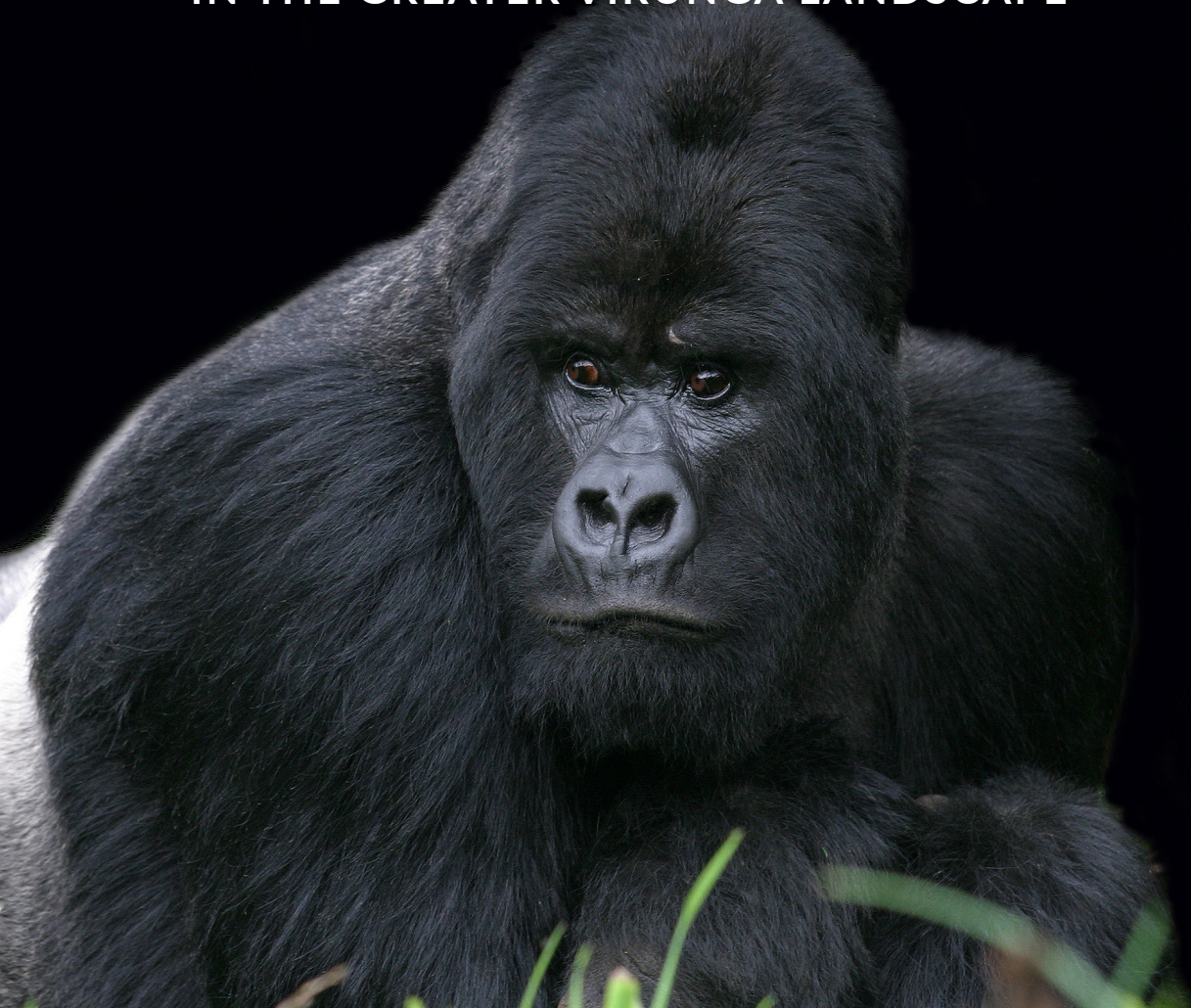


A SPECIES AND CLIMATE CHANGE BRIEF FOR



THE VANISHING TREASURES PROGRAMME

GETTING CLIMATE-SMART WITH THE MOUNTAIN GORILLA IN THE GREATER VIRUNGA LANDSCAPE



VANISHING TREASURES
PROTECTING ENDANGERED MOUNTAIN SPECIES



THE GOVERNMENT
OF THE GRAND DUCHY OF LUXEMBOURG



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GETTING CLIMATE-SMART WITH THE

