Gorilla Conservation and One Health

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Abstract

Disease is one of the key threats to gorillas along with high human population growth rates, habitat loss, and poaching of wild animals in their habitat. Though mountain gorillas were once critically endangered, a One Health approach has contributed to reversing the trend and increasing the number from 700 to just over 1000 in the past 17 years, leading to a downgrading of the IUCN status of this subspecies to endangered. Conservation Through Public Health (CTPH) founded in 2003, establish a One Health or integrated Population Health and Environment (PHE) approach that addresses human, animal, and ecosystem health together in order to reduce threats to wildlife and fragile ecosystems. CTPH established integrated programs that improve wildlife health, conservation attitudes and practice, community health, and alternative livelihoods. This includes regular gorilla health monitoring and comparative pathogen analysis and support to community volunteers including Village Health and Conservation Teams (VHCTs) and Human and Gorilla Conflict resolution (HUGO) teams; as well as, providing premium prices for good coffee from farmers bordering Bwindi Impenetrable National Park. This One Health approach to gorilla conservation has contributed to reduced disease incidences in the gorillas, increased adoption of family planning methods, improved hygiene and attitudes toward conservation, and reduced conflict between people and gorillas. CTPH has built upon this award winning model that addresses 10 out of the 17 Sustainable Development Goals (SDGs) to mitigate the impact of COVID-19 on gorilla conservation.

Keywords

Mountain gorillas · Conservation · One Health · Zoonoses · Disease · Sustainable development goals

Introduction

According to the IUCN, mountain gorillas (*Gorilla beringei beringei*) are classified as an endangered species, with an estimated population of 1063 free-ranging individuals. An estimated 459 individuals inhabit Bwindi Impenetrable

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Fig. 1 Photograph of a mountain gorilla at Bwindi Impenetrable National Park, Uganda

National Park in southwestern Uganda, with the remainder inhabiting the Virunga Volcanoes Mountain Range that spans Rwanda, the Democratic Republic of Congo (DRC), and Mgahinga National Park in Uganda. The IUCN status of the mountain gorilla was downlisted from critically endangered to endangered in 2018 due to positive growth trends over the past two decades. The mountain gorilla is also the only gorilla subspecies in recorded history to demonstrate a rise in population this century, from 650 in 1998 to 1063 in 2018 (Hickey et al. 2018) (Figs. 1 and 2).

Threats to Gorillas

Habitat loss, poaching, competition for food, poverty, high human population growth, human–wildlife conflict, and the spread of zoonotic diseases between people, wildlife, and livestock all threaten the continued survival of endangered mountain gorillas and other gorilla subspecies.

Gorillas and other nonhuman great apes are particularly vulnerable to zoonotic diseases because they share 98.4% genetic material with humans, and are thus highly susceptible to

