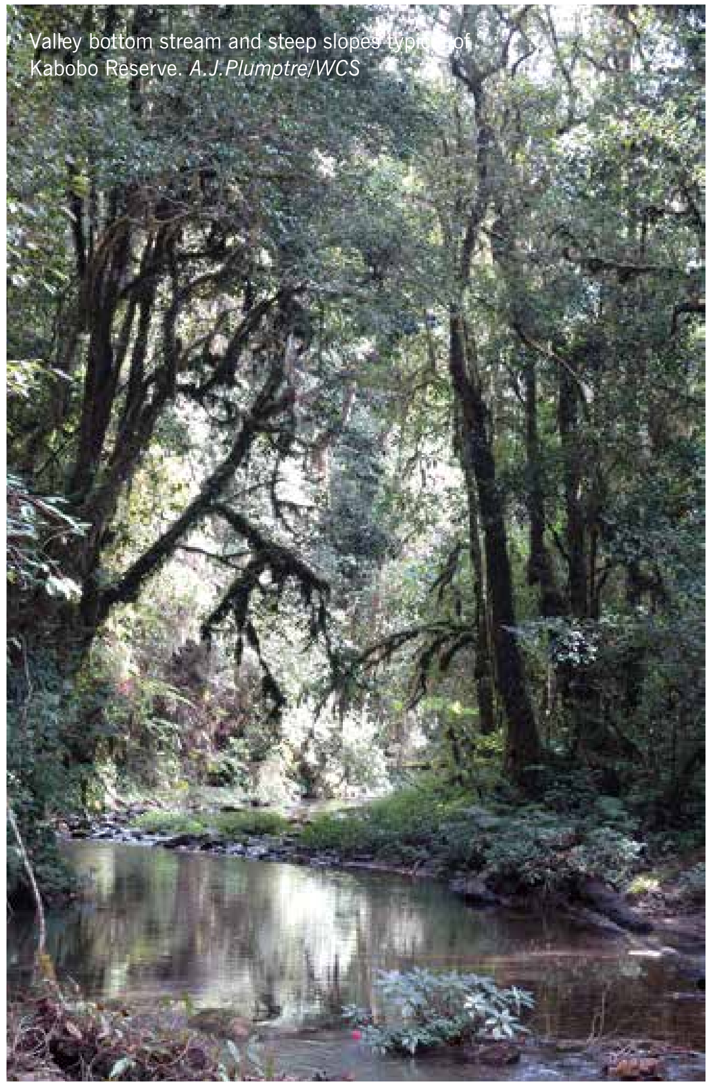
Biological surveys were made of the Kabobo region in the 1950s. Prigogine sent a field team to collect bird specimens in 1954, 55 and 57 (Prigogine, 1960). Laurent also collected amphibians in the forest (Laurent, 1952). Specimens were sent to the Africa Museum at Tervuren in Belgium. The bird surveys concentrated their efforts primarily around a hill top that was called Kabobo by the Belgians. They discovered that there was an endemic species of Apalis, which they called the Kabobo Apalis (*Apalis kaboboensis*). WCS made an expedition to survey the massif in 2007 (Plumptre et al. 2007c) and again in 2012 which included the Luama Katanga Reserve, which increased the number of species documented for the region. These surveys also documented the presence of several new species to science which are in the process of being published in the scientific literature (Kerbis Peterhans 2013a; 2013b; Leal, 2014). The Kabobo-Luama landscape has 558 terrestrial vertebrate and 1,410 plant species of which 39 vertebrates and 71 plants are endemic to the Albertine Rift, and 17 vertebrates and 17 plants globally threatened (table 8). It is likely more species will be found with further survey effort.

Table 8. The total number of terrestrial vertebrates and plants, together with the number of globally threatened species and species endemic to the Albertine Rift, in the Kabobo-Luama Landscape.

	Mammals	Birds	Reptiles	Amphibians	Plants
Endemic	5	22	2	10	71
Threatened	4	8	0	5	17
Species	63	452	12	31	1,410

Threats to Landscape

This landscape has been affected by civil war or conflict since the 1960s when Joseph Kabila led a rebellion against then president Mobutu. His rebels hid for 20 years in the Itombwe and Kabobo massifs and were finally dislodged from Kabobo in 1980 by Mobutu's army. Kabila fled to Tanzania but remnants of his rebels remained in Kabobo and made it insecure to live there. Consequently many people moved out of the region, deserting the fishing villages along the lake shore, and along the road that separates Luama Katanga Reserve and the Kabobo Natural Reserve and which links Kalemie and Fizi towns. Subsequently Kabila overthrew Mobutu with the help of Uganda and Rwanda in 1996 but insecurity remained in the area until 2007. This meant that few people lived in the landscape until recently, and it is only since the return of some level of security that people have started to move back into the area, settling in the Luama Katanga Reserve as well as the villages along the road. The insecurity and presence of armed groups in the forest led to poaching of the large mammals and mining for gold to support the purchase of weapons and munitions. However the habitat remained intact and the smaller species have been able to thrive with little impact on their populations.



Valley bottom stream and steep slopes typical of Kabobo Reserve. *A.J.Plumptre/WCS*

Fire, set for hunting and to clear land for agriculture, is one of the main threats to the landscape together with unsustainable hunting of wildlife and the recent immigration of people who are clearing forest for agriculture. Artisanal mining is potentially a threat but it is not widespread and is mainly carried out by people from north of the landscape as it is not very profitable (A.Plumptre conversations with local people in the landscape). Some mining concessions exist for mineral exploration but these have not been taken up to any great extent. Unsustainable fishing is a potential threat in future on Lake Tanganyika but is currently confined to a few areas.

Conservation plan for landscape

WCS led a process with ICCN to develop a conservation plan for the landscape in 2015 (Plumptre et al. 2015b). This brought together traditional leaders, provincial authorities, conservation partners to ICCN and civil society groups from the landscape.

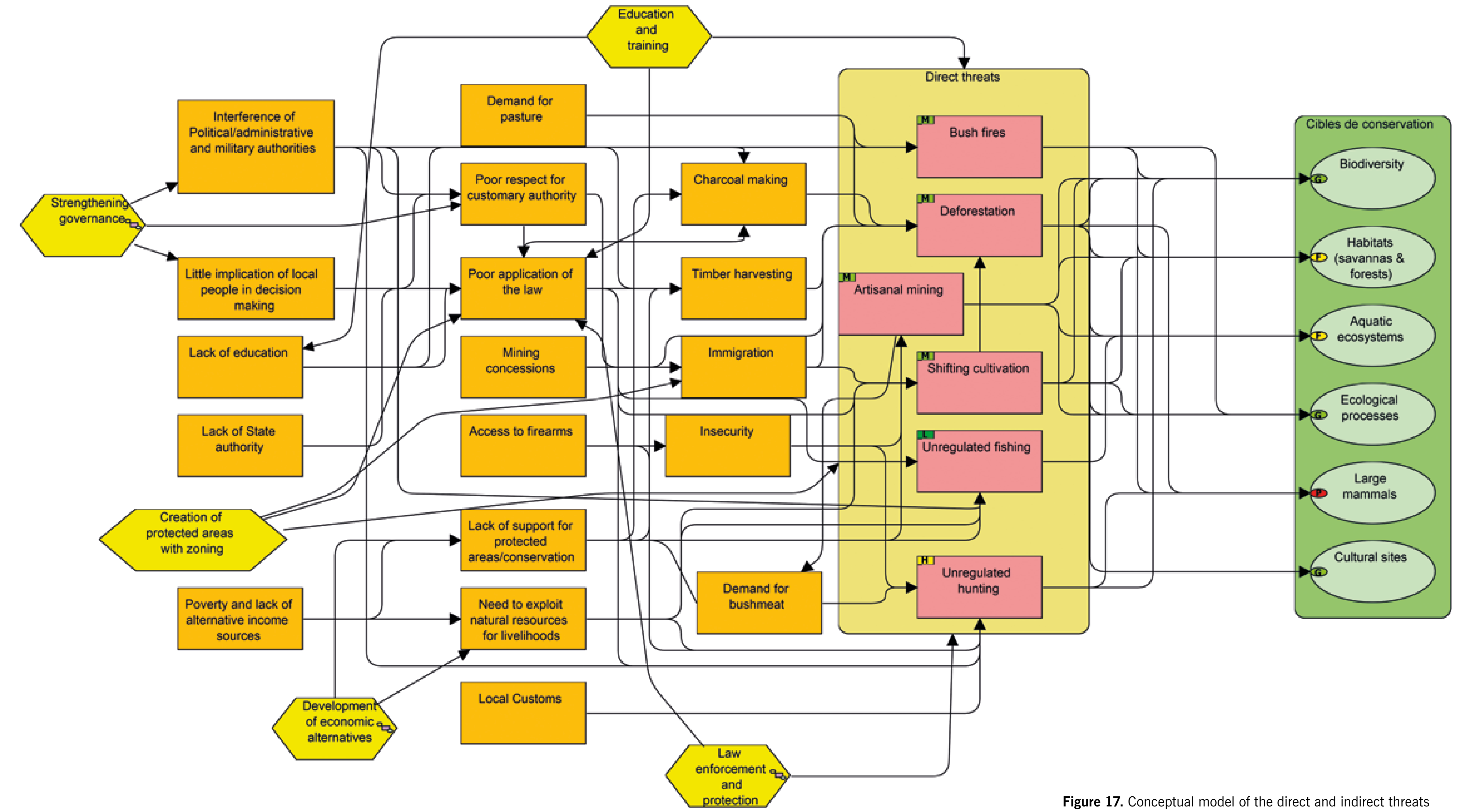


Figure 17. Conceptual model of the direct and indirect threats affecting six conservation targets in the Kabobo-LuamaLandscape

Conceptual model

A conceptual model was developed that identified six conservation targets: 1) Biodiversity of the landscape; 2) Terrestrial habitats (savannas and forests); 3) Aquatic ecosystems; 4) Ecological Processes; 5) Large mammals and 6) Cultural sites. This is the only plan that identified cultural areas as being of importance and this is one of the reasons the local people support the creation of new protected areas.

Six direct threats were also identified (figure 17):

1. Bush fires
2. Deforestation
3. Artisanal mining
4. Shifting cultivation
5. Unregulated fishing
6. Unregulated hunting for bushmeat

A vision and goal were developed as follows:

Vision: *The ecological integrity of the Kabobo-Luama Landscape is ensured, conserving its unique biodiversity with local communities benefiting through sustainable land use, use of its natural resources, and through its ecosystem services.*

Goal: *In 10 years protected areas are established to ensure the protection of the rich biodiversity of the Kabobo-Luama Landscape and a participatory zoning in place to ensure the sustainable management of natural resources where the local communities benefit from revenue generated by innovative and sustainable activities.*

Five strategic objectives were also identified:

Objective 1. By 2025 the park and reserves are legally established with zones of natural resource use

Objective 2. By 2025 the protected areas in the Kabobo-Luama Landscape are sustainably managed

Objective 3. By 2025 the livelihoods of the local communities are improved through less destructive activities for the Kabobo-Luama Landscape

Objective 4. By 2025 the provincial and national authorities and the customary authorities are involved in the governance of the natural resources of the Kabobo-Luama Landscape

Objective 5. By 2025 the local communities are aware of the existing/ new laws and obeying them.

Strategic objectives and activities

Several activities were identified to enable the objectives to be achieved:

Objective 1. *By 2025 the park and reserves are legally established with zones of natural resource use*

Activity 1.1: Mobilize Funds to manage protected areas
Activity 1.2: Establish the park/reserves in the landscape
Activity 1.3: Support the process of creating or changing the reserve boundaries
Activity 1.4: Develop a zoning plan for the landscape

Objective 2. *By 2025 the protected areas in the Kabobo-Luama Landscape are sustainably managed*

Activity 2.1: Secure financing for a minimum of three years to manage the protected areas
Activity 2.2: Engage and equip ecoguards and wardens from local community to work in protected areas
Activity 2.3: Train PA staff to strengthen the capacity of the management institution managing each protected area
Activity 2.4: Develop a management plan for each protected area
Activity 2.5: Establish patrol posts and improve access to the site
Activity 2.6: Improve the knowledge of the ecological values of the landscape
Activity 2.7: Establish alternative income generating projects

Objective 3: *By 2025 the livelihoods of the local communities are improved through less destructive activities for the Kabobo-Luama Landscape*

Activity 3.1: Identify material and training needs of the local community
Activity 3.2: Training of local educators
Activity 3.3: Education programs that identify needs of the local communities
Activity 3.4: Strengthen capacity of local communities in agricultural methods, provide improved varieties, livestock management, micro-enterprise and creation of cooperatives
Activity 3.5: Animal husbandry improved (small livestock, fish, bees, rodents and poultry
Activity 3.6: Identify and demarcate areas for timber production
Activity 3.7: Identify and demarcate areas where artisanal mining can take place
Activity 3.8: Establish tourism sites in different areas of the landscape and more widely around Kalemie and Fizi to encourage this industry
Activity 3.9: Reforestation of cleared forest

Objective 4: *By 2025 the provincial and national authorities and the customary authorities are involved in the governance of the natural resources of the Kabobo-Luama Landscape*

Activity 4.1: Strengthen capacity through training (training of the Decentralised authority of the Province on governance)
Activity 4.2: Educate and promote the laws on good governance and conservation
Activity 4.3: Enforcement of the laws of DRC (Conservation laws and others)
Activity 4.4: Establish good relations between the government and the people being governed
Activity 4.5: Sharing of taxes with local communities through the process of 'Retrocession'

Objective 5: *By 2025 the local communities are aware of the existing/ new laws and obeying them.*

Activity 5.1: Work with National Education Authorities to ensure conservation and natural resource management is taught in schools
Activity 5.2: Establish local community education groups to teach people about conservation and protection of the landscape
Activity 5.3: Organise education workshops and events to teach people about the environmental laws of DRC)

A coordinating committee, formed of provincial authorities, traditional leaders and conservation partners is being established to ensure the implementation of this plan.

SUMMARY ANALYSIS OF LANDSCAPE PLANS

The six landscapes are in very different habitats: Maiko-Itombwe and Congo-Nile Divide are both primarily forested, the Greater Virunga, Murchison-Semliki and Kabobo-Luama have a mix of forest and savannas while the Greater Mahale Landscape is primarily savanna and bushland with a few fragments of forest left. Similarly human population pressure varies by an order of magnitude between sites with over 1000 people per km^2 in some landscapes (Greater Virunga and Congo-Nile Divide) but less than 100 per km^2 in the southern landscapes. Conservation targets in these landscapes included large mammals affected by the activities of man, the rich biodiversity of the site, the varied habitats that exist and ecosystem processes benefiting wildlife and people.

Despite these differences the main threats to the biodiversity of these six landscapes are very similar and include:

1. Hunting of wildlife for bushmeat and to a lesser extent for trophies
2. Habitat loss through conversion to agriculture or from industries such as mining for minerals or oil
3. Habitat degradation from shifting cultivation, fires, charcoal kilns, or human use of fuel wood and other NTFPs
4. Habitat fragmentation creating small islands of forests with no connectivity
5. Poor management of fisheries on lakes
6. Disease effects on primates, particularly Great Apes, but also transmission between wild herbivores and domestic ones
7. Invasive species, particularly plants
8. The potential impacts of climate change

Tackling these key threats requires varied strategies and depends on the political and socioeconomic situation in a landscape as well as the existing national laws and international conventions that the country has signed. For instance until recently the Kabobo-Luama Landscape primarily consisted of proposed protected areas and an old hunting reserve that has had no management support for more than 30 years. Much of the conservation of this landscape relied on the cooperation and interventions of traditional leaders. The Congo-Nile Divide on the other hand consists of two national parks that are managed fairly well by their national protected area authorities and while requiring local support there are fewer options for local community management because of the high human population density around the parks.

The two transboundary landscapes, Greater Virunga and Congo-Nile Divide, are more complex to manage and in the case of the Greater Virunga Landscape extensive dialogue and discussions have been required to finally arrive at a treaty between the three countries for the management of the landscape and to establish a Transboundary Secretariat (GVTCS) which oversees the management of the transboundary agreement. Both landscape plans were accepted by the transboundary nations associated with each landscape and can be used to further develop transboundary collaboration and closer coordination to the point that the landscapes are managed as one coherent conservation region and all associated management plans factor in the importance of the transboundary linkages.