MOUNTAIN GORILLA

IN THE GREATER VIRUNGA LANDSCAPE



The goal of this information brief

This brief is one of three in a series that also includes the snow leopard and Royal Bengal tiger, produced under the Vanishing Treasures programme. Its goal is to highlight how climate change is – and will be – impacting the conservation of the mountain gorilla. The brief examines how climate change

has multiple, and often interacting, impacts on the mountain gorilla – be it on its physiology, on the ecosystems on which it depends, or on the behaviour of humans living in its surroundings – with important feedback loops that directly affect the conservation of this magnificent animal.



Portrait of a baby mountain gorilla, Virunga National Park, Democratic Republic of Congo, 2017. Credit: iStock/PedroBige

“ We gorillas have a lot in common with you humans, as we share 98% of our DNA. Now with the warming climate our lives are equally threatened, as we all need to provide for ourselves and our families. Even if we are relatives, we should keep a little distance. We mountain gorillas need undisturbed areas to live a healthy life. Also, the same viruses can damage my health just as yours, and they can be passed on between gorillas and humans. We all have responsibilities for our shared future. I need to ensure the well-being of my troop in order to proudly carry the silver shimmering hairs on my back. At the same time, you can do your part to help keep our landscapes healthy. By working together, we will all have enough space and resources that we need for a good life.

– Karisimbi, mountain gorilla, Virunga mountains

Executive summary

Mountains are an important refuge for biodiversity, with their high-altitude, relatively inaccessible landscapes providing shelter to many endangered plant and animal species. In Africa, the biodiverse Albertine Rift is a region of global significance in terms of its high endemism. It is home to many endangered species, including the emblematic mountain gorilla, found in the transboundary Virunga Volcanoes, Bwindi Impenetrable National Park and Sarambwe Nature Reserve. Made famous by primatologist Dian Fossey, mountain gorillas dwindled to an estimated 250 individuals in the Virunga Massif in 1981, but the population has been recovering in recent years. Thanks to intensive efforts in conservation, research and surveillance, the global population now stands at just over 1,000 individuals. Despite this positive trend, mountain gorillas remain endangered. In addition to the emerging threat of climate change, the region has one of the highest human population densities in rural Africa, and pressure on natural resources is very high.

While the global temperature has risen by an average of 0.7°C since 1980, many mountain regions have experienced a much higher temperature increase. In the Albertine Rift, climate change impacts are already being observed in the form of increased temperatures, changes in rainfall patterns and seasonal shifts. It is expected that climate-related risks will intensify current threats to the species such as unselective hunting with snares (not targeting gorillas but often affecting them), habitat degradation and infectious disease. Mountain gorillas are thought to be adaptable animals, but many research questions remain regarding the direct and indirect impacts of climate change on gorillas through changes to their habitats and food availability or through the behaviour of people who are also adapting to a changing environment. For example, in the event of water scarcity, local people may enter the parks in search of drinking water, resulting in increased disturbance and risk of disease transmission.

As such, it is important to advance understanding of the diverse climate change impacts and interactions between mountain gorillas, local



Silverback mountain gorilla from the Virunga mountains, Rwanda, 2013. Credit: iStock/erwinf

communities and the broader ecosystem. The Vanishing Treasures programme aims to enhance knowledge and support climate-resilient integrated conservation planning in Rwanda and Uganda, with the ultimate goal of ensuring the co-existence of people and wildlife in times of rapid climate and environmental change.

“The recovery of the mountain gorilla population is an incredible conservation success story, but it is a fragile one. Working together with governments, local communities and protected area authorities, we wish to integrate climate change into conservation strategies, with the goal to ensure the coexistence of mountain gorillas and people.

– Johannes Refisch, Great Apes Survival Partnership, Coordinator

Introduction

Mountain gorillas, or *Gorilla beringei beringei*, are the best known of all gorilla populations, having been studied since 1967 and made famous through the work of primatologist Dian Fossey. They can live up to around 45 years, in social groups averaging 10 individuals (range 1-50+), comprised of one or more silverback males, several adult females and their offspring. Mountain gorillas can be found between elevations of 1,100 and 4,500m (Advani 2014), with a species range of 635km².