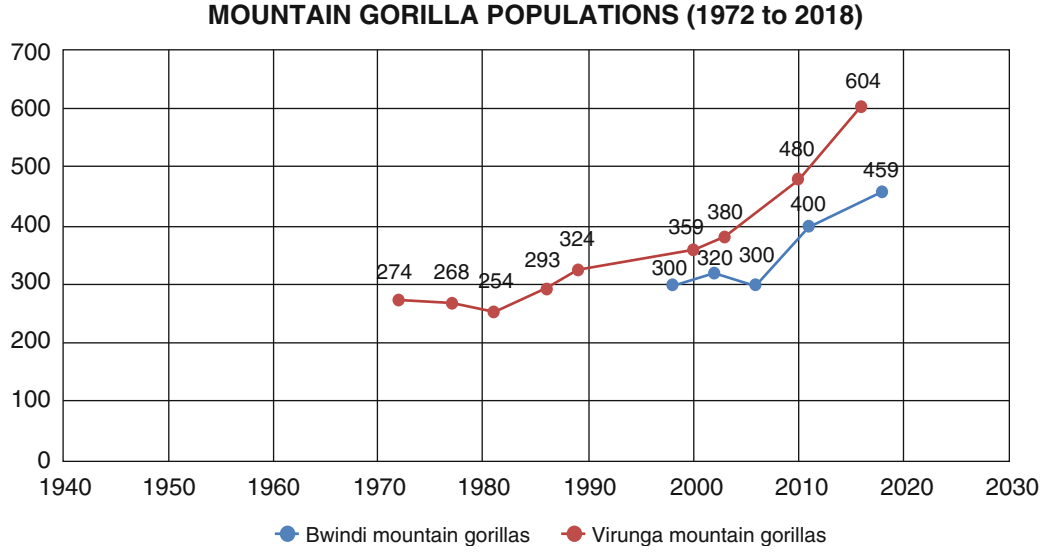

Fig. 2 Mountain gorilla population census results from 1970 to 2020

virulent pathogens spreading between humans and nonhuman great apes (Köndgen et al. 2011; Scully et al. 2018; Coscolla et al. 2013, Patrono et al. 2018; Grutzmacher et al. 2018; Negrey et al. 2019). Pathogens of concern include those of global pandemic scale such as SARS (Severe Acute Respiratory Syndrome), novel coronaviruses (COVID-19), and Ebola, as well as endemic human pathogens such as measles, and scabies, a contagious skin disease spread via direct contact with *Sarcoptes scabiei* mites (Graczyk et al. 2001; Kalema-Zikusoka et al. 2002; Walsh et al. 2003; Melin et al. 2020; Damas et al. 2020). Outbreaks have occurred in mountain gorillas, from contact with the local communities, resulting in morbidity in many gorilla groups, with a few mortalities. Tourists have also been implicated as potential reservoirs of disease transmission. In 2009, an outbreak of human metapneumovirus, a respiratory illness was traced to a tourist outside Rwanda, and resulted in the death of a mother and infant gorilla (Palacios et al. 2011).

One Health

One Health is described as an approach that promotes human, animal, and ecosystem health as a whole, and thus encourages veterinarians, medical practitioners, and conservationists to work together to address issues that require a multidisciplinary solution, such as zoonotic disease prevention and control, and promotion of environmental health.

This chapter will focus on how the One Health approach has been implemented in order to achieve conservation outcomes. We will illustrate this with a case study of Conservation Through Public Health (CTPH), a grassroots nongovernmental and nonprofit organization established in 2003 to prevent and control disease transmission at the human/wildlife/livestock interface, while cultivating a winning attitude to conservation and public health in local communities. The mission of CTPH is to promote biodiversity conservation by enabling people, gorillas, and other wildlife to coexist through improving health and community livelihoods in and around protected areas in Africa. CTPH's goal is for people, wildlife, and livestock to live together in balance, health, and harmony, with local communities acting as stewards of their environment. CTPH envisions a world where gorillas live in a secure environment, coexisting with healthy communities. To achieve these goals, CTPH has three main integrated programs: wildlife health, community health, and alternative livelihoods. CTPH aims to:

- Promote biodiversity conservation by reducing threats to gorillas and their habitat through proactive health monitoring of gorillas; preventive care for gorillas, people, and livestock; and emergency care for animals.
- Provide an early warning system for disease outbreaks through regular analysis of gorilla fecal samples, and comparative pathogen analyses of people, gorillas, and livestock, in order to minimize cross-species disease transmission.
- Promote community hygiene and sanitation and reduce infectious disease transmission by encouraging health-promoting behaviors.
- Improve community reproductive health outcomes using an integrated approach to population, health, and the environment (PHE).
- Improve community attitudes toward conservation practices.

This chapter describes how a One Health approach contributes to gorilla conservation. Direct impacts include the reduction of anthropozoonotic disease transmission. Indirect impacts include improved public health and family planning outcomes for local communities, and improved attitudes toward gorilla conservation, which in turn may reduce dependence on the utilization of vital gorilla habitat for food and firewood.

Assessment of Disease Risks to Gorillas

Gorillas come into close contact (less than 7 m) with humans through the following ways:

foraging outside their protected habitat, research, and tourism (Kalema-Zikusoka and Rwego 2016; Weber et al. 2020). This close proximity increases the risk of transmission. Bwindi Impenetrable National Park currently has 18 habituated gorilla groups utilized for tourism and research. Approximately half of these gorilla groups also periodically leave the park to forage on community land an estimated 30% of the time.