The threats analyses or conceptual models for each site provide a good analysis of the current threats and their underlying causes, together with suggested strategies to tackle the threats. However, there is no spatial component to the threat analysis in these conceptual models and this would strengthen the threats analysis. An approach such as the Landscape species approach which aims to spatially map the threats to target species and identify where to intervene to best address these threats would provide one such method (Didier et al. 2009; Coppolillo et al. 2004; Sanderson et al.2002). Plumptre et al. (2014) made such an analysis for the landscape species of the Greater Virunga Landscape (figure 18) which modeled threats such as snaring, poaching, grazing, charcoal production, bamboo harvesting, timber harvesting and mining to develop an overall threats score for the landscape (figure 18). The results showed that the higher areas of threat are clustered along the edges of the protected areas in the landscape or outside the protected areas, indicating that law enforcement within these protected areas likely has some impact (figure 18).

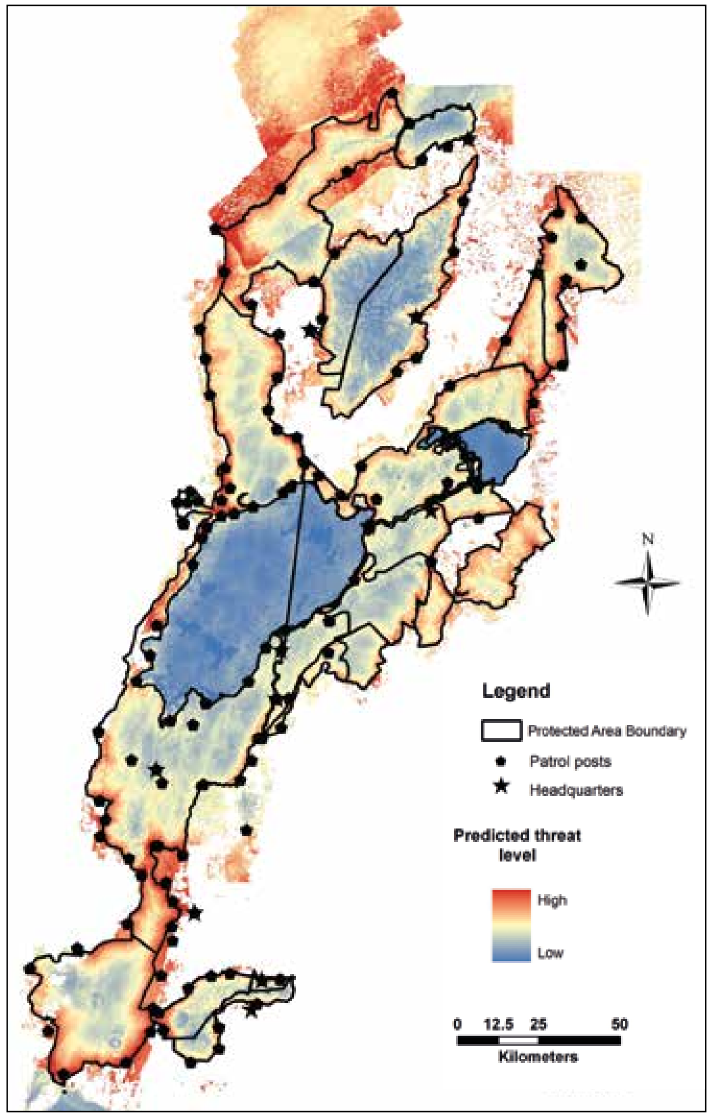


Figure 18. Mapped analysis of threats to Landscape Species in the Greater Virunga Landscape in 2010 (Plumptre et al. 2014).

CONSERVATION PLANNING FOR THE ALBERTINE RIFT

Conservation planning methods

Various statistical methods exist for conservation planning that aim to ensure the conservation of all targets (Moilanen, Wilson & Possingham, 2009). Three commonly used approaches include Zonation (Moilanen & Kujala, 2006), Marxan (Possingham, Ball & Andelman, 2000; Ball, Possingham & Watts, 2009) and C-Plan (Pressey et al. 2005). These methods aim to efficiently invest conservation resources by either identifying the minimum cost needed to conserve a suite of conservation targets or maximize return on given investment. The tools begin by establishing targets, and then dividing the landscape into planning units within which the species composition, abundance or contribution towards the conservation targets can be calculated. Then the cost of "conserving" each planning unit is calculated. The analysis then aims to identify the more 'irreplaceable' cells (i.e. those that have unique assemblages of species) and where else is required to ensure enough area is conserved for each target species. This conservation action plan was developed using the Marxan optimization tool, which allowed for the exploration of different conservation scenarios through the use of different assumptions about the cost of conservation.

Marxan analysis for Albertine Rift

WCS has been collecting georeferenced biodiversity data across the Albertine Rift since 1997, undertaking biodiversity surveys in all of the major forests and savanna regions within the Albertine Rift. WCS has also been collaborating with experts from other institutions, notably Chicago Field Museum, Makerere University, University of Texas at El Paso, Trento Science Museum, Centre de Recherche en Sciences Naturelles de Lwiro, and Missouri Botanical Garden, to compile additional geo-referenced records for the endemic and threatened (IUCN global red list) species of the Albertine Rift. Consequently there are more than two hundred thousand georeferenced records for mammals, birds, reptiles, amphibians and plants which we use here to identify the critical sites for conservation within the Albertine Rift. The aim of the analysis is to identify the sites within the six landscapes which are most important for conservation as well as identify areas outside the landscapes or existing protected areas that need to be conserved. In order to make the analysis, species distribution models were developed for the conservation target species (endemic and globally threatened species) in five taxa: mammals, birds, reptiles, amphibians and plants).

Modelling species distributions

We estimated the current and future distributions areas for 160 endemic species using field data observations and species range maps. Species occurrence records for 117 species across 5 taxa: birds(25), mammals(18), plants(49), reptiles(11) and amphibians (14) were obtained from Wildlife Conservation Society biodiversity survey data, Tanzania mammal atlas data, Global Biodiversity Information Facility (GBIF 2012: http://www.gbif.org/), records of amphibian collections made by Mathias Behangana, Michele Menegon and Eli Greenbaum, plant collections made by Roy Gereau in Tanzania, and small mammal collections by Julian Kerbis Peterhans, Prince Kalemie and B. Ndara. A total of 32,854 presence records were used in the modelling process; birds (8,765), large mammals (17,345), small mammals (1,448), plants (4,473), reptiles (436) and amphibians (387) and these are mapped in figures 19a-19c. The sample

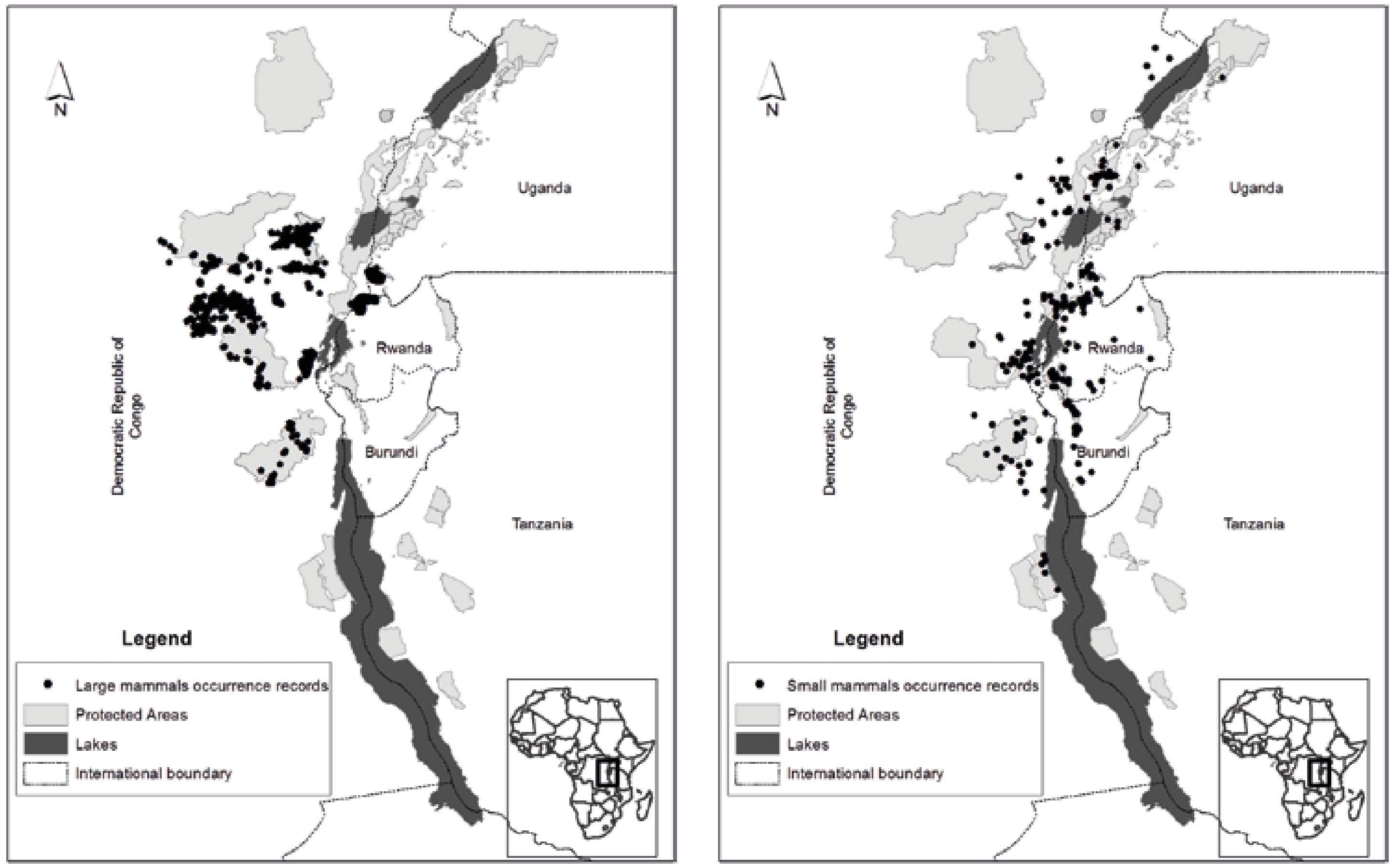


Figure 19a. Species occurrence records for Mammals: Left - Large mammals; Right- small mammals

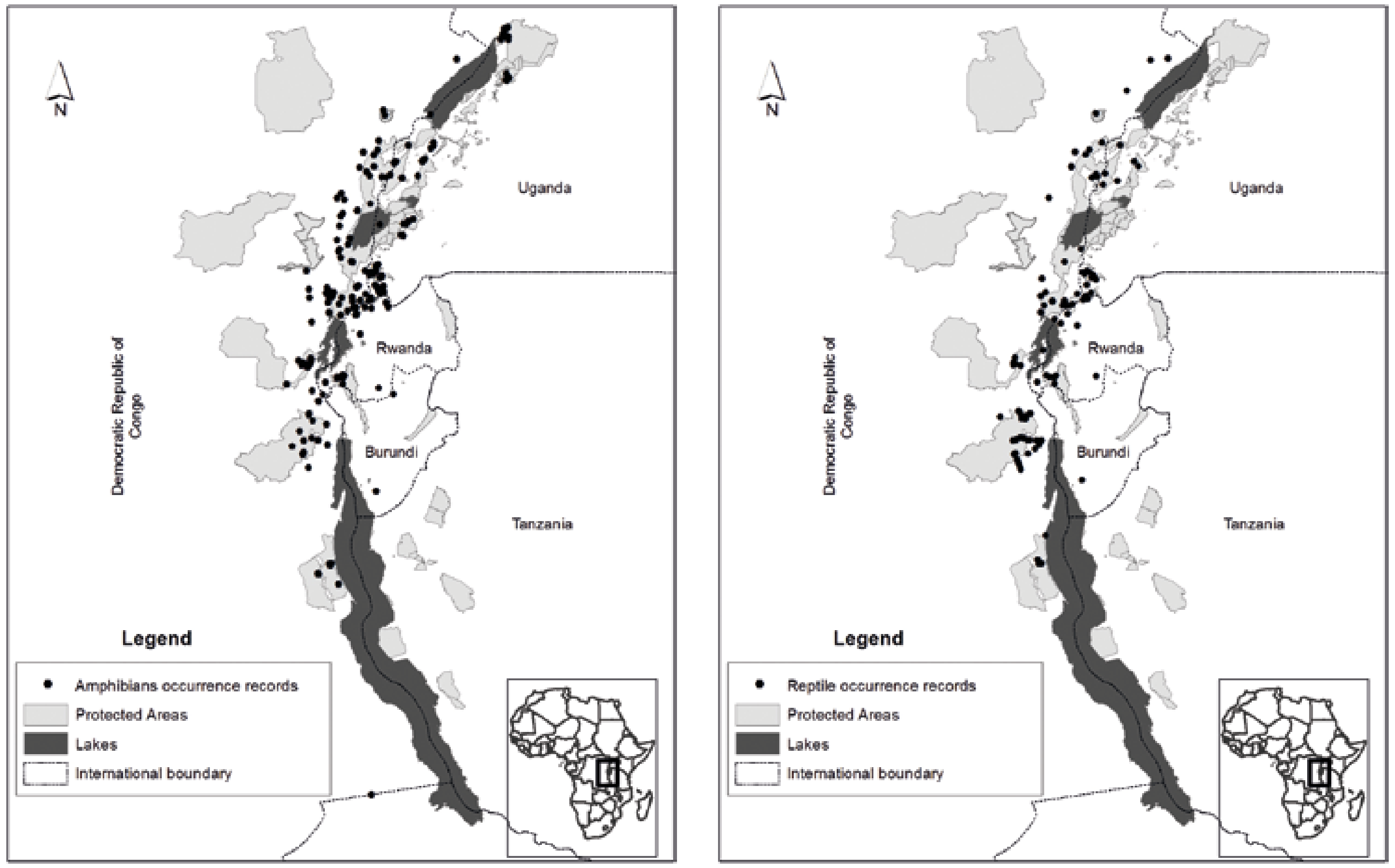


Figure 19b. Species occurrence records for amphibians (left) and reptiles (right)

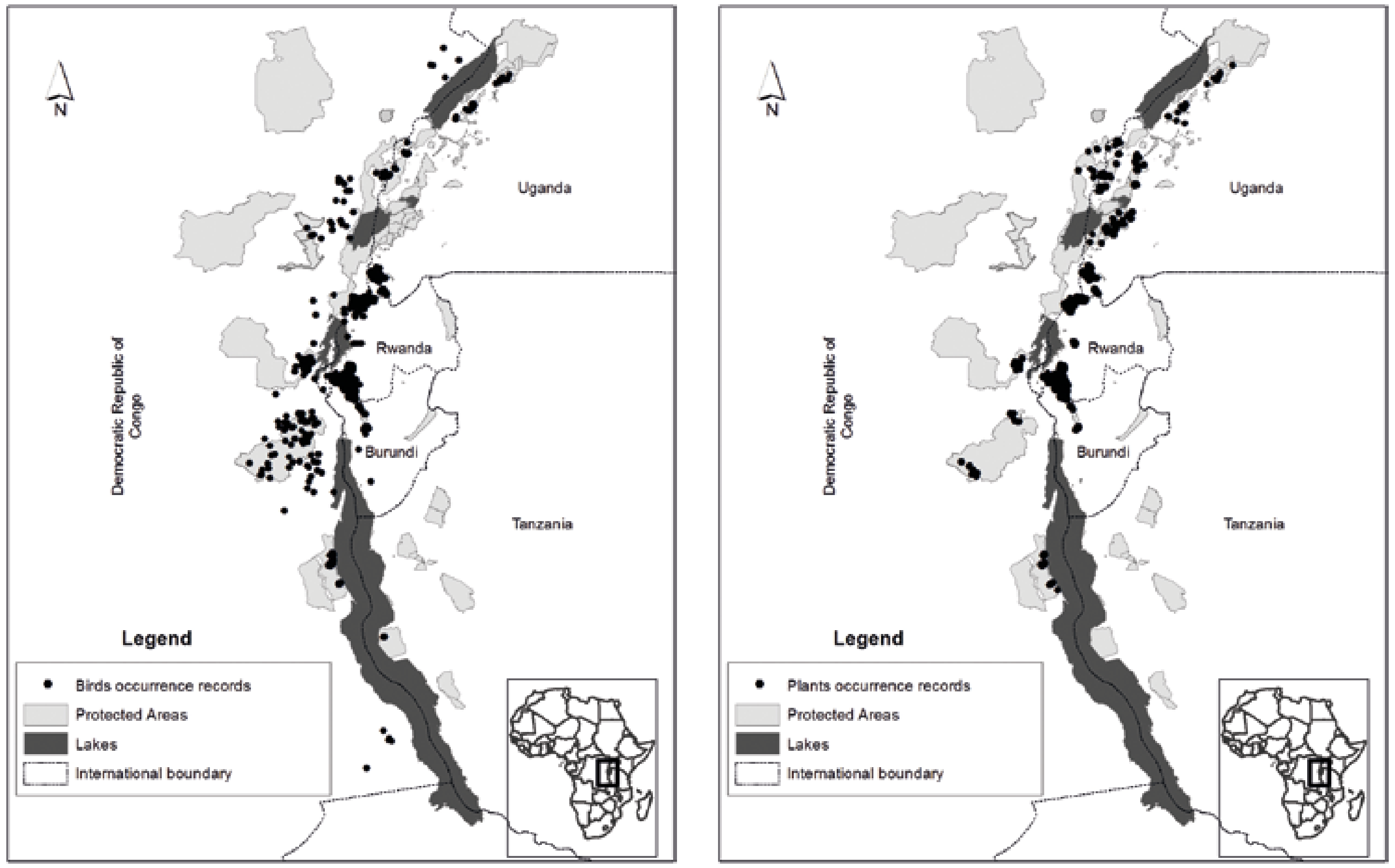


Figure 19c. Species occurrence records for birds (left) and plants (right)

sizes for each species used for model parameterization varied between 10 to 1,200 localities at a resolution of a 1km^2 grid cell.