Mountain gorilla numbers dwindled in the Virunga Massif to an estimated 250 individuals in 1981, but thanks to intensive conservation, research and surveillance efforts over the last 40 years, the total population number is now slowly recovering. According to the most recent surveys, there are at least 1,004 mountain gorillas in the wild (Granjon et al. 2020; Hickey et al. 2018, 2019). The emblematic species is divided into two isolated subpopulations: one in the Virunga Volcanoes region straddling the border between

Rwanda, Uganda and the Democratic Republic of the Congo (DRC), and another in the Bwindi Impenetrable National Park (Uganda) and the adjacent Sarambwe Nature Reserve (DRC).

The larger geographic region of the Albertine Rift is an area of global significance in terms of biological richness, hosting 40 per cent of continental Africa's mammal species and more than 50 per cent of its bird species, many of which are endemic and threatened (Plumptre et al. 2007). As a result, the Albertine Rift is considered a biodiversity hotspot, a Global 200 Ecoregion and an Endemic Bird Area. It is home to a vast variety of habitats, ranging from lowland rainforests to alpine moorlands, and maintains important ecological processes and ecosystem services (ibid.). While the mountain gorilla habitat constitutes only a small fraction of the whole Albertine Rift region, the species' role as a flagship and umbrella species cannot be overemphasized, as their dedicated protection also benefits a wide variety of other species and larger ecosystems. For example, the Virunga National Park and the Bwindi Impenetrable National Park, which host mountain gorillas, are among the top sites in terms of endemic and globally threatened species richness in the region (ibid.).

Despite their growing numbers, mountain gorillas are still listed as endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species and appear in Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Mountain gorillas are indeed highly vulnerable to threats such as habitat loss, indiscriminate poaching (snares) and disease. Another challenge is the confined habitat size, which will eventually restrict the growth of the gorilla population (Great Apes Survival Partnership and International Union for Conservation of Nature 2018). With more than 600 people/km², the region has one of the highest human population densities in rural Africa, and human pressure around protected areas is extremely high due to local communities' high dependence on natural resources. It is expected that climate change will increasingly exacerbate adverse impacts, intensifying existing challenges and creating new combinations of risks.



Young mountain gorilla in the natural habitat of the Virunga National Park, Rwanda, 2019. Credit: iStock/Photocech

Climate change in the Greater Virunga Landscape: key trends

Global

Mountain regions are no longer isolated and remote. Worldwide, an estimated 1.15 billion people live in such regions, representing just under 16 per cent of the global population in 2015.* In addition, climate change exacerbates pressure on mountains' natural resources and is already having very noticeable impacts on mountain regions: the well-studied phenomenon of elevation-dependent warming means that these regions are warming faster than lowlands (Wang, Fan and Wang 2016). Temperature increase in mountainous areas (+ 0.3°C per decade) has outpaced the global trend (+ 0.2°C) (Hock et al. 2019). Even under medium-emission scenarios, many mountain regions will be faced with novel conditions, where the coldest years will be notably warmer than the warmest years of today (GRID-

*Analysis done by GRID-Arendal applies the definition of mountain regions initially developed by Kapos et al. (2000) to the 2015 UN adjusted Gridded Population of the World version 4 (GPWv4) to provide updated global, regional and national estimates on the number of people living in mountain regions in 2015.

Arendal 2018). The most visible impact of such warming is the melting of mountain glaciers and changes in snow cover in high-altitude areas (the cryosphere), which have impacted the amount and seasonality of run-off in snow-dominated and glacier-fed river basins (Hock et al. 2019). Globally, the trend is towards lower snowfall accumulation, especially at lower altitudes, due to higher temperatures.

Regional

Climate change impacts are already observed in the region in the form of increased temperatures, changes in rainfall patterns, longer dry spells and shifts in seasons. Most projections indicate changing rainfall seasonality for eastern Africa. Although there is significant uncertainty, precipitation is also expected to increase and is likely to become more erratic, rather than evenly distributed over time (Advani 2014). The region will experience more intense rainfall (i.e. more rain falling per event), which will increase hazards such as floods or landslides (GRID-Arendal 2018). Heat extremes will also occur more frequently (Advani 2014).



Agriculture occurs even on the steep hills. Days with morning fog have become rare because of the drying of swamps for agriculture. Credit: Johannes Refisch.