Outbreaks of scabies have occurred among mountain gorillas in 1996 (Kalema-Zikusoka et al. 2002), and again between 2000 and 2001 (Graczyk et al. 2001). The outbreaks were traced to local communities with limited access to basic health care and adequate hygiene practices. This is an example of anthropozoonotic disease transmission, or transmission of a pathogen from humans to animals. The 1996 outbreak resulted in a high morbidity rate of all gorilla group members who displayed symptoms of alopecia, pruritus, and scaling and crusting of the skin, and one fatality of an 8-month old in the Katendegyere group. The severity of the disease was age and size related, with the infant being the worst affected, and the lead silverback gorilla exhibiting only scratching with no hair loss (Kalema-Zikusoka et al. 2002). Three of the four individuals in the Katendegyere gorilla group only recovered after being treated with ivermectin using a remote injection (dart).

In 2000, another scabies outbreak affected 17 gorillas who also developed the same symptoms, and recovered after treatment with ivermectin (Graczyk et al. 2001). The source of the outbreak was again traced to the local human community surrounding Bwindi Impenetrable National Park, Uganda (Graczyk et al. 2001). Gorillas have opportunities for close contact with communities surrounding the Park when they range outside of park boundaries to forage on banana plants and other appealing crops. Gorillas are curious animals, and it is theorized that they may have touched infected clothing placed on scarecrows to deter wildlife from eating crops (Kalema-Zikusoka et al. 2002).

Bwindi Impenetrable National Park is surrounded by some of the most economically depressed regions in Africa, where access to proper hygiene, sanitation, and basic health services is limited. There is significant spread of communicable disease among the human population, and the rate of chronic immunosuppressive diseases such as tuberculosis and HIV/AIDS is high (https://www.cdc.gov/globalhivtb/cdcs-impact/cdconthefrontlines.html).

Bwindi Impenetrable National Park is 321 square kilometers and considered by many conservationists as an island of biodiversity in Uganda amidst a sea of human habitation. The human population surrounding Bwindi has one of the highest global densities, at 200–600 people per square kilometer (Kalema-Zikusoka 2013). When CTPH programs began, the average family size was 10, and higher than the Ugandan national average of 7 (Uganda Demographic and Health Survey 2016). Thirteen years after CTPH implemented a community-based family planning program, the fertility rate has reduced to 4.2 children per family in Kanungu District with the two parishes where the program was implemented. Additionally, Uganda has one of the highest global population growth rates, at 3.1% in the latest Demographic and Health Survey (UDHS 2016). These figures contribute to the increasing human pressure for land utilization, resulting in a hard edge with no buffer zone around much of the park, exacerbating human, gorilla, and other wildlife conflicts.

Promoting Health and Conservation Using a Community-Based Model

CTPH's community health program is centered around strengthening community-based health care by working with Village Health Teams (VHTs) established by the Ministry of Health (MOH). The field program began in 2004 in two high human–gorilla conflict parishes, Mukono and Bujengwe, in Kanungu District, where CTPH implemented ongoing educational programs for local communities. Trusted members of the community were selected in 2007, based on their ability to read and write, and were trained by CTPH to conduct both health and conservation outreach, creating a model of Village Health and Conservation Teams

(VHCTs). Thus, CTPH links the community to local health centers through the VHCTs who are trained in the promotion of hygiene and sanitation; infectious disease prevention, referral, and control with a focus on zoonoses; family planning promotion, including the administration of family planning measures such as the Depo-Provera injection for women; advancement of good nutrition; and the referral of children with malnutrition to the nearest health centers. The VHCTs additionally promote gorilla conservation, forest conservation, and sustainable agriculture. The program expanded to the neighboring Kisoro District in 2010, and the most active VHTs were trained to become VHCTs.