Species range maps represent the area of occupancy of a species and have been used for mapping species richness (Graham & Hijmans, 2006). For species that had fewer than 10 presence records we used the altitudinal ranges recorded for the species to estimate area of occupancy within the extent of occurrence (given by the IUCN red list site) and randomly selected point locations within this region to develop a species distribution model (see below). The distribution areas for 43 endemic species; birds (13), amphibians (15) and small mammals (15) were estimated using these randomly generated presence records from species' range maps. It was felt these would be better estimates of the species area of occupancy than simply using the IUCN range maps.

Predictor variables

We selected 17 potential predictor variables relating to climate (9), topology (4), hydrology (2), geology (1) and human activities(1) that are likely to influence the distribution of the birds, mammals, plants, reptiles and amphibians in the Albertine rift (Table 9). All the predictor variables were clipped to the area of interest and a pairwise pearson correlation between predictor variables was obtained using ENMTOOLs (Warren et al. 2010; a toolbox for comparative studies of environmental niche model; http://purl.oclc.org/enmtools). To minimize the effect of multicollinearity and overfitting, only variables with less than (+/-0.75) correlation were retained. Predictor variables were resampled to a 1 resolution using Arcgis 9.3 for model input.

Climate layers at a spatial resolution of 1km^2 were obtained from the WorldClim database (Hijmans et al. 2005; http:\\www.worldclim.org). Additional variables used in model prediction included: average cloud cover (cloud mean), maximum cloud cover (cloud max), digital elevation model, aspect, slope, eastness, northness, distance to rivers, drainage basin, lithology and distance to roads. Cloud mean and cloud max were computed from MOD09GA Surface Reflectance data which is provided in Hierarchical Data Format (HDF) at daily temporal resolution and was calculated by G. Picton-Phillipps. A 90m digital elevation model was obtained from the USGS (http://srtm.usgs.gov/) and the slope, aspect, eastness and northness were derived as well. Drainage basins were obtained from USGS Global data set of 2003.The distance to roads and rivers were derived by computing the euclidean distance from each point in the study area to the nearest road or river. Rivers and roads data layers were obtained from the African data sampler dataset (WRI 2010). Lithology reflects key geological parent materials which are determinants in the distribution of vegetation (Source; U.S. Geological Survey/ The Nature Conservancy).


Data were collected on tree size as part of WCS's botanical surveys. *A.J.Plumptre/WCS*

Table 9. Covariates used for modelling the distribution of endemic and threatened species in the Albertine Rift

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 average percent cloud cover
Cloud max	Maximum percent cloud cover
DEM	Digital elevation model
Aspect	Direction a slope is facing
Slope	Rate of maximum change in elevation
Easteness	Orientation East - West
Northness	Orientation North- South
Drainage basins	Topographically delineated area drained by a stream system
Roads	Distance to nearest road
Lithology	Geological parent material
Rivers	Distance to nearest river

Modeling methods

We used a Maximum Entropy Species Distribution Modelling approach (hereafter 'Maxent', Maxent version 3.3.3e; Phillips et al., 2006), to estimate the current and future distribution areas for endemic and threatened species in the Albertine rift. We selected Maxent, a machine learning approach, because it requires only species' presence data and environmental variables (continuous or categorical), and has been shown to perform as well or better than other species distribution modelling techniques (Phillips et al. 2006, Elith et al.2006). Maxent makes inferences from incomplete information and estimates species' distributions by generating a probability distribution of maximum entropy (i.e. closest to uniform), subject to constraints imposed by the information regarding presence records and the background information across the study area (Phillips et al. 2006; Elith et al. 2011). Maxent default parameters (Auto features, convergence threshold of 0.00001, maximum number of background points =10,000, regularization multiplier=1) were used to fit the models. However, about a third of the species were fitted using hinge features, which are functions for piecewise linear splines and fit models closely related to Generalized Additive Models (Elith et al. 2011). Model accuracy was assessed by testing how well the model prediction differentiates between suitable and unsuitable habitat at varying thresholds using the area under the receiver operating characteristic curve (AUC) test statistic (Fielding & Bell, 1997; Freeman & Moisen, 2008). AUC is a threshold independent metric that represents how likely a random selection from a presence site is ranked compared to a random selection from an absence/pseudo absence site (Fielding and Bell 1997; Phillips & DudÃk, 2008). An AUC value of 0.5 indicates a model that performs no better than random while a model with perfect discrimination has a value of 1. Model outputs with AUC values ≥ 0.8, were selected for the

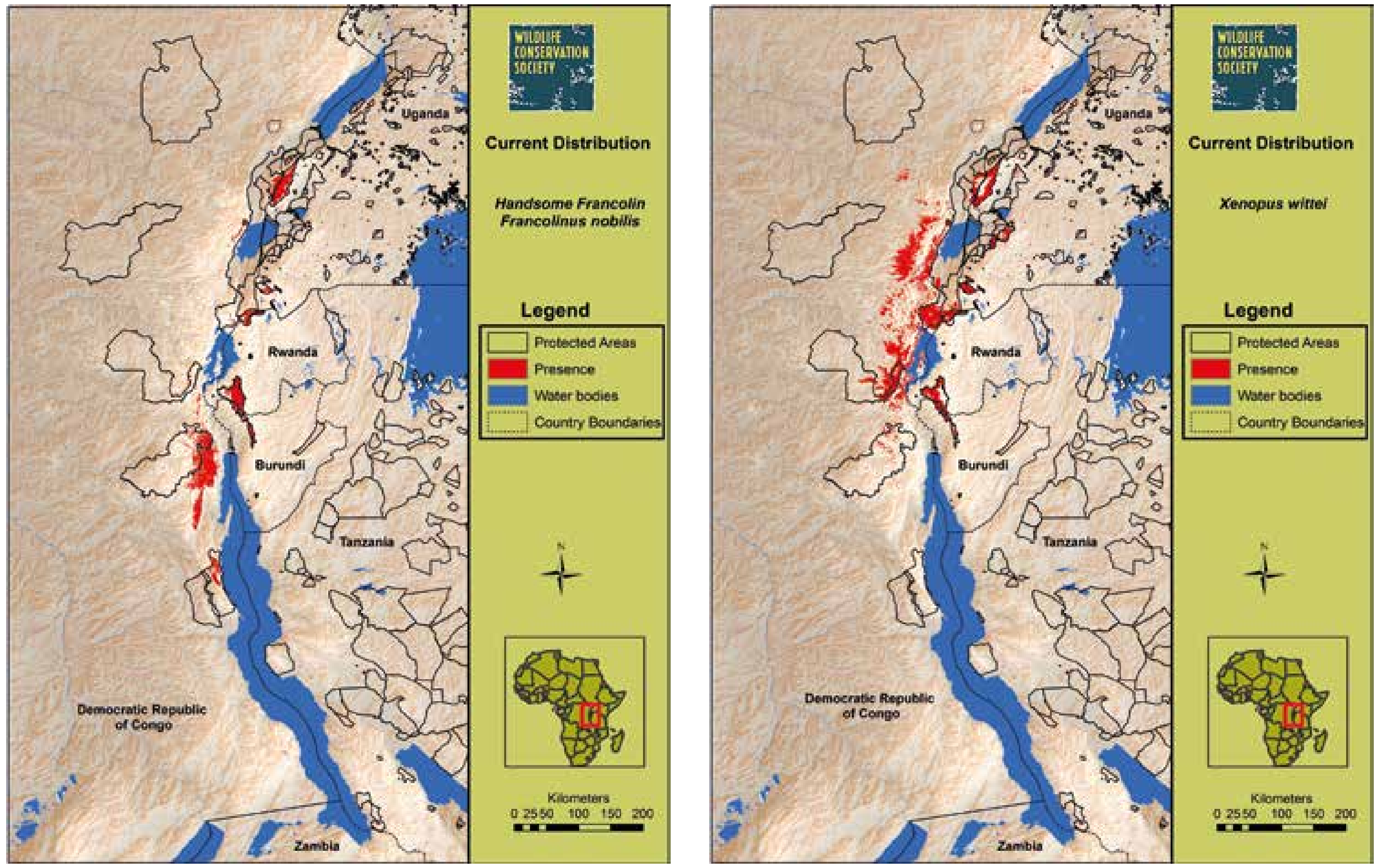


Figure 20. Example distribution maps of 1) a bird left - Handsome francolin (*Francolinus nobilis*) and 2) an amphibian right - Clawed toad (*Xenopus wittei*).

final analysis (Manel et al. 2001). 75% of the occurrence records were used for training and 25% for testing. After assessing model accuracy, the final models for all the species were fitted using all occurrence records. To convert the predicted habitat suitability from a continuous logistic output format into a binary (presence/absence) output , the "maximum training sensitivity plus specificity" threshold rule was used (Liu et al. 2005; Freeman and Moisen, 2008). This threshold rule minimizes the mean error rate for positive observations and the error rate for negative observations (Freeman and Moisen, 2008).

The predicted species' distributions represent a range of environmental values within which a species likely occurs. However, some of the suitable habitat has been modified by human activities and it is unlikely species occur here. To remove areas that have been modified by human activities, we clipped species distributions using the GlobCover 2009 land cover map that was re-classified into three land cover classes; water, other, and natural vegetation (ESA, 2010). The "other" class was characterized by agriculture, plantation forestry and human settlements. When exploring the GlobCover 2009 land cover map in ArcGis 9.3 we found that there were vegetation misclassifications in our study area. For example some of the tropical high forest had been classified as mosaic vegetation/cropland. We edited the landcover map by locking in protected areas, as natural vegetation and using landcover maps WCS had developed for some landscapes to produce the final human-modified layer. Figure 20 shows an example distribution map for a bird and an amphibian.

Scenarios for conservation planning

Three scenarios were run in Marxan to evaluate how different factors could affect the final solution produced. Marxan (Possingham et al. 2000) is a software program that helps develop conservation plans that ensures that all species are represented adequately in the final conservation plan. It uses an algorithm called simulated annealing to try to find the optimum solution to this problem from several billion possible options. We overlaid 5km^2 hexagonal cells across the Albertine Rift as a whole covering 993,044 km^2. We assigned each species range to a cell if more than 50% of the cell was predicted as containing the species. Targets are set in Marxan by the user to ensure that a viable population for each species is conserved. For species that are relatively abundant where they occur we selected 30% of the species current range as a target. Some species require large areas of habitat to maintain viable populations such as elephants, apes and large carnivores. For these species, or those that occur at very low density or within a very restricted area, we selected higher percentages of cells (40-100%) to ensure their needs would be ensured in the final conservation plan. Marxan doesn't necessarily find the optimal solution but usually gets close to it. It therefore is useful to run Marxan many times and assess which cells are selected regularly and which are not selected so often. We ran Marxan 100 times to obtain a selection frequency for each cell.

The first scenario assumed that the cost of conservation was equal in each cell. This scenario therefore identified the minimum possible area required to conserve all species. It is useful as a baseline analysis to compare with the results of other scenarios but is not very realistic.

The second scenario locked in the existing protected areas by fixing cells within the protected areas within the solutions generated. This scenario identified areas outside the existing protected areas that best complemented the existing protected area network. It is more realistic than the first scenario because it recognized the investments in conservation to-date and didn't assume a landscape that is a clean slate. Only existing gazetted protected areas were locked in. Proposed protected areas (figure 21) were not locked in.

The third scenario identified efficient conservation investments that avoided the current network of mining concessions. Governments in the five countries of the Albertine Rift have been establishing mining concessions across much of their land (figure 21). Most concessions are in the exploration phase for the moment, but in several countries these exploration areas overlap with protected areas. In this scenario, the cost of conservation increases inside a mining concession, but if a mining concession occurs within a protected area its cost is reduced slightly (making the assumption that mining will not be so destructive within a protected area because there will be stringent rules to minimise impacts). This ensures that if cells within a mining concession must occur they will tend to be selected within existing protected areas. This scenario combines both the effects of protected areas and mining and aims to identify where to conserve given the existing protected area network and recognizing future mining impacts. Where mining concessions overlap with other cells or with protected areas the formula to calculate cost was as follows:

Cost = 5+(2xarea of cell (5km^2) x proportion of cell that is mining concession)-(Area of cell x proportion that is protected area)

Given this formula:
If a cell has no mining concession or protected area its cost was =5
If a cell had 100% mining concession and no protected area its cost = 15
If a cell had 100% protected area and no mining concession its cost = 0
If a cell was 100% mining concession and 100% protected area its cost = 10

Where to conserve if all costs equal

The scenario that treats every cell as having the same cost for conservation gives the baseline assessment that shows where you would conserve all the threatened and endemic terrestrial vertebrates and plants for minimum cost if all costs were equal. All other scenarios presented below cost more because they are sub-optimal. In all of the figures presented the percentage frequency of selection of a cell is given with darker greens showing cells that are selected more frequently than lighter greens. This indicates those cells that are more important for the final solutions and are required to conserve all the conservation targets. At the time the analyses were made Itombwe and Kabobo Reserves were not established and so they were included as proposed protected areas.

All species

An assessment based on all the endemic and threatened species shows that even with all costs equal most of the important areas fall within the existing protected area network (figure 22). Key areas identified outside the protected areas included the highlands of Itombwe massif and the Kabobo massif as well as areas around Tayna and Kisimba Ikobo in DRC and east of Mahale Mountains in Tanzania.