National projections

Table 1 presents national-level predictions for temperature and precipitation levels in the Greater Virunga Landscape under the Representative Concentration Pathway (RCP) 4.5 and 8.5 scenarios for the 2020-2040 period. Increased temperature and rainfall are likely for both RCP 4.5 and 8.5, but changes will vary from one country to another.

Climate change impacts on mountain gorillas

The two mountain gorilla populations are very small but are increasing, thanks to strict conservation measures. However, their remaining habitat is heavily restricted, with farms and human settlements located beside the protected areas (Hickey et al. 2019), and the mountain gorilla population may soon reach carrying capacity. When predicting the future range of African great apes under global change modelling, Carvalho et al. (2020) indicated that gorilla subspecies might need to shift their range. For mountain gorillas, other anthropogenic factors leading to habitat degradation seem to play a more important role than climate change.

Mountain gorillas are thought to be an adaptable species in the face of climate change. Indeed, certain traits – such as their tolerance to a certain degree of climatic variability, low freshwater requirements and diverse diet – promote their resilience to a changing climate. However, their long generation time, slow reproductive rate and

low genetic diversity could limit their adaptive capacity (Advani 2014). There is currently no evidence of direct impacts of climate variability on mountain gorillas, but further investigation is needed.

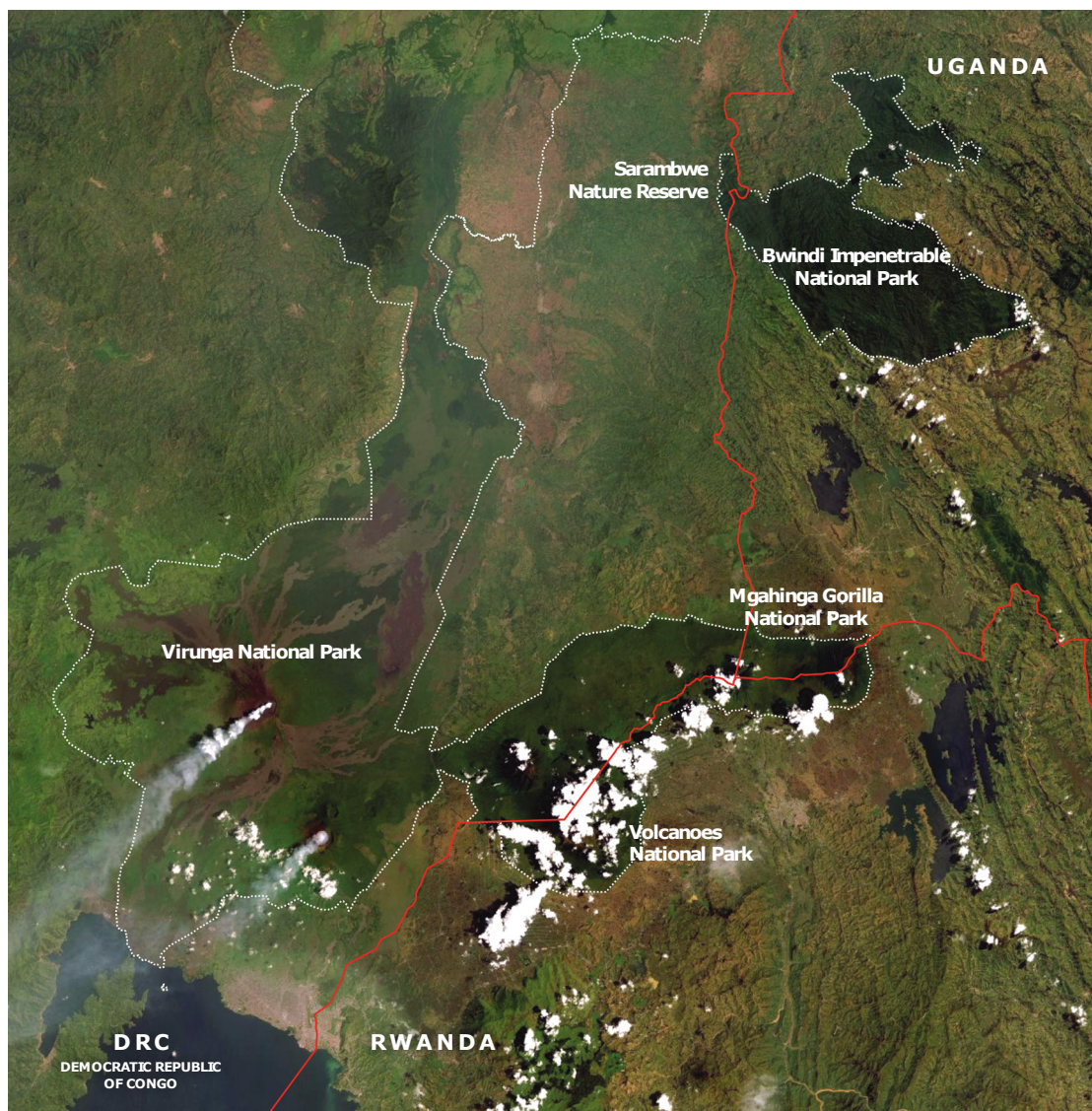
According to unpublished data from the Dian Fossey Gorilla Fund, the monitored Virunga groups increasingly reside in elevations higher than 3,300m, which could be evidence of gorillas trying to avoid neighbouring groups as their population numbers increase, but also a sign of them adapting to a warmer climate (Eckardt et al. 2019). By measuring the levels of faecal glucocorticoid metabolites, the researchers found increased stress levels in gorillas associated with higher rainfall and temperatures. Mountain gorillas may therefore be better acclimatized to a colder climate and future exposure to heat and erratic rains could create further stress. Since the Bwindi population lives at a lower-altitude range than the Virunga gorilla population, there may be some differences in how gorillas are adapted to their current habitats. Confirming these potential relationships will require further research.