In addition to the risk of anthropozoonotic disease transmission, gorillas may also transmit emerging infectious diseases such as Ebola to humans. The Ebola case fatality rate in humans is as high as 90%, and often associated with consumption of meat from monkeys and close contact with infected people. However, at Bwindi Impenetrable National Park, people do not have a culture of consuming monkeys though they hunt duiker and bush pigs in the forest bringing them into closer contact with gorillas. VHCTs place an emphasis on decreasing such risks through the avoidance of bushmeat consumption, which may include great apes in other countries.

Evaluating Monthly Data on Positive Behavior Change Within the Local Communities

From the outset, CTPH established a system to monitor and evaluate human behavioral change each month. After external and internal reviews of the methodology, a decision was made to develop a simpler data collection tool, which mirrored MOH methodology, namely the ticking of indicators, and individual pages for each household. This system minimizes errors in data entry by simplifying collection and reducing the use of subjective assessment, facilitating the ease of both monitoring and evaluation. CTPH made a strategic decision in 2018 to engage all VHTs as VHCTs, based on a recommendation from Travers et al. (2019) to improve conservation outcomes. This reduced the number of homes each VHCT was responsible for, enabling them to visit homes more frequently and facilitated data sharing with MOH, who is ultimately responsible for the VHTs and other relevant health NGOs.

Results from a comparison between 60 households frequently visited by the VHCTs with a control group of 60 non-visited or much less frequently households over a duration of 10 years revealed that VHCT-visited homes had better markers for health and conservation, including hand-washing facilities outside of pit latrines, greater knowledge of human and gorilla disease transmission, knowledge of family planning, less human–gorilla conflict, and reduced dependence on the forest to meet their basic needs (Ainerukundo et al. 2019). This information was subsequently used to demonstrate the success of VHCTs and community outreach efforts by CTPH.

Village Health and Conservation Teams

In order to support the efforts of community health volunteers, CTPH has invested in a number of measures to increase their health, overall livelihood, and boost morale. CTPH encouraged the volunteers to establish group livestock income-generating projects. Income from these projects is reinvested into VHCT Village Saving and Loan Associations (VSLAs), and members meet monthly to lend and borrow money, as well as to exchange knowledge related to their work within the communities served. Additionally, CTPH conducts routine quarterly engagements with the groups, as well as on an individual basis, for progress review and continuing education in methodology and emerging issues. As a result of these efforts, there has been no volunteer loss or turnover among the 29 volunteer workers during the first 10 years of the program.

Training Park Staff and Community Volunteers to Monitor Gorilla Health

CTPH trains park staff, who are the first line of contact with the mountain gorillas, to report gorillas showing overt signs of disease and to

conduct daily observations for clinical signs of abnormal appearance or behavior, as well as to collect routine fecal samples from each habituated gorilla group on a monthly basis. Human and Gorilla Conflict resolution (HUGO) teams are community volunteers trained and supervised by the Uganda Wildlife Authority (UWA), with support from International Gorilla Conservation Programme (IGCP) and CTPH to safely herd gorillas and other wildlife back to the park when found foraging in community land (Kalema-Zikusoka and Rwego 2016). In addition to reducing conflict between people and wildlife, CTPH also trains HUGOs to monitor the health of gorillas when the risk of disease transmission is highest, at the interface between gorilla habitat and community lands. Both park staff and HUGO members receive training in One Health. Park staff are also trained to manage tourists during gorilla viewing in order to enforce rules such as: maintaining a minimum distance of 7 m during visits to the gorillas; encouraging people to turn away to cough or sneeze, proper disposal of human defecation while in gorilla habitat; and the refraining of eating, drinking, smoking, or flash photography while in the presence of the gorillas (Hanes et al. 2018; Weber et al. 2020). The HUGOs, like the VHCTs, are a volunteer organization, and are given the same support of group livestock income-generating projects by CTPH as described above for the VHCTs.