Threatened and endemic species

Analyses of globally threatened species and the endemic species of the Albertine Rift separately show fairly similar patterns (figure 23) except in the southern landscapes (Greater Mahale and Kabobo-Luama). In the Greater Mahale Landscape endemic species such as Kungwe apalis (*Apalis argentea*) occur in the Mahale Mountains National Park and the Sitebi highlands to the east while threatened species such as elephant and African Wild Dog (*Lycaeon pictus*) tend to occur further east in the game reserves. More of the Kabobo massif is selected for the endemic species found there rather than threatened species, partly because several of the new endemic species WCS has discovered there have not been evaluated for their IUCN Red List status. The areas selected in the Kahuzi Biega-Maiko-Tayna region are more concentrated around the Tayna and Kisimba-Ikobo Reserves for

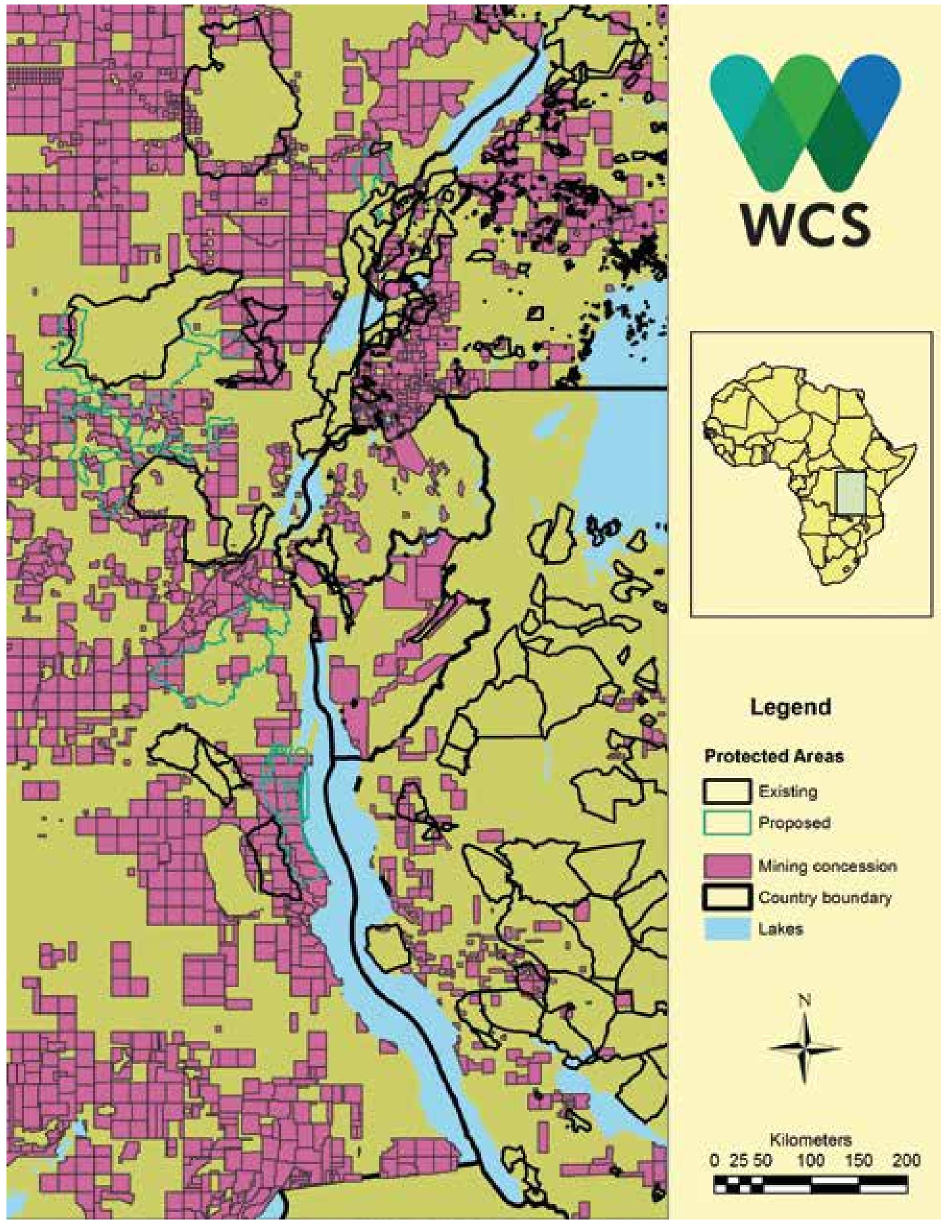


Figure 21. Map of mining concessions designated across the Albertine Rift region. Most concessions are currently exploration concessions rather than production concessions.

A cobalt mine at the edge of Queen Elizabeth Park with vegetation killed in the park from pollution. *A.J.Plumptre/WCS*

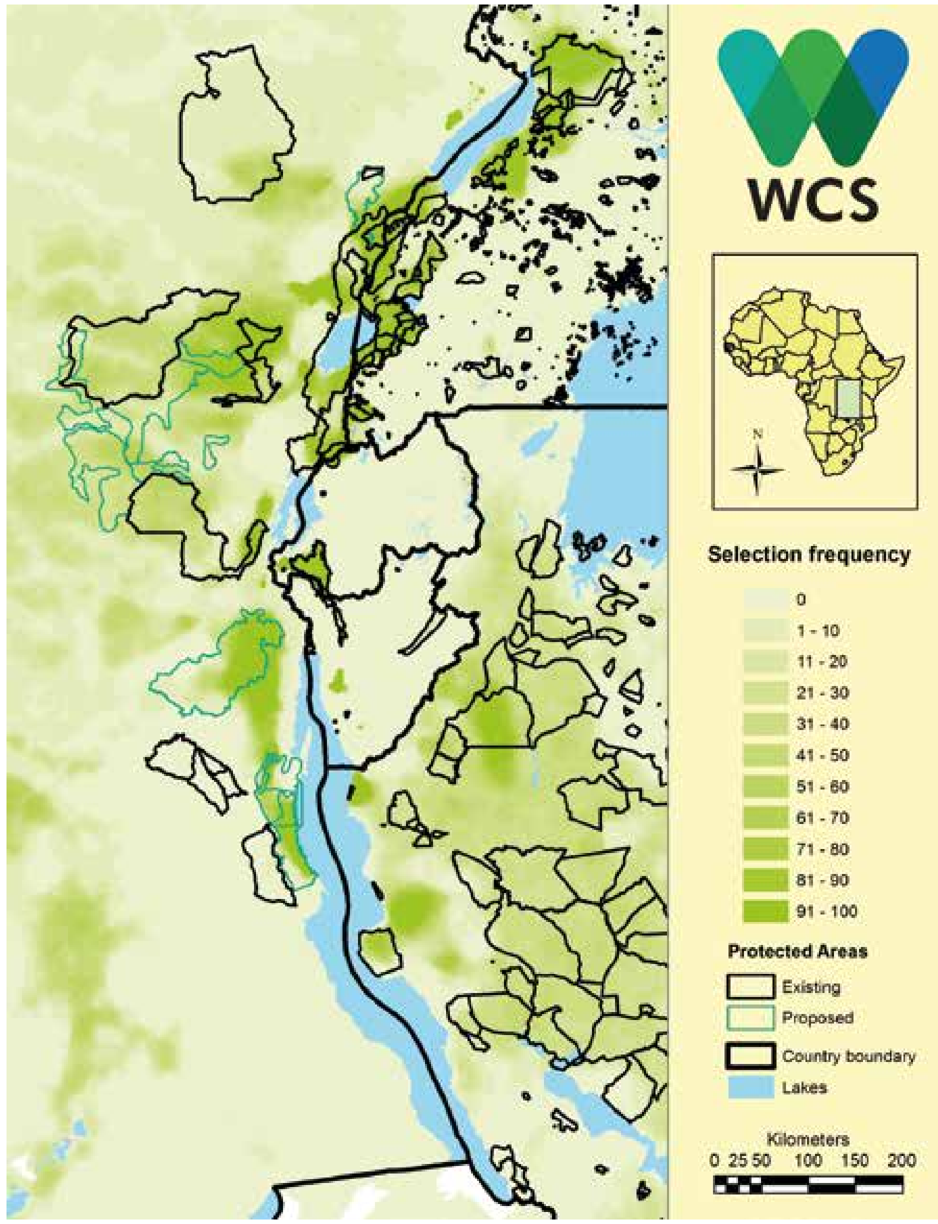


Figure 22. Percentage selection frequency of 5km^2 cells assuming equal costs of conservation, aiming to conserve all threatened and endemic terrestrial vertebrates and plants.

Rangers clearing snares set for bushmeat. *A.J.Plumptre/WCS*

Mountain gorillas are an endemic and threatened species for the Rift. *A.J.Plumptre/WCS*

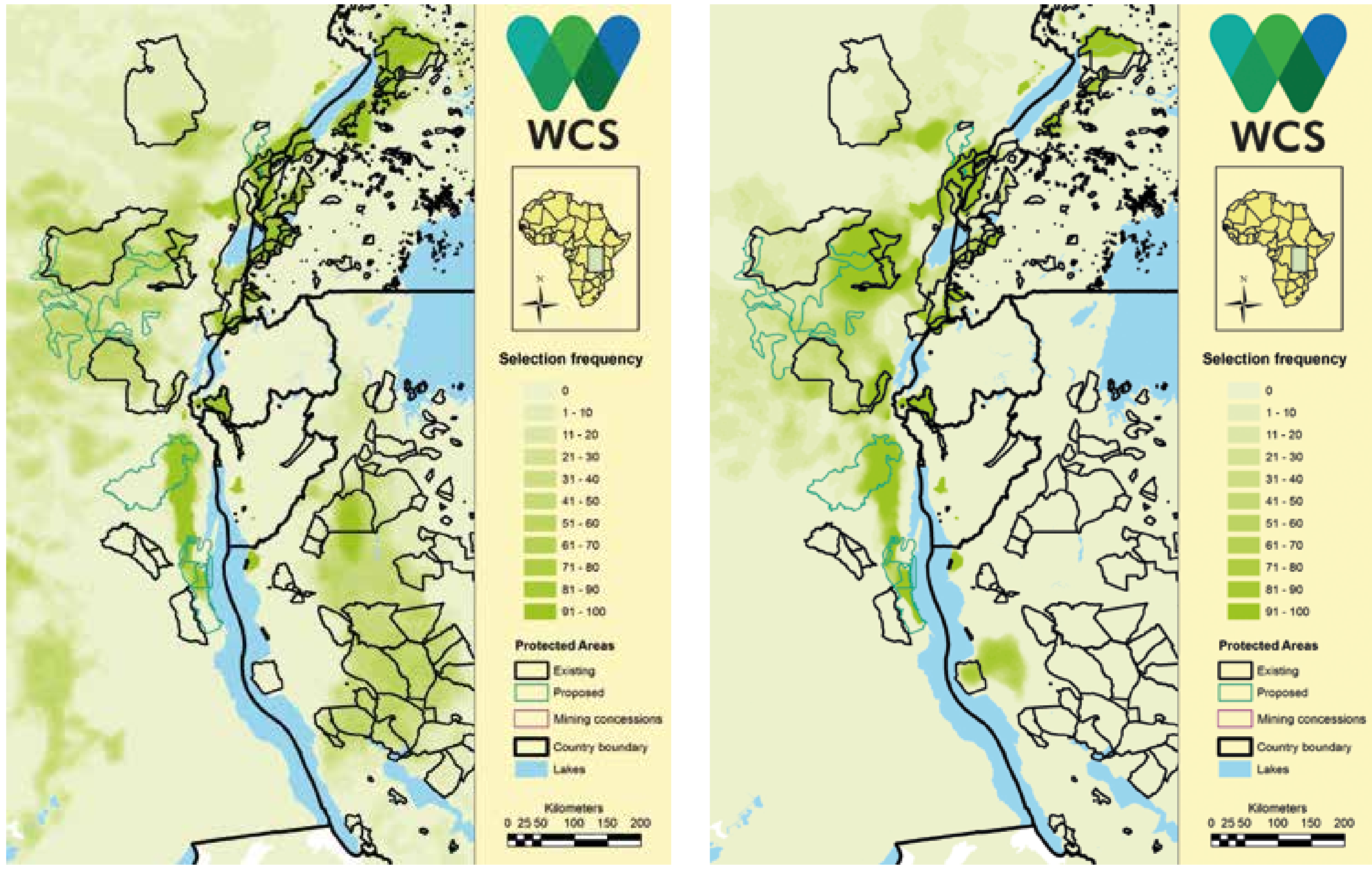


Figure 23. Selection frequency of cells for threatened species (left) and endemic species (right).

endemic species, an area of importance for Grauer's cuckoo shrike (*Coracina graueri*) as this area is at higher altitude than further west which is selected for threatened species such as Grauer's gorilla and Okapi. The Itombwe highlands and the escarpment down to Kabobo was selected as important for both threatened and endemic species. The Murchison-Semliki Landscape tends to be more important for threatened species than endemic species.

Where to conserve outside the existing protected area network

In this scenario existing protected areas are locked into the analysis and the analysis identifies which additional areas are required to conserve all the threatened and endemic terrestrial vertebrates and plants outside the existing protected area system. This is a more realistic scenario as it recognises that there are already existing protected areas although these may be conserving more than is required to maintain viable populations of all species and therefore the cost is more expensive than the previous scenario.

All species

At the time this assessment was made Itombwe Reserve and Ngandja/Kabobo Reserves had not been established and this analysis highlights the importance of these sites because many cells were selected as important in these two areas in order to conserve the endemic and threatened species here. Some cells around Bugoma Forest Reserve in Uganda are also selected because they capture the Ugandan mangabey (*Lophocebus ugandae*) and chimpanzees in forest corridors and fragments in this region.

Hippos are vulnerable due to hunting for meat and ivory. *A.J.Plumptre/WCS*

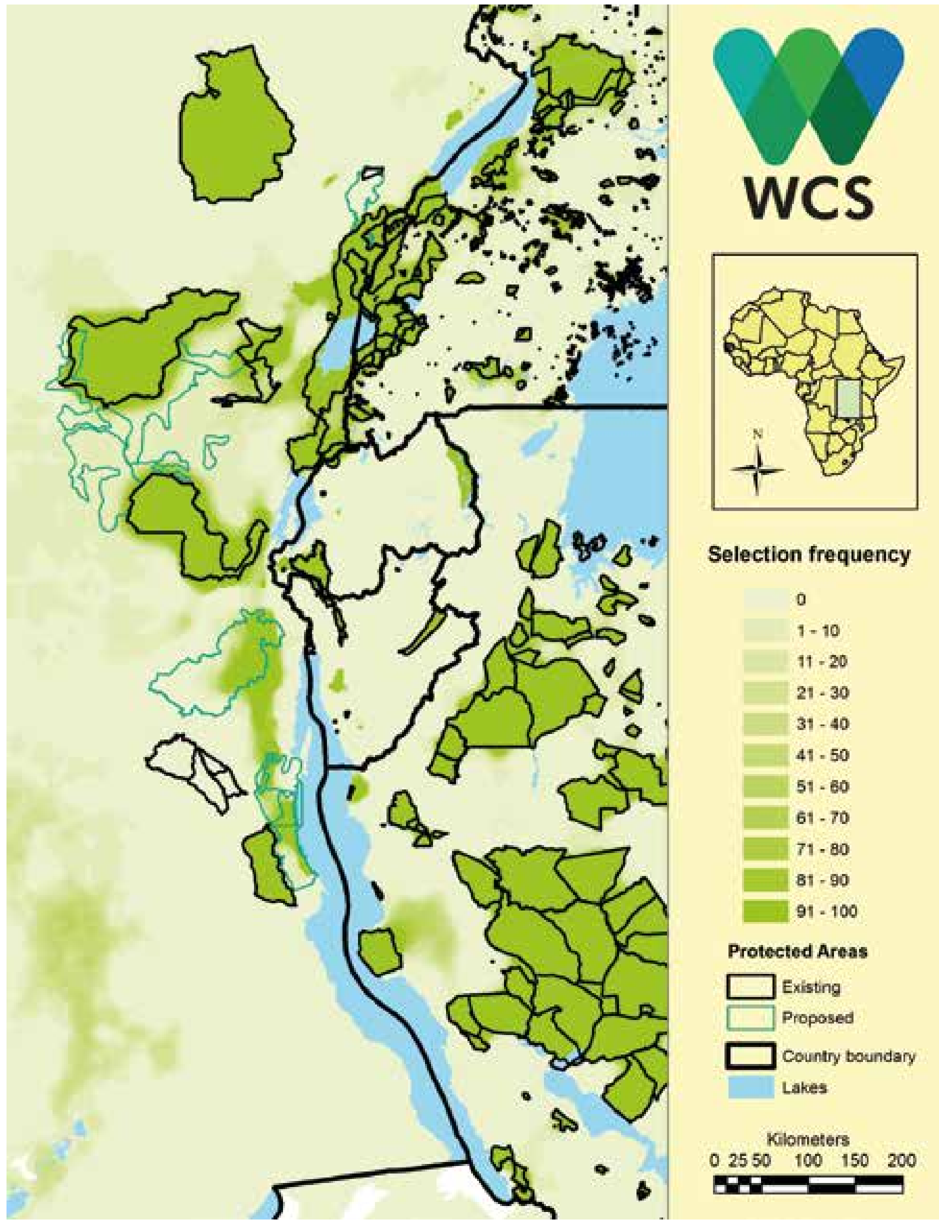


Figure 24. Percentage selection frequency of 5km^2 cells, locking in all cells within protected areas initially. Only existing protected areas were locked in but proposed protected areas are shown with blue-green borders. This analysis selects parts of the recent Itombwe and Ngandja Reserves.