Important knowledge gaps also still exist with regards to other effects of climate change on mountain gorillas, such as changes in food availability and habitat quality. Gorillas show seasonal movement patterns in response to food availability (Musana and Mutuyeyezu 2011; Seiler et al. 2018), but are those patterns influenced by climate change? The Vanishing Treasures programme will help answer some of these questions.

Table 1: Projections for changes in temperature and rainfall for Greater Virunga Landscape countries in 2020-2040

Country	RCP 4.5			RCP 8.5		
	ΔT max °C	ΔT min °C	Increase in rainfall %	ΔT max °C	ΔT min °C	Increase in rainfall %
DRC	1.05	1.44	28.59	1.02	1.72	26.63
Rwanda	0.77	0.96	5.01	0.94	1.00	3.53
Uganda	1.05	1.51	12.62	1.21	1.59	11.36

Source: Modified from Greater Virunga Transboundary Collaboration [GVTC] 2019a



“ There is growing evidence that climate change will become one of the major drivers of species extinction in the 21st century. This includes the Greater Virunga Landscape and its famous mountain gorillas which are already highly vulnerable to threats such as habitat loss, indiscriminate poaching and disease. A major challenge is mountain gorilla’s confined habitat size, which will eventually restrict population growth when maximum carrying capacity will be reached. It is crucial that we improve our understanding of the interactions between climate change impacts and other socio-economic factors, such as high human population densities, and their implications for food security and future economic growth. It is my hope that this greater understanding will enable us to adequately cope with climate change effects, reinforce resistance and adaptability, while simultaneously maintain our desired development targets.

– **Andrew Segoya**, Greater Virunga Transboundary Collaboration, Executive Secretary

Climate change impacts on the mountain forest ecosystem

Rather than being an immediate threat, climate change is anticipated to generate longer-term stress to species in the Albertine Rift. Ayebare et al. (2018) predict that climate change is likely to reduce the remaining habitats for endemic species by 75 per cent by 2080. However, there will probably be a large overlap between the existing and future habitats – 68 per cent of which is already under protection – which could increase the likelihood of species survival in those areas (ibid.).

The changes already under way in the ecosystems of the Virungas will increase as climate change progresses. Altitudinal species distribution shifts will likely become more common as ecological zones are driven to higher elevations following changes in regional temperatures (Seimon et al. 2012). This leads to a decrease in available habitat through the “tapering” effect. Indeed, it is expected that changes in temperature and rainfall will lead to high-altitude alpine areas being substituted for lower-altitude ecosystems. Decrease in low-level cloud cover could disrupt the current dynamic equilibrium of forests (GVTC 2019a). Drier seasons, droughts, fire, rainstorms (causing erosion) and non-native plant invasions also increase montane forest degradation, leading to biodiversity loss and community modification.