Threatened and endemic species

Comparisons of the results for globally threatened species and endemic species to the Albertine Rift show very similar results (figure 25). The only areas that differ include greater representation of the Tayna and Kisimba-Ikobo reserves for endemic species as this site is important for Grauer's cuckoo shrike amongst other endemic species. The Ntakata Forest and Sitebi highlands east of Mahale Mountains is also a site identified as important for endemic species conservation because of the several plant species and the Kungwe apalis. The Itombwe highlands and the escarpment down to Kabobo massif are important for both threatened and endemic species and this emphasizes the importance of this region for conservation. In the Murchison-Semliki Landscape the corridor forests between Bugoma and Budongo Forest are also identified as being important for threatened species. These four areas are identified as critical areas outside the existing protected area network to conserve all the threatened and endemic species in the Albertine Rift.

Where to conserve in the face of future developments

In this scenario the cost of conservation within a mining concession is tripled (15), the cost of conserving outside a protected area is the unit cost (5) and the cost of conserving within an existing protected area is down-weighted to zero if no mining concession exists. If a mining concession exists in a protected area is it more costly (10) than conserving outside the protected area. This scenario therefore tries to balance the

Mubwindi swamp, an important site for the endemic Grauer's Rush Warbler. *A.J.Plumptre/WCS*

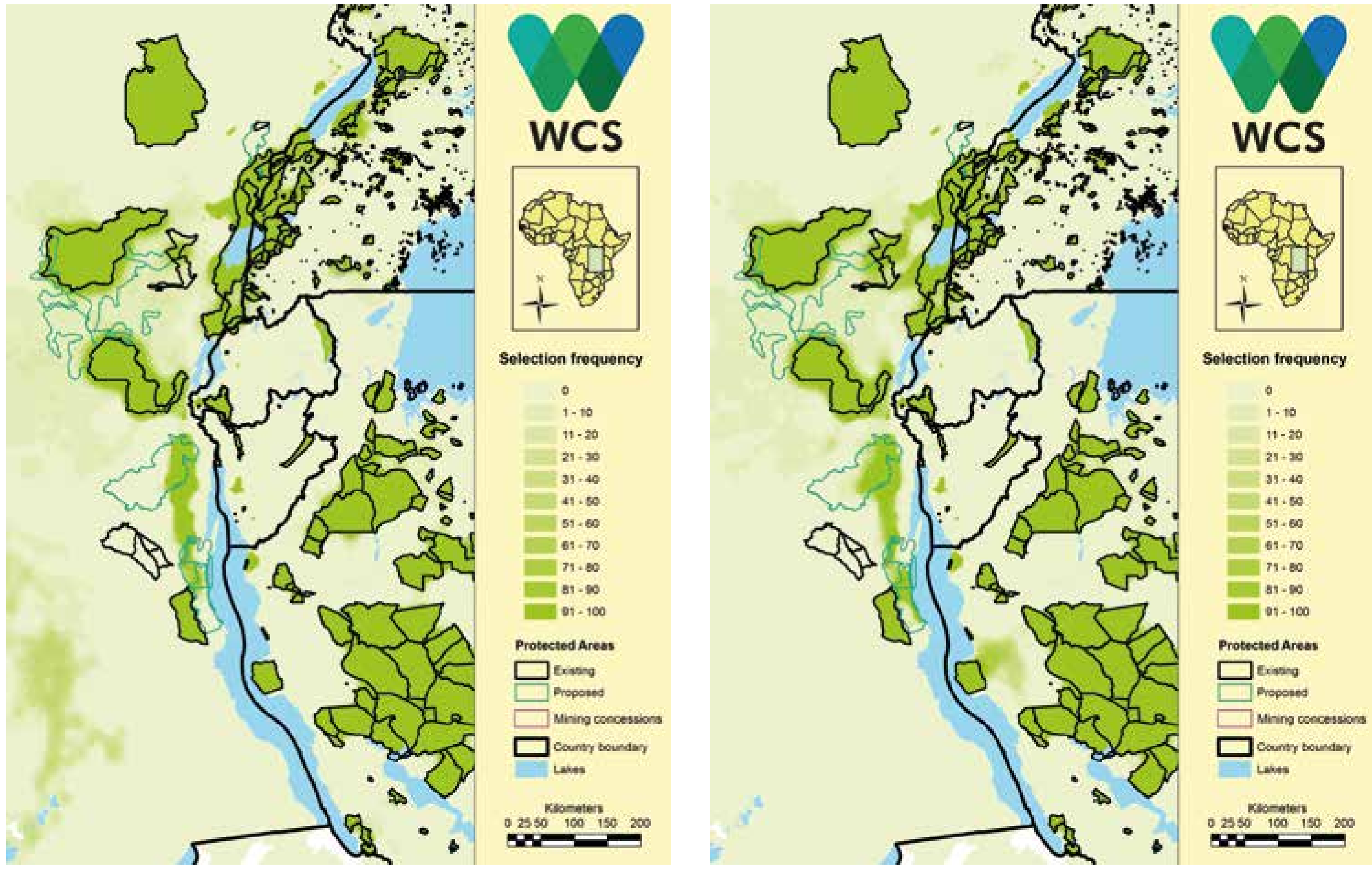


Figure 25. Selection frequency of cells with protected areas locked in initially for threatened species (left) and endemic species (right). Only existing protected areas were locked in but proposed protected areas are shown in green.

existence of protected areas with the planned mining developments in the Albertine Rift.

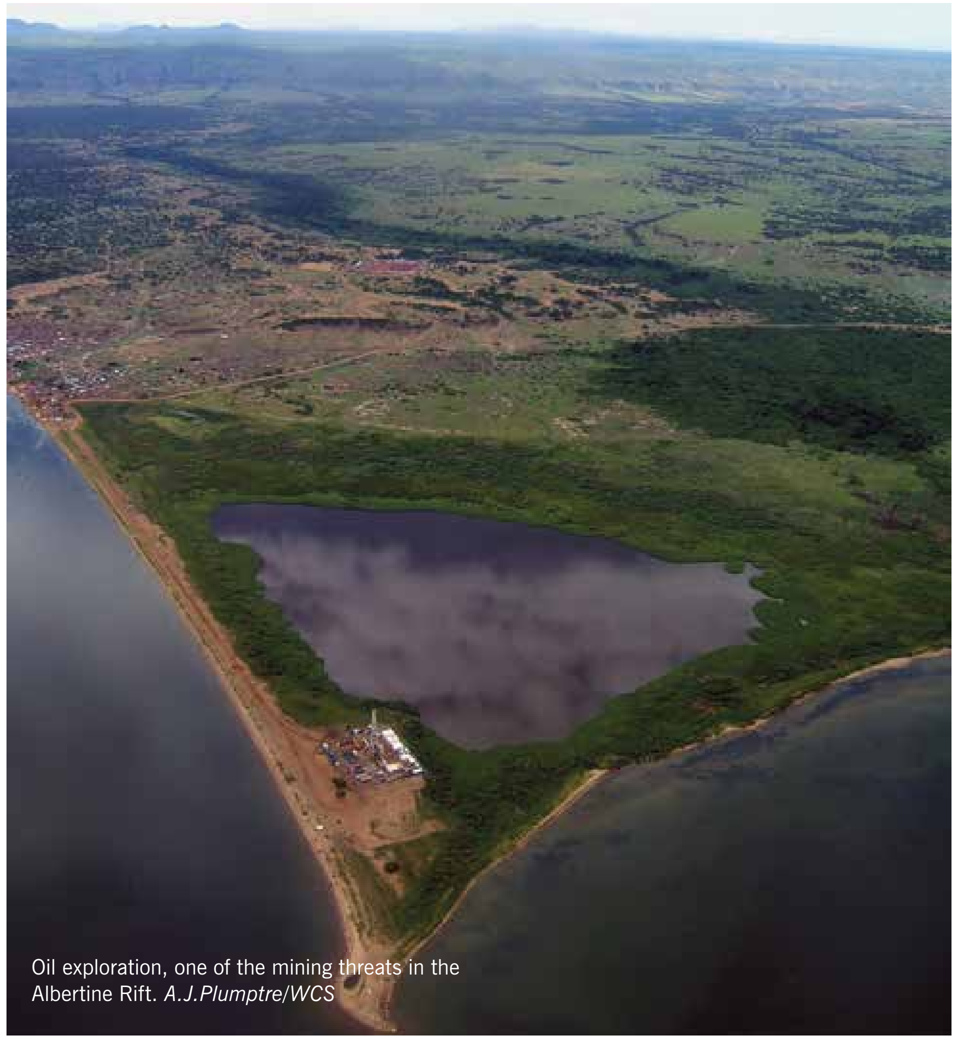
All species

The findings show that, while for most species they can still be conserved outside the planned extensive coverage of mining concessions across the Albertine Rift, there are some areas where conservation has to take place within mining concessions to achieve the conservation targets set in Marxan. These include proposed mining concessions in Kahuzi Biega National Park, Tayna Reserve, Itombwe and Kabobo Massifs and concessions around Bugoma Forest Reserve in Uganda (Figure 26).

We would encourage governments to review these specific mining concessions and ideally annul the concessions given there are few of them in comparison with all the other concessions in the Albertine Rift.

Threatened and endemic species

Patterns for threatened and endemic species were similar (figure 27). Threatened species can mostly be conserved within existing protected areas except for those in the Itombwe massif and the escarpment above Lake Tanganyika down to Kabobo massif. There are also areas around Maiko National Park where no mining concessions exist where species need to be conserved. A critical area for Grauer's gorilla in the Oku Community Reserve is omitted however with several mining concessions, because Marxan has calculated that sufficient gorillas can be conserved within Kahuzi Biega National Park for a viable population. This would be true if there wasn't the extensive hunting of gorillas in this park and the fact that the gorillas are thought to have been better protected in the Oku Community Reserve. It highlights the need to develop a cost analysis based on actual threats as well as likely threats as we have done here. Endemic species require the whole of the Kabobo Massif in DRC and also the Mahale Mountains National Park and Sitebi highlands to the east in Tanzania.



Oil exploration, one of the mining threats in the Albertine Rift. *A.J.Plumptre/WCS*

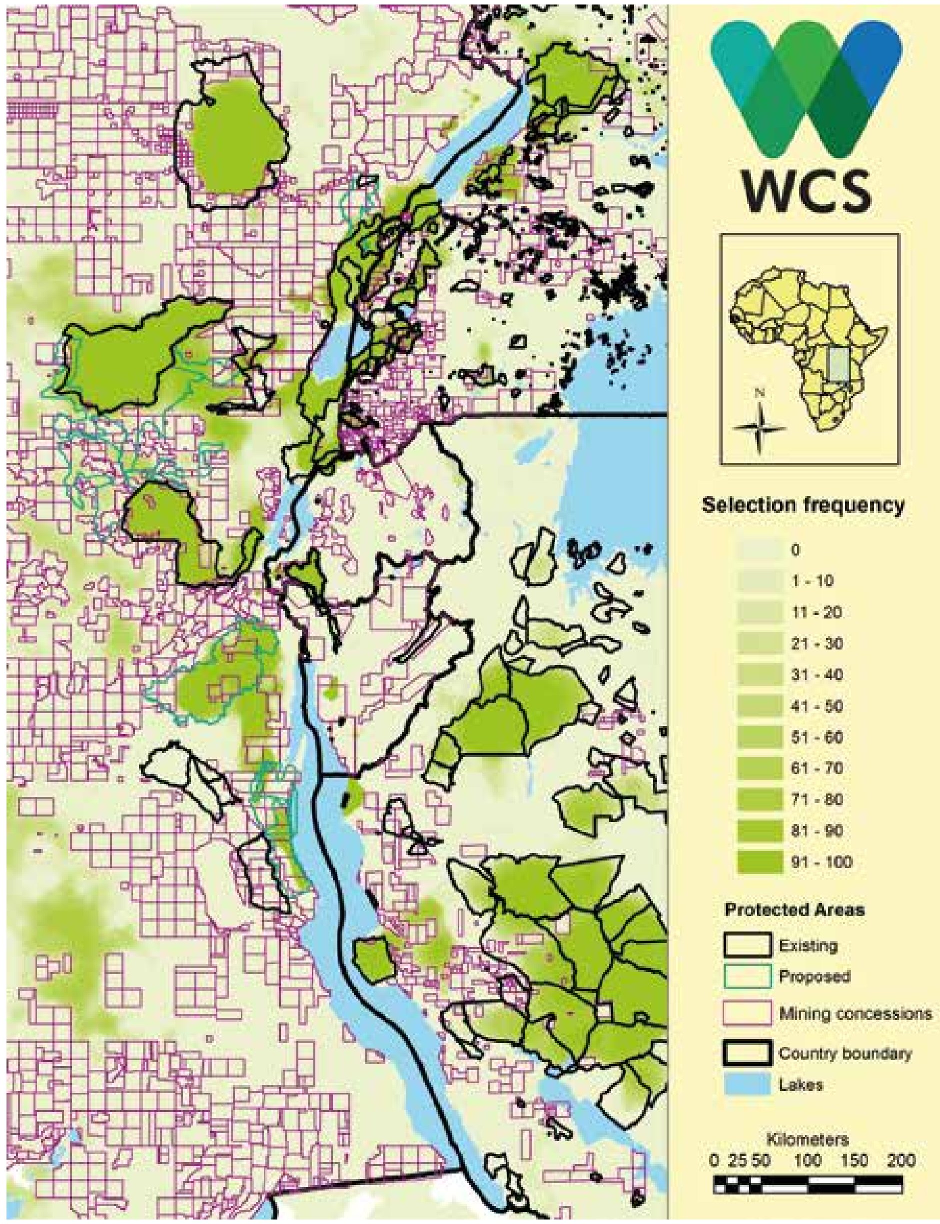


Figure 26. Percentage selection frequency of $5km^2$ cells making sites with mining concessions twice as expensive and down-weighting cells within existing protected areas.

National parks and reserves are protected with an armed ranger force. *A.J.Plumptre/WCS*

Impacts of future climate change

Global warming and the subsequent future climate change will impact any plans for conservation of the biodiversity of the Albertine Rift in the long term. Climate in the region is predicted to become warmer by at least 2ºC by the end of the century and across most of the Albertine Rift it is predicted to become wetter, although in the south it will become drier (Seimon & Picton-Phillipps, 2010; Seimon, Picton-Phillipps & Plumptre, 2012). Coupled with the global changes there have also been local changes in climate as forest has been cleared and swamps drained for agriculture and in some areas in the Albertine Rift there has already been an increase in 2ºC as a result of these local changes (Plumptre, 2012). The changes in climate will have significant impacts on the distribution and abundance of species depending on their traits and vulnerability to climate change (Carr et al. 2013) and an attempt to predict them is presented here by assessing the changes in the species distribution models when predicted under future climate scenarios in 2080.

Predicting under future scenarios of climate change

There are four storylines (A1, A2, B1 and B2) in the Special Report on Emissions Scenarios that describe scenarios of the future in relation to a wide range of demographic, economic and technological driving forces and how Green House Gas Emissions are likely to vary (IPCC, Special Report on Emissions Scenarios, 2000).The A2a storyline describes a very heterogeneous world, that is self-reliant, with a high rate of population growth, slow economic development that is regionally oriented and has slow technological change compared to other

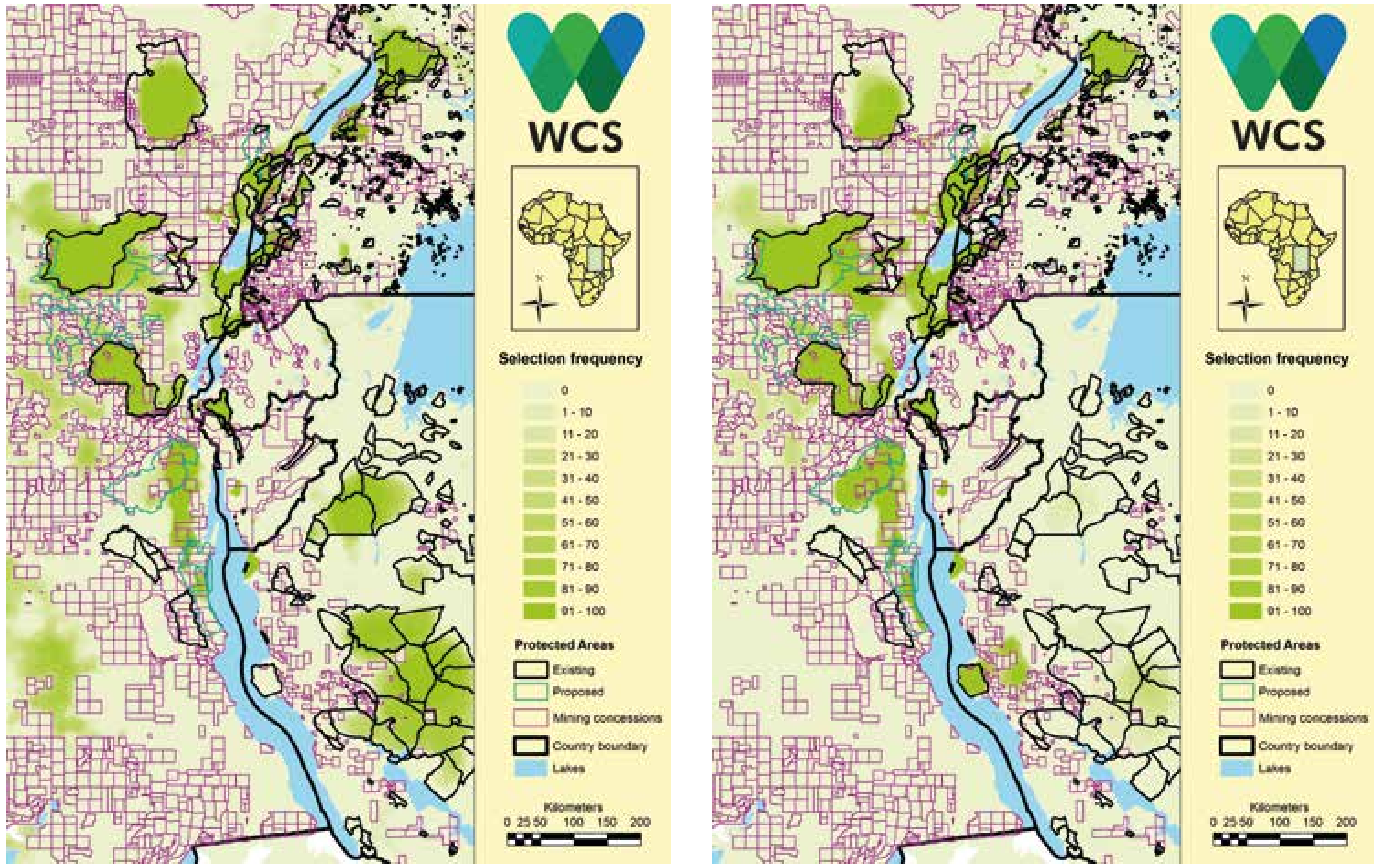


Figure 27. Selection frequency of cells where mining concessions are avoided where possible. Threatened species (left) and endemic species (right).

storylines (IPCC 2007). The A2a scenario is pessimistic compared to other scenarios with regard to GHG emissions and is considered to be more realistic (Pauw & Gobel, 2011).

The analysis focused on the impacts of climate change on the endemic species only because these are the species that are confined to the Albertine Rift and which were modelled over their global range. However we separated the analysis to look at all endemic species and only those endemics that are globally threatened. To assess the impact of climate change on the future distribution areas for endemic and only threatened endemic species in the Albertine rift, three General Circulation Models for the year 2080 under the A2a storyline were used;

i. CCCMA: CGCM2, simulated at the Canadian Centre for Climate Modeling and Analysis.
ii. CSIRO: MK2, simulated at the Commonwealth Scientific and Industrial Research Organization.
iii. HADCM3, which was simulated at the Hadley Centre for Climate Prediction and Research.

Maxent was used to model the distribution of species currently (see previous section) and in 2080 under these three climate models. The future models were also masked for existing agriculture to remove areas that are currently cultivated.

Threatened and endemic species under current and future climate scenarios

In order to quantify the richness of the predicted current distribution areas of all endemic, and globally threatened endemic species, we overlaid individual species threshold (presence/absence) outputs in ArcGIS 9.3. These threshold maps were summed for all taxa (birds, plants, mammals, amphibians, reptiles) to obtain an estimate of the richness of these species conservation targets across the Albertine rift (Figure 28).

Elephant poaching has been on the increase in the region

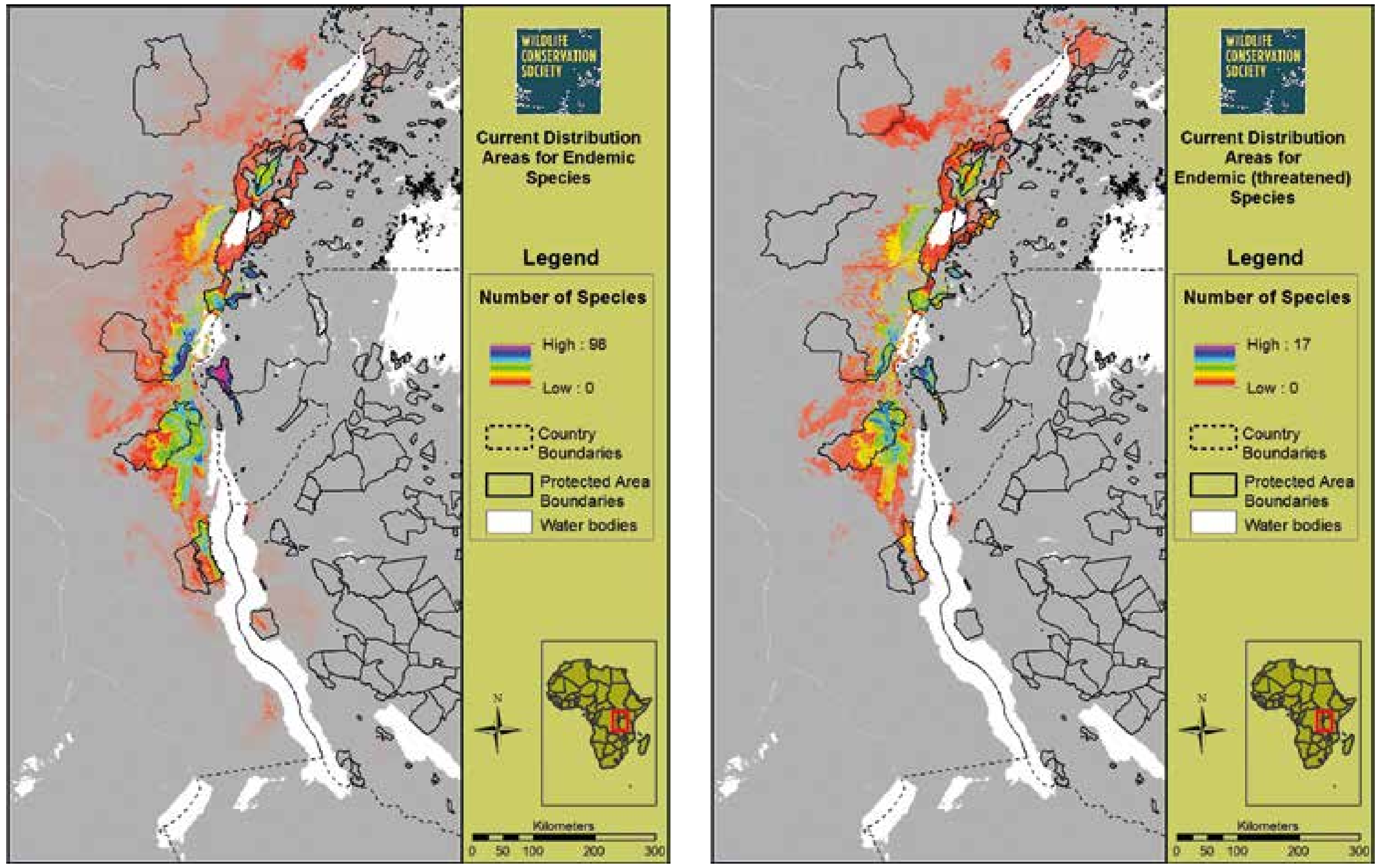


Figure 28. The current species richness of all endemic species (left) and threatened endemic species (right).

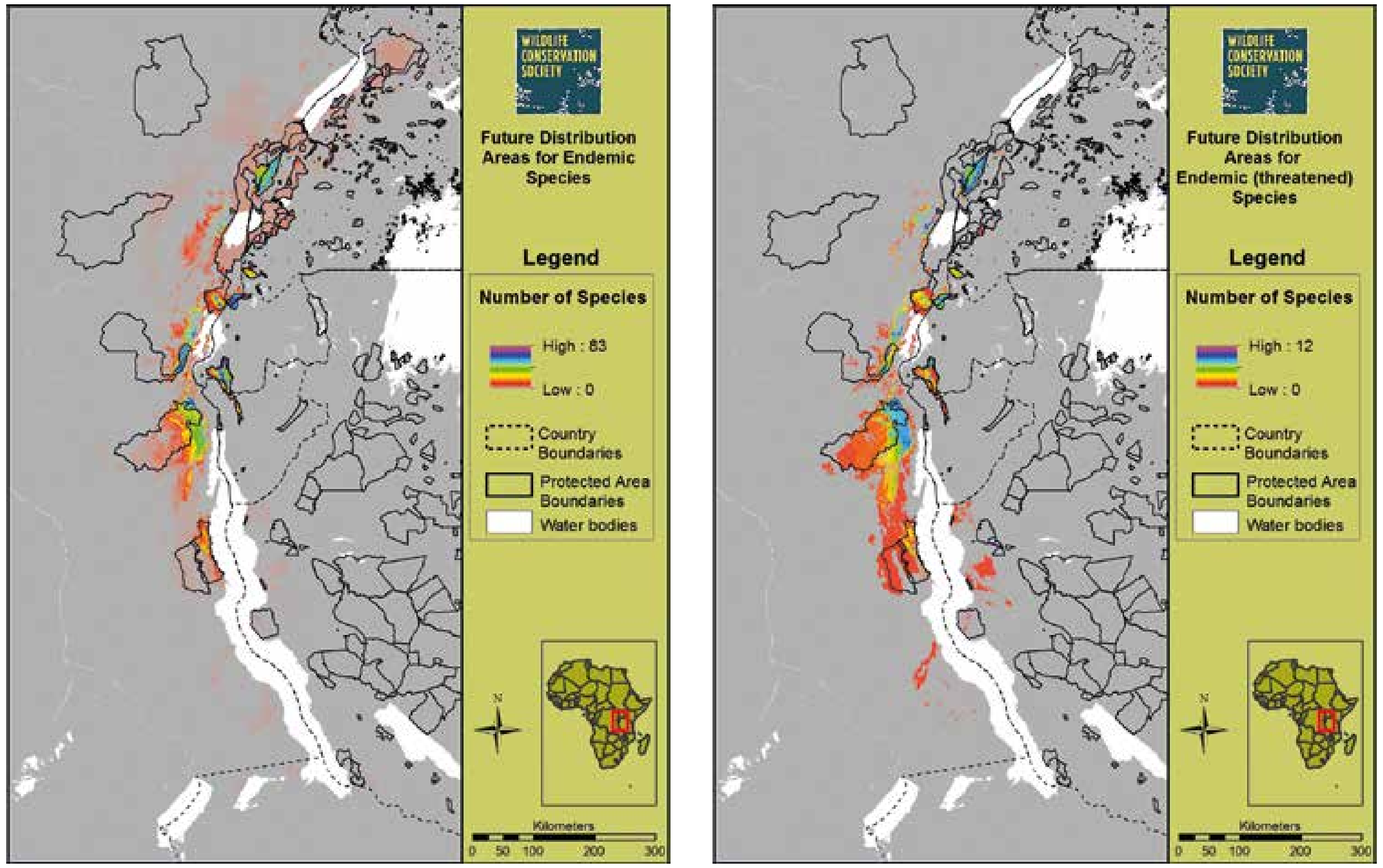
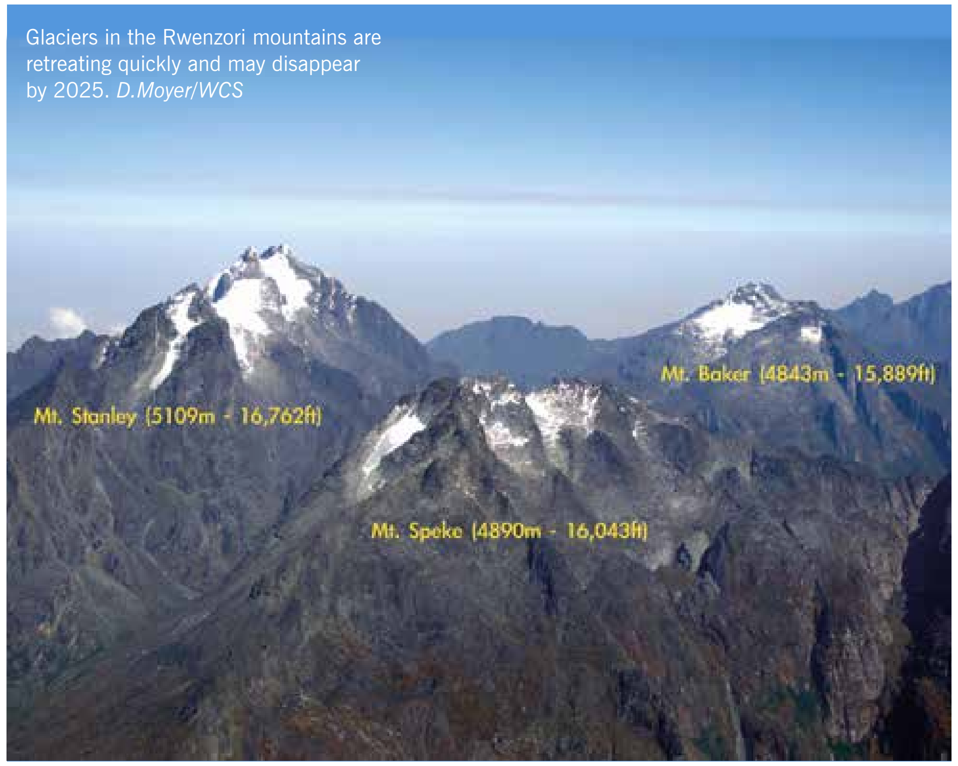


Figure 29. The predicted future species richness of all endemic species (left) and threatened endemic species (right).

The future distribution areas for each species were obtained by combining threshold outputs from the three GCMs used for model projection. Areas where two of the three models predicted presence of a species were selected to represent the future distribution of a species. Individual species threshold outputs were summed using the raster calculator in ArcGIS 9.3 for all taxa (birds, plants, mammals, amphibians, reptiles) to produce the species richness of future distributions (figure 29). This figure shows that ranges will contract to the higher elevation areas of the Albertine Rift and that the highland area of Itombwe Massif will be particularly important for future conservation efforts in the Albertine Rift.

To evaluate the extent to which climate change is likely to influence species range contraction and expansion, we compared the current distribution areas of each species with the projected future distribution areas for the year 2080 (Table 10).



Glaciers in the Rwenzori mountains are retreating quickly and may disappear by 2025. *D.Moyer/WCS*

Table 10. Impact of climate change on range size and percentage loss of range to climate change between the current and predicted future ranges.