Climate change impacts on communities and spillover effects on mountain gorillas

Agriculture is the main source of income for the majority of households in the region and subsistence farming is the predominant form of land use. Communities in the Greater Virunga

Landscape are particularly vulnerable to climate change, because of their strong dependency on natural resources and subsistence farming and the absence of alternative livelihood options. There is significant uncertainty regarding future ecosystem service provision, coupled with the pressure exerted by a fast-growing human population (GVTC 2019a). As the principal caregivers, women are in an increasingly vulnerable position.

Agricultural expansion has had an overwhelming impact on wildlife habitats in the past, including that of mountain gorillas. For example, Ayebare et al. (2018) estimate that farmland now covers about 30 per cent of land in the Albertine Rift, a figure which is due to increase in the future driven by continued human population growth. As a combined result of agricultural expansion and climate change, they estimate that by 2080, on average only 15.5 per cent of the original species habitat will persist in the Rift region. The conversion of forests, grasslands and wetlands into agricultural plots and woodlands will further fuel climate change by increasing the release of greenhouse gases (GVTC 2019a). Considering mountain gorilla habitats, land degradation observed in 2001-2015 was particularly severe around the Bwindi Impenetrable National Park in Uganda (ibid.). The destructive impact of increasing fire incidents is also notable, whether caused by climatic factors or expanding human activities related to vegetation clearing, poaching or apiary (ibid.).

According to a community survey conducted around the seven national parks of the Greater Virunga Landscape, 95 per cent of households have observed changes in rainfall, 83 per cent have experienced drought, 78 per cent have observed changes in temperature and 77 per cent in winds (GVTC 2019b). Among the negative, mainly farming-related consequences borne by community households, 90 per cent reported low yields, 81 per cent suffered from food insecurity and 67 per cent from farmland loss, whereas 41 per cent had witnessed an increase in human-wildlife conflicts (GVTC 2019b). Farmland on steep hillsides is particularly vulnerable to climate change due to degradation caused by erratic weather, whereas important valley areas are expected to increasingly turn unfertile



We need to be vigilant through research and actions to ensure that climate change does not reverse the substantial efforts made in the past decades that have made mountain gorillas a rare case of population recovery.

– Martha Robbins, Max Planck Institute for Evolutionary Anthropology

and polluted (GVTC 2019a). Communities are adopting adaptation strategies, such as planting fast-maturing crops, increasing inputs or terracing. Nevertheless, they are limited by several factors, including uncertain land ownership, fragmentation of plots among many smallholders and a lack of tools. The increasing water stress and its direct impacts on farming productivity are likely to pose the most significant threat to local communities, which are highly dependent on rain-fed crop production and ecosystem services (GVTC 2019a). Adjusting the historic cropping cycles to the unpredictable, changing circumstances is highly challenging (ibid).

Water stress has increased the demand for land and natural resources for agricultural production and has significantly exacerbated conflict over land use in and around African national parks (Seimon et al. 2012). In the Greater Virunga Landscape, collection of drinking water inside national parks also leads to further stress and interference with species. Water collection is



Majority of park edge communities depend on subsistence agriculture which has been negatively impacted by climate change. This affected income, food security, nutrition, access to safe water among others.

– **Henry Mutabaazi**, International Gorilla Conservation Programme, leading the community programmes

usually the responsibility of women and children. With the lack of drinking water in the prolonged dry season, it is often women who enter the national parks in search of drinking water. National park rangers have difficulty in ensuring that no other resources are taken from the parks. Indeed, if climate change limits farming as a viable livelihood option, there is an increased likelihood of locals turning to poaching as an alternative means of income. This may fuel additional conflicts with the local communities.



Agricultural development and the associated clearing of the land pushes right up to Bwindi Impenetrable National Park. Eastern edge of Bwindi Impenetrable National Park. Credit: flickr/Jason Houston (CC BY-NC-ND)

Mountain gorillas are rarely a direct target of wildmeat hunting, as primates are not part of the surrounding communities' normal diet, nor is trophy hunting seen as a significant threat (Basabose and Gray 2015). Instead, a much larger challenge relates to accidental snaring of individual gorillas in traps meant to capture other wildmeat species (ibid.). This risk could grow in the future if local communities' food security situation keeps deteriorating as a result of climate change (Belfiore 2015) and fast-growing human populations.