Taxon (Species)	Range size currently (km²)			Range size in 2080 (km²)			Range Loss (%) to CC		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Endemic species									
Birds (32)	324	15,513	34,941	48	4,540	16,198	51.9	77.9	99.1
Large mammals (4)	317	30,294	119,333	51	3,298	12,376	37.5	69.4	89.4
Small mammals (27)	354	8,629	46,460	0.0	4,051	19,087	34.8	69.2	100.0
Plants (48)	256	7,079	41,346	0.0	1,907	9,025	11.7	80.1	100.0
Reptiles (10)	929	21,965	52,418	1,128	8,930	23,188	55.9	68.1	80.2
Amphibians (25)	83	11,234	44,342	0.0	5,612	22,091	7.2	74.6	100.0
Threatened Endemic species									
Birds (11)	324	7,791	19,818	135	3,097	16,198	54.3	79.2	96.9
Amphibians (13)	123	7,257	26,721	0.0	4,105	14,124	7.2	79.9	100.0
Small mammals (4)	1,358	7,676	12,771	1,087	3,266	7,428	34.8	59.2	92.3

Up to 153, endemic species (birds (37), large mammals (4), small mammals (29), plants (48), reptiles (10), and amphibians (25) are projected to lose between 7% to 100% of their current range by the year 2080 (Table 8) with averages between 59.2%-80.1% for each taxon. This indicates that on average most species will lose at least half and possibly 75% of their current distribution range by 2080. About 33 species are at higher risk with the models predicting a likelihood of range contraction of up to 90 -100% of their current range. The species that are likely to experience the highest risk (losing between 98% to 100% of their current range) from climate change impacts are, (*Kupeornis rufocinctus* (99%), *Rhinolophus willardi* (100%), *Crocidura stenocephala* (99%), *Psychotria palustris* (100%), *Otiophora pauciflora* (100%), *Arthroleptis discodactylus* (98%), *Boulengerula fischeri* (100%) and *Phrynobatrachus sulfureogularis* (100%). However, 7 endemic species (*Apalis kaboboensis, Balsamocitrus dawei, Kinyongia carpenteri, Chrysobatrachus cupreonitens, Laurentophryne parkeri, Phrynobatrachus asper, and Xenopus itombwensis*) are likely to experience an increase in their future extent of occurrence, ranging between 3.5% and 139%.

Effectiveness of current protected area network in the future

We estimated the proportions of the species distributions that are already under some conservation designation and how these might change under climate change (Table 11). For species that are projected to experience range contractions due to changing climate, the proportion of areas of overlap between current and future distributions that lie in protected areas vary on average between 19% and 38% for endemic species and 21% to 40% for threatened endemic species.


Species near the tops of mountains are at greatest risk of extinction. *A.J.Plumptre/WCS*

Table 11. Percentage of current range within protected areas and the predicted percentage in the same protected areas in 2080. The effect of establishing the Itombwe and Kabobo protected areas on the average percentage of range protected and the increase above the current average percentage range protected currently is also calculated

Taxon (species)	% protected currently			% protected in 2080			Average percentage protected by conserving Itombwe and Kabobo currently	
	Min	Mean	Max	Min	Mean	Max	Mean	% Increase
Endemic species								
Birds (38)	0.0	28.4	100.0	3.4	56.2	100.0	53.5	25.1
Large mammals (4)	18.1	75.2	100.0	13.8	77.9	100.0	75.4	0.2
Small mammals (29)	1.3	25.1	82.2	0.0	64.3	100.0	31.7	6.7
Plants (49)	11.5	41.7	100.0	0.3	62.2	100.0	59.6	17.9
Reptiles (11)	13.4	19.2	38.8	9.6	46.2	92.8	28.6	9.4
Amphibians (29)	0.0	12.8	40.3	0.0	35.4	81.9	28.2	15.4
Threatened Endemic species								
Birds (11)	9.4	39.4	100.0	9.1	50.0	92.4	54.7	15.3
Amphibians (15)	0.0	7.2	40.3	0.0	15.0	66.2	29.9	22.7
Small mammals (4)	12.7	31.7	55.6	0.0	47.4	89.7	32.7	1.0

The results in Table 11 show that the percentage of most species ranges found within existing protected areas will increase in the future, indicating that many of the protected areas already have been placed in areas that will support species under future climate change. The establishment of the Itombwe Reserve and Ngandja Reserve in June and August 2016 respectively, and establishment of Kabobo Natural Reserve in December 2016 increases the average percentage area of species under protection from 25.5% to 43.1% and under future climate from 49.3% to 63.8%. Establishing these protected areas significantly increases the area protected for all taxa except large mammals.

Climate impacts on habitats

A similar assessment was made on the impacts of climate change on the seven main habitats of the Albertine Rift (Ayebare et al. 2013; Ponce-Reyes in prep.). These were: Lowland forest, Medium altitude semi-deciduous forest, montane forest, bamboo, alpine, *Combretum*/ *Acacia* grasslands and woodlands and Miombo (*Brachystegia*) woodland. Maxent models were made of each habitat type and then predicted under future climate models except in this case 17 global circulation models from the Representative Concentration Pathways 8.5 (IPCC-CMPI5) for the years 2050 and 2070 were used and the mean value per cell used across all models.

Results show that five of the habitats (Lowland forest, Medium altitude semi-deciduous forest, montane forest, bamboo, and alpine) are predicted to lose between 57-100% of their current range by 2070. Miombo woodland would also decrease in area but not by as much as the forests and montane habitats and is predicted to lose 30% of its range by 2070. Only one habitat, *Combretum/Acacia* grasslands and woodlands, was predicted to expand its range under future climate change, increasing by 38% by 2050 but then contracting again so that by 2070 it will have a 14% larger range than currently (Ponce-Reyes in press).

Climate change impacts conclusions

These analyses show that climate change will significantly reduce the sizes of the global ranges of most of the endemic species in the Albertine Rift. Across all taxa an average of 75.8% of a species range will be lost and eight species are likely to become extinct by 2080 if the predictions hold. It will also create major changes in the extent and distribution of habitats with some of the alpine habitats disappearing all together from some mountains, together with their endemic species. This is likely to have significant impacts on agriculture in the region also and may lead to large changes in the types of crops grown together with the extent and distribution of cultivation as a result of these changes. Changes in agricultural practices have the potential to greatly increase pressure on the remaining protected areas and the future of this plan and this requires more research.

On the positive side the protected areas appear to be in the correct locations to protect species and habitats under future climate change. Key areas that needed to be established that would further protect species under climate change were the recently established Kabobo Natural Reserve which with Itombwe and Ngandja Reserves greatly improves the protection of species both currently and under climate change scenarios (Table 11).

REDD+ potential for the Albertine Rift

WCS and its partners have investigated the potential for carbon credits under the Reduced Emissions from Deforestation and forest Degradation (REDD+) at several sites within the Albertine Rift. In the Murchison-Semliki Landscape the REDD+ potential would provide funds to ensure the conservation of the forest corridors linking protected areas which are currently under great threat and a consortium of NGOs led by WCS have developed a REDD+ project for the region that needs financing to conserve these corridors (Leal et al.2011; Leal, 2012a). Support to provide incentives to farmers to conserve these forests is already underway but there is a need to establish a REDD+ financing mechanism to augment these other incentives. WCS has also made REDD+ feasibility analyses in the Itombwe Massif (Leal, 2012b), Kabobo Massif (Leal 2012c), Greater Virunga Landscape (Leal et al. 2013) and the forest corridor linking Virunga National Park to Mt Hoyo Reserve (Leal, 2011). A REDD+ project design document was also developed by Conservation International for the Tayna Reserve.

A project to protect the forest in the Mt Hoyo Corridor region has recently started with Congo Basin Forest Funds (CBFF). Much depends on the future of carbon markets and the willingness to offset carbon emissions through mechanisms that stop deforestation such as REDD+. ER-Pin documents have been developed for Itombwe Massif and Kabobo and have been presented to the REDD+ focal point in Kinshasa. Each site that has been assessed has great potential for developing REDD+ projects which could generate between $10-45 million USD over the coming years for the protection of the forests at each of these sites.

Priority areas outside existing protected areas

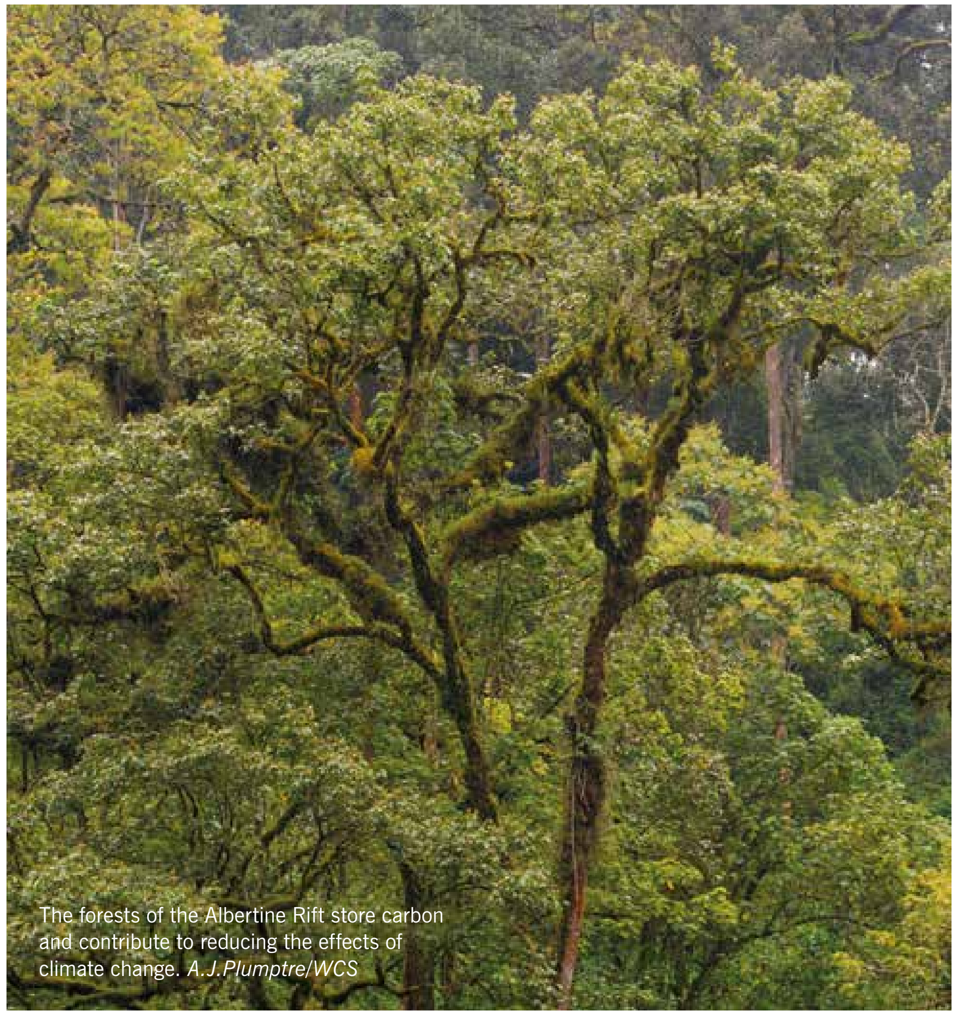
The results of both the assessment of the impacts of climate change and of the Marxan planning analysis show that despite there being good coverage of the protected area networks across the Albertine Rift there are still some key areas that need to be established and supported if all species of conservation concern are to be conserved both now and in the future.

Four critical sites identified outside existing protected areas

Four key sites have been identified by the two analyses and these are discussed here together with the current interventions that are being employed to protect the sites.

Itombwe Massif

The Itombwe Massif in the Maiko-Itombwe Landscape comes out as a critical site for conservation both now and in the future. Since the late 1980s it has been identified as being of conservation importance (Wilson & Catsis, 1989; Doumenge, 1998; Greenbaum & Kusamba, 2012) but the analyses we have made here show that it has even greater value than had previously been recognised. The



The forests of the Albertine Rift store carbon and contribute to reducing the effects of climate change. *A.J.Plumptre/WCS*

massif together with the escarpment above Lake Tanganyika (including Balala Forest) is the largest area for the conservation of endemic species in the Albertine Rift (figure 28) and this becomes even more marked under future climate change (figure 29). Itombwe has long been predicted to have been a refugial area during the last glacial maxima and it also appears that it will act as a refuge under global warming also.

Current efforts to conserve Itombwe have been led by a consortium of WCS, WWF and AfriCapacity/Rainforest Foundation. In 2006 a Natural Reserve was gazetted by the Minister of Environment but with no clear boundaries which led to much friction with the people who lived in the massif. Since that time there has been a process of consultations with the local communities to reduce these conflicts and to identify where they would be happy to establish boundaries for the reserve. A gazettment document was drawn up and presented to the Provincial Ministry of Environment and discussed by a Comite de Conseil Provinciale des Forets and the gazettment was approved by the Governor of South Kivu Province at provincial level in June 2016.

Future plans require a zoning system to be established across the Reserve that will delimit where core protected areas, sustainable use areas, cultural areas, and village development areas will be established. WCS has already developed guidelines for zoning of the reserve (Plumptre et al. 2013) and worked with a local NGO, RACCOMI, to pilot a zoning scheme in one valley of the Reserve, Mwana Valley which forms about 5-10% of the reserve. There is a need to fully zone the reserve before human population increases and parts of the reserve get converted to other land uses. ICCN, the DRC Parks authority, has a presence in Itombwe Reserve already but it cannot patrol effectively until these zones are agreed.

While the reserve protects a large part of the Itombwe massif it doesn't protect all of the high altitude area which is the most important region for the endemic and threatened species and also will become more important under future climate change. This region also includes the escarpment that runs south towards Kabobo. It is unlikely to be possible to conserve all of this area, much of which is a mosaic of grassland, forest and bamboo, but there are areas along the escarpment such as Balala Forest which have potential as tourism sites and might be able to generate revenue for conservation. For

Mountain gorillas are confined to two small protected sites. *A.J.Plumptre/WCS*

example Balala Forest contains a few gorillas and many endemic birds including those unique to Itombwe. It also has a road up to the edge of the forest which would make tourism feasible, unlike Itombwe where a 2-3 day hike is needed to reach the forest.

Kabobo massif

Since WCS's surveys in 2007, 2008 and 2012 the Kabobo Massif in the Kabobo-Luama Landscape is becoming more and more important for conservation. While there are great similarities between the fauna and flora of Kabobo and Itombwe there are also several unique species that only occur here and nowhere else. These include three shrews and a bat (Kerbis Peterhans et al. 2013a; 2013b) as well as several plants (Leal, 2014; E. Fisher in prep.) and several potentially new amphibian species (E.Greenbaum and M. Menegon pers. comm.). Conservation of this forest, the largest block of forest on Lake Tanganyika, is important and has been possible recently because of the low human population density in the area.

WCS has been working with the traditional leaders and provincial leaders to obtain agreements on the creation of a new protected area in Kabobo and this has been moving ahead steadily since 2010. Boundaries of the proposed Kabobo Natural Reserve were agreed by communities around the park and they actively protected it from settlers moving into the region. Boundaries of parts of the Ngandja Reserve, which was established in August 2016, have been agreed but the Reserve encompasses a larger area than was initially envisioned and there is a need to clearly identify the full boundary of the reserve. These boundaries need to be established following consultations with communities. Kabobo Reserve was established by provincial decree in December 2016. While local "ecoguards" have been recruited to monitor the forest and Miombo woodland in the Kabobo-Luama Landscape there is a need to establish formal management. WCS has already constructed a park headquarters and patrol posts. Funding is required to actively manage the landscape.

Tanya-Kisimba-Ikobo-Usala

The region that includes Tayna and Kisimba-Ikobo Reserves and the Usala forest region to the west of these in the Maiko-Itombwe Landscape is a region that is important for several endemic species but also a likely stronghold for Grauer's gorilla. The two reserves were established by Conservation International (CI) & Dian Fossey Gorilla Fund (DFGFI) with community consultations but in the process many promises were made to the people that couldn't be met, and as a result the communities do not recognise these reserves. There is currently little ongoing management of the sites because of insecurity for management staff.

Future work here needs to re-build confidence between the communities and the conservation community and to seek ways in which communities can benefit from the presence of the reserves. In many parts of eastern DRC communities are willing to establish protected areas, not because they hope for revenue generation, such as gorilla tourism, but more to protect ancestral lands from people moving in to the region to settle.

Sitebi Highlands and Ntakata Forest

The highland areas east of Mahale Mountains National Park in the Greater Mahale Landscape are also important for endemic and unique species. Several plant species are only known from this region (Vollesen & Bidgood, 1994;1997), as well as endemic butterflies (Kielland, 1990), and it is an important region for Kungwe apalis although this species does occur further north into the Masito-Ugalla region. Conservation work has mainly focused on the Mahale Mountains National Park in this region but more recently JGI and researchers Alex and Fiona Piel have been working in the Masito-Ugalla region where they are studying and conserving chimpanzees. While the Sitebi highlands probably have fewer numbers of chimpanzees the other species of conservation concern justify a conservation presence here and as yet little is being done to conserve the region.

Other areas of importance for some key species

Besides these four clearly important sites there are a few areas where conservation around the existing protected areas would be important for the conservation of some key species.

Oku Community Reserve

This proposed community reserve occurs west of Kahuzi Biega National Park in the Maiko-Itombwe Landscape and is likely to be a critical site for the conservation of Grauer's Gorilla (Plumptre et al. 2016). While this site conserves forest at lower altitudes than where many endemic species are found, this region is relatively remote and consequently contains some of the remaining elephants and larger ungulates in the region as well as likely containing the largest number of Grauer's gorilla remaining in the wild. The conservation of Oku Community Reserve for this ape, which is now Critically Endangered, is of global importance. WCS is working with local communities in this proposed reserve under a CARPE/USAID project and with US Fish and Wildlife Service funding support.

Virunga-Mt Hoyo Corridor

The corridor of forest that links the Virunga National Park to the Mt Hoyo Reserve to the north in the Greater Virunga Landscape will protect forest for elephants, okapis and chimpanzees which would not be viable in the Virunga Park alone. It is also an important area for the Golden-naped weaver (*Ploceus aureonucha*) and Yellow legged weaver (*Ploceus flavipes*), two birds only found in this part of the World but likely conserved in Virunga Park if the forest region is protected. This region is also the most species rich part of the Albertine Rift (figure 3). The CARPE/USAID project and CBFF project with WCS is working to establish conservation of this corridor with local communities.

Private forests between Bugoma Forest Reserve and Budongo/Itwara Forest Reserves

The corridor forests around Bugoma Forest Reserve in the Murchison-Semliki Landscape are important for the conservation of the Uganda mangabey as well as chimpanzees and some forest raptors (Plumptre et al. 2010;2011). Conserving these forests will also ensure the species confined to the larger forest reserves such as Budongo, Bugoma and Itwara can remain viable and migrate as climate changes. WCS is working with several NGO partners in a consortium, the Northern Albertine Rift Group, to conserve these vital corridors with private forest owners.

Lendu plateau

The Lendu Plateau on the western side of Lake Albert has been almost completely denuded of its forests and as a result hasn't been a priority for surveys. However, the discovery of several unique species from this region (Greenbaum et al. 2012b; 2015) means that it would be worth an exploration to identify any remaining forest and forest-savanna ecotones that could be conserved.

Marungu Massif

The Marungu Massif at the south western tip of lake Tanganyika, now primarily grassland habitat, has several species that are unique to this region also (Greenbaum et al. 2012a; Larson et al. 2016) and efforts should be made to explore the massif further and assess how best to protect these species.

Poaching of elephants have led to major population declines in the Albertine rift.
A.J.Plumptre

Illegal timber harvesting is depleting the Bugoma forests of threatened tree species.
A.J.Plumptre/WCS

Table 12. Estimated costs to implement the landscape plans. Costs per square kilometre of land and costs per species (terrestrial vertebrates and plants) in the landscape are also given.

Landscape	Total budget for 10 year plan ($US)	Annual budget ($US)	Cost per km² per year ($US)	Cost per species per year ($US)
Murchison-Semliki	17,082,900	1,708,290	163	542
Greater Virunga	92,383,005	9,238,301	588	2,023
Maiko-Itombwe *(not estimated in plan)*	40,000,000	4,000,000	99	1,130
Congo Nile Divide	36,539,000	3,653,900	2,520	1,903
Greater Mahale *(not estimated in plan)*	20,000,000	2,000,000	136	777
Kabobo-Luama *(excl Ngandja north)*	4,740,000	474,000	98	241
Total costs	**210,744,905**	**21,074,491**	**241**	**2,509**

Implementation of plan

To conserve the six landscapes of the Albertine Rift over the long term will not be easy and will require sustained financing as well as commitment from governments, NGOs and donors in order to succeed. Critical components of the plan are in place or nearly so. The creation of the Itombwe Reserve, Ngandja and Kabobo Reserves have occurred and have local community support. Community support also exists for the Oku Community Reserve in DRC and some of the private forests in Uganda. Areas that need more attention and support are the Sitebi highlands, Virunga-Mt Hoyo corridor, and the Tayna and Kisimba-Ikobo Reserves. In addition it would be useful to explore and assess options for conserving the unique species of the Lendu and Marungu highlands.

Budgeting to conserve Africa's Vertebrate hotspot

Costs of implementing plans

Four of the landscape plans developed relatively detailed budgets for each objective and activity over the ten year life span of the plan. Greater Mahale and Maiko-Itombwe plans did not have a budget associated with them (only a ranking of the costs - high, medium, low) but we here estimate the costs required to implement these plans given our experience supporting conservation in the region (Table 12). Various factors contribute to the costs, notably human population density in and around the landscapes, the size of the landscapes, local community support for the conservation of the landscapes, and pressures such as the presence of armed groups and the need for transboundary collaboration.

While the total costs of the conservation of the Greater Virunga Landscape are highest, when evaluated by costs per square kilometre it is less than the Congo-Nile Divide because of the high pressures from high human population density around Nyungwe and Kibira National Parks. On average across the Albertine Rift it costs about $241 USD per square kilometre or $2,509 per species if these plans were fully funded and implemented. These costs are much lower than many single species conservation programs. If only the threatened and endemic species are considered, these would cost about $31,930 per year to conserve if conserving them across all of the landscapes. These numbers are significantly lower than many sites in the world and show that by investing in the Albertine Rift a greater impact can be had for the same amount of funding because of the high species richness and diversity of globally threatened and endemic species.

Options for generating income

Those sites with community support such as the Kabobo-Luama landscape have significantly lower costs predicted for the implementation of the landscape plan. Sites such as this which initially have fewer opportunities for generating

Timber from DRC at a Uganda customs post.
A.J.Plumptre/WCS

funding for the site, will require community support if they are to be established and conserved. Other sites such as the Greater Virunga Landscape and Maiko-Itombwe Landscape have options to generate income from gorilla tourism in particular but also chimpanzee and primate tourism and savanna tourism in the rift valley of the Greater Virunga Landscape. Similarly the Murchison-Semliki Landscape can generate income from savanna tourism in the Murchison Falls National Park and Kabwoya Wildlife Reserve, and chimpanzee viewing in the Budongo Forest Reserve. Nyungwe and Kibira Parks in the Congo Nile Divide are generating income from primate and bird tourism although not enough to cover their running costs. Chimpanzee tourism in Gombe and Mahale Mountains National Parks in the Greater Mahale Landscape also generates significant income for these sites.

Besides tourism, REDD+ funding could generate significant income for many of the landscapes. Feasibility assessments made by WCS at several sites in the rift indicate that funding of the order of $1-2 million per year could be generated for specific protected areas with areas of forest totalling 2-3,000 km^2. With planning for REDD+ financing for the Congo Basin Forests being developed with DRC as a pilot country, there is potential for significant funding that could support the conservation of both the forests and carbon of the Albertine Rift together with the rich biodiversity of these forests and World bank and the government of DRC should be encouraged to invest in these highly biodiverse sites to augment the carbon conservation with biodiversity conservation.

Umbrella species such as mountain and Grauer's gorilla, chimpanzees, lions, African wild dogs and elephants have the potential to garner additional funding for their conservation as well as supporting conservation of other species that occur in the same habitats as these species. Fundraising for Mountain gorillas has been particularly successful over the past 30 years and can continue in the future. There is a need to target some of the other endemic but charismatic species such as the golden monkey, Congo bay owl and even some chamaeleons which are used to generate funds for sites in places such as Madagascar.

Engaging stakeholders to implement the plan

Each of the landscape plans were developed with a variety of relevant stakeholders including the national protected area authorities, national and local government, community leaders, conservation NGOs and other institutions of civil society. The plans for Murchison-Semliki, Maiko-Itombwe, Greater Mahale and Kabobo-Luama are all being implemented at national and district/provincial level in their respective countries. Conservation NGOs, protected area authorities and communities are working together to implement where resources have been raised. Some plans are better resourced than others and there is a need to support those that are under-financed, particularly the Murchison-Semliki Landscape Plan.

The Greater Virunga and Congo-Nile Divide Landscape plans are more complex and involve transboundary collaboration across international borders. In the case of the Greater Virunga Landscape this transboundary collaboration is far advanced and has recently led to a treaty signed between Uganda, Rwanda and DRC for the management of this landscape. A Greater Virunga Transboundary Core Secretariat has been formed with staff from each country participating in the management of the landscape. The fundraising for the Virunga National Park by ICCN/African Conservation Foundation has been particularly impressive, raising several million dollars for the conservation of this park each year over the past 8 years. Revenue from tourism in Uganda and Rwanda also funds most of the operating costs for the protected areas in the rest of the landscape and donors, notably USAID and DGIS, have been supporting the transboundary collaboration. In the case of the Congo-Nile Divide Landscape transboundary collaboration occurs more informally although there is an MOU which formalises the cooperation between Ministries of the Environment in Rwanda and Burundi. There is a need to move the transboundary collaborative process to the point of reaching a more formal agreement such as a treaty between these two countries and to finance the collaboration more fully.

Future needs for Planning and Research in the Albertine Rift

While this plan compiles most of the recent work that is relevant to the conservation of the Albertine Rift, like all plans it is never complete and will change with time. Having been involved throughout the whole process at all sites, we are aware that new threats appear over time,

Large carnivores such as hyaenas are at risk because of conflicts over livestock loss at protected area borders. *A.J.Plumptre/WCS*

conceptual models change, strategies that sounded good at the time they were proposed may not always generate the desired results when implemented and consequently the plans for the Albertine Rift will require changing and updating in the future. Areas that we can see that require more work include:

Biodiversity surveys

1. More biodiversity survey work in the Tayna-Kisimba-Ikobo-Usala region - conflict has prevented this to date
2. More biodiversity surveys of Maiko National Park - conflict has prevented this to date
3. More herpetological survey work combined with genetic analysis of specimens to determine the species and their distributions in the Albertine Rift as this is very much in flux at the moment
4. Compiling herbarium data on plant collections from the region to identify species and their distribution outside protected areas and to complete the plant list for the Albertine Rift

Conceptual model and threats analysis

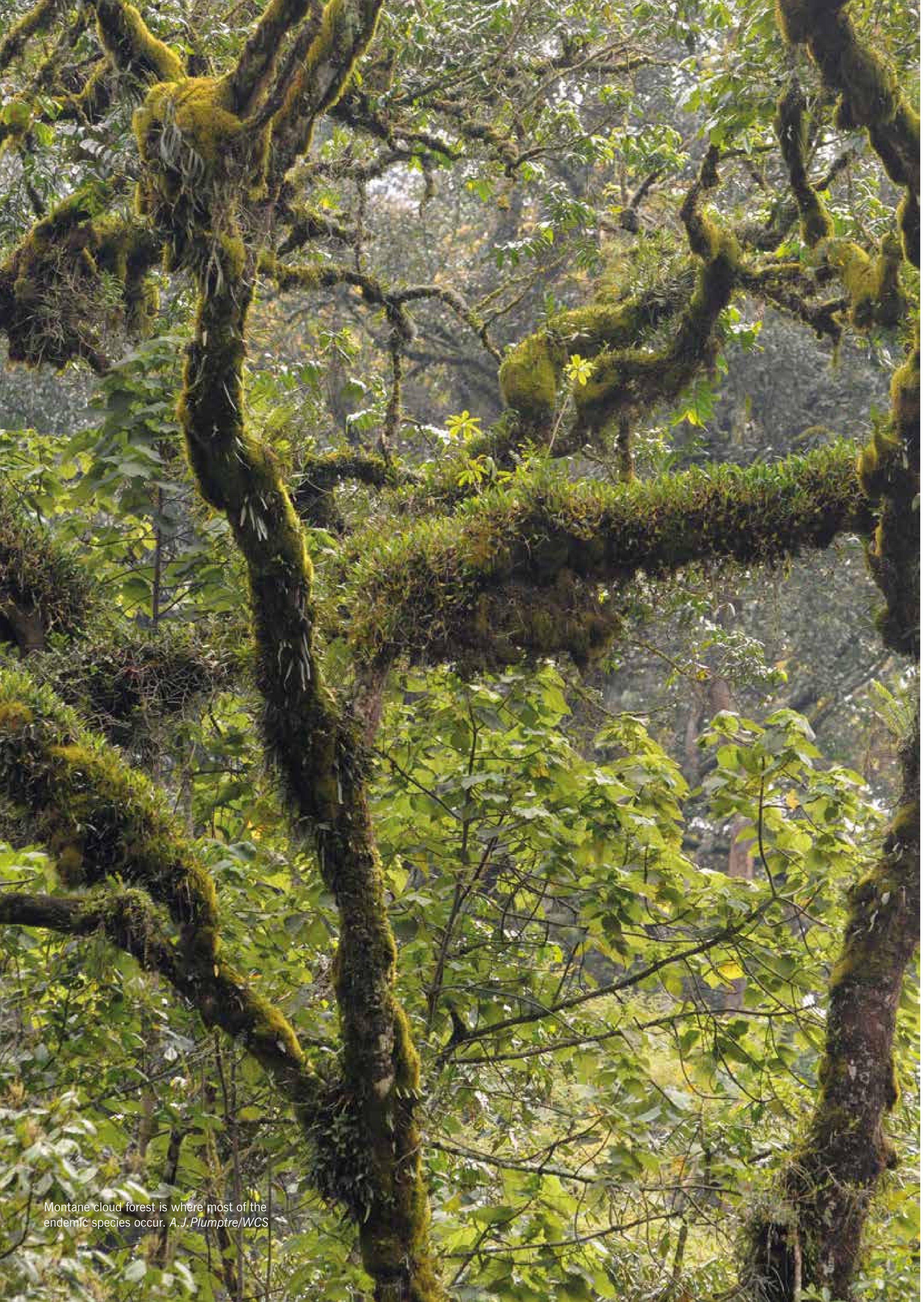
1. Mapping threats to each of the conservation targets and assessing the spatial distribution of threats in each landscape is a need for the future understanding and improved management of the landscapes. This can be achieved using SMART data which are being collected across most of the landscapes by protected area authorities.
2. Assessing where to intervene spatially to generate the best return on investment - is it better to target the most threatened areas with interventions or the least threatened? This will depend on the resources available and what impacts can be achieved.
3. Identifying which strategies are working and which are not through regular monitoring of target species, habitats and ecosystem processes. Where strategies are failing they need to be revisited and revised.
4. Updating the threats analysis as new and emerging threats appear (e.g. oil mining in the lakes along the Albertine Rift).
5. As climate change proceeds there will be a need to assess those species most likely to become extinct as a result of the changes and to monitor their numbers and responses. It is possible some may need to be translocated to better areas or taken into captivity for breeding.

Implementing and financing the plan

1. Each landscape plan is for 10 years and will require updating and revising. Already the first Greater Virunga Landscape Plan has been completed and a second 10 year plan made. Others will need following up and revisions are due soon for several of them. Interim reviews every 3-5 years are recommended to update strategies as they are tested and also update threats if they change.
2. Fundraising for the plans is variable and there is a need to identify sources of more constant financing over the longer term for each landscape. Ideally this will be coordinated between stakeholders who work to conserve the various landscapes to improve the cooperation and joint planning of activities. Marketing the idea of return on investment in the Albertine Rift makes sense as so many species can be conserved in a relatively small region.
3. Donors need to commit to long term financing of the region, as MacArthur Foundation did over a ten year period when most of this strategy and planning occurred.
4. Monitoring the pressures resulting from changes in land use as climate changes will be critical to better predict future pressures on the remaining protected areas.
5. More effort is needed to conserve the priority areas identified in this plan, particularly those sites receiving no attention from conservation at present such as the escarpment above Lake Tanganyika and the Sitebi highlands.

It is our hope that this plan will re-galvanise funding for the region and encourage potential donors to channel funding to ensure this region of incredible biodiversity is preserved for future generations.

Great lakes bush viper, *Atheris nitschei*.
F. Pupin/Trento Science Museum



Montane cloud forest is where most of the endemic species occur. *A.J.Plumptre/WCS*

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