The risk of disease transmission

As climate change progresses and human settlements potentially move closer to park boundaries, the risk of conflicts between community members and gorillas competing over the same resources may increase (Basabose and Gray 2015). At worst, such encounters can lead to disease transmission, human injuries and gorilla casualties (ibid.).

Because they are physiologically similar to humans (sharing over 98 per cent of DNA),

great apes are susceptible to diseases that affect humans (Gilardi et al. 2015), including Ebola, anthrax, Marburg viruses and respiratory diseases. Leendertz et al. (2006) showed that transmission risks increase as human populations advance into great ape habitat. Pathogens can thus be transferred from humans to gorillas, in particular when exposed to high numbers of tourists, researchers, trackers and locals who go to the forest in search of drinking water, bamboo or firewood or to set snares, but also when gorillas leave park boundaries to forage in cultivated fields. Several human-induced outbreaks have occurred over the years (Spelman et al. 2013).

Additionally, disease is easily transferred within mountain gorilla populations because of frequent contacts between the individuals of a group, the clustered distribution of groups with high home-range overlaps, intergroup interactions, their extremely limited range and the frequent transfer of individuals between groups. Meanwhile, bushmeat consumption can cause infections in humans (Leendertz et al. 2017).

The global COVID-19 crisis is a threat not only to human health, but also to great apes. However, it is still not known whether mountain gorillas would suffer from the same morbidity and mortality rates as those associated with the virus in humans. Mountain gorillas are particularly exposed to zoonotic disease transmission, as the majority of gorilla groups are habituated to human presence. Range states have taken strong measures, temporarily suspending tourism sites and research activities. However, great ape tourism is an important source of income for governments and communities.

Countries, national parks, research projects and conservation initiatives have faced a severe loss of funds, in a context of significant economic strains due to the pandemic. Reduced presence in the forests can have dire consequences, as broad loss of employment could potentially lead to an increase in hunting for bushmeat and habitat degradation. The establishment of financial mechanisms to offset losses, keep staff employed and protect local communities' health thus represents a critical conservation opportunity (International Gorilla Conservation Programme [IGCP] 2020).



With COVID-19, nature has sent us a stronger message. To protect ourselves and Earth's precious wildlife for the long term, we must tackle habitat and biodiversity loss. These briefs show the path to the future we all want – one where people's well-being and livelihoods go hand-in-hand with thriving habitats and species.

– Bruno Pozzi, United Nations Environment Programme, Europe Director

Potential solutions

A significant amount of ecological data has been collected on mountain gorillas in recent decades. The Max Planck Institute for Evolutionary Anthropology has focused its field research in the Bwindi Impenetrable National Park since 1998. In the Volcanoes National Park, the Karisoke Research Center founded by Dian Fossey in 1967 is managed today by the Dian Fossey Gorilla Fund. In addition to continued research and monitoring, there is a need to couple existing data with climate data in order to find possible correlations and fill knowledge gaps on the impact of climate change on mountain gorillas. This includes studying the potential impacts of local changes in climate on vegetation and on mountain gorilla diet and feeding behaviour. Another point of interest is heat stress to assess how resilient and adaptive gorillas are to the rising temperatures. This is particularly important considering how confined their habitat is. These upcoming research activities will be supported by the Vanishing Treasures programme.

Another important factor impacting the future of mountain gorillas are the human settlements immediately surrounding the national parks. In order to reduce the dependency of the growing human population on natural resources – such as drinking water, bamboo, firewood and wildmeat – more sustainable rural livelihoods are needed to reduce the subsequent pressure on national parks. As climate change is anticipated to negatively impact subsistence farming in the region, the Vanishing Treasures programme will conduct pilot activities in the Nkuringo buffer zone around Bwindi. Improved buffer zone management is expected to have a dual positive economic impact on communities by reducing human-wildlife conflict and crop losses caused by wild animals while also enhancing income through dedicated buffer crop cultivation. Improved livelihood activities will focus on food security, access to clean water and more efficient household energy sources. Women's active role and participation in related programme activities will be encouraged.



The Virunga volcanoes photographed from the Ugandan side. Credit: Johannes Refisch.

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