Building a Gorilla Health and Community Conservation Center for Analysis of Pathogens from Wildlife, People, and Domestic Animals

In 2005, the first initiative for CTPH's wildlife health program was to build a field laboratory that would facilitate proactive gorilla health monitoring through regular analysis of normal gorilla fecal samples, as well as abnormal gorilla fecal samples from gorillas showing clinical signs of disease. The Gorilla Research Clinic enabled monthly laboratory analysis of fecal samples from each habituated gorilla group, gorillas showing clinical signs, and unhabituated gorillas during the gorilla census, conducted once every 4–5 years (Rubanga and Kalema-Zikusoka 2013). In 2015, the clinic was upgraded and expanded to a permanent Gorilla Health and Community Conservation Centre. Disease investigations to date at the Gorilla Health Centre field laboratory include testing for: intestinal helminths and other parasites; protozoa, including entamoeba, giardia, and cryptosporidium; and bacteria, including *Salmonella* and *Shigella* (Kalema-Zikusoka 2015; Nolan et al. 2017).

During the first year, data collected from CTPH identified the Nkuringo gorilla group to have the highest rate of parasitic infections, which likely correlated with their preference for regular foraging in community lands. This prompted UWA to recruit and train additional HUGO community volunteers to herd the Nkuringo gorillas from community land, in an effort to reduce their risk of disease transmission from humans. A few years later the parasite infection rate was reduced and was comparable to other gorilla groups.

Linking with Local Human Health Centers Through Comparative Disease Investigations

A study implemented in 2010 investigated the prevalence of cryptosporidium and giardia species in people, gorillas, and livestock that interface with one another (Kalema-Zikusoka et al. 2018). Samples collected from habituated and non-habituated gorillas, community-owned livestock herds, and humans around Bwindi were screened for cryptosporidium and giardia using the ImmunoSTAT Commercial Field Kit (Johnstone et al. 2003; Scheffler and Van Etta 1994), and dubious samples confirmed with Direct Fluorescence Antibody Test (DFA) (Chalmers et al. 2011).

Giardia was detected in 5.5% of livestock, 40% of symptomatic humans from the local hospital, and 9.5% of asymptomatic park staff, but not in gorillas. *Cryptosporidium* was detected in 3.1% of habituated gorillas, 4.7% of livestock, and 62.4% of park staff. Unlike previous studies

in Bwindi and Virunga National Parks, no giardia species were detected in gorillas.

The Village Health and Conservation Teams (VHCTs) may have contributed to the decreased prevalence of giardia in the mountain gorilla population through the implementation of improved hygiene and sanitation of local communities living at the interface with gorillas.

Cryptosporidium species found in the habituated gorillas may have been associated with human interaction, similar to previous studies (Graczyk et al. 2001) where a VHCT was selected for each village with positive human samples, and where gorillas often range. Local health centers were mobilized to educate patients on the health risks of collecting water from unprotected sources, and cattle water troughs were built to prevent cattle from defecating and contaminating water that is shared by humans and gorillas.

Linking with Local Human Health Centers Through Community Based Health Promotion

Over the past 10 years of work at the Gorilla Research Clinic, we have contributed to the identification of some of the primary causes of diarrhea in the community, such as giardia, *E. coli*, and other coliforms. CTPH encourages communities to better manage their water resources in order to reduce contamination with diarrhea-causing pathogens. Prevention education includes: teaching farmers to dig water troughs for their cattle in order to reduce defecation in streams where water is collected for human use; collecting water with clean containers from protected water sources; and boiling drinking water prior to consumption.

In 2015, CTPH built a permanent home by expanding the Gorilla Research Clinic to a larger Gorilla Health and Community Conservation Centre, with more rooms for laboratory work and a community resource meeting room. Through partnerships with UWA, local health centers, and local veterinary centers, the new One Health Center conducts a regular analysis of both normal and abnormal gorilla, human, and livestock fecal samples. Results from gorilla fecal sample analysis help to guide teams in how often and where to deworm people, livestock, and in extreme circumstances, gorillas that have a high parasite burden, or abnormal parasites from people and livestock causing clinical signs.

Conclusion: Impact on Gorilla Conservation

Since 2003, CTPH has contributed to an increase in the overall mountain gorilla population, from 700 to an estimated 1063, and at Bwindi specifically, from 320 to an estimated 459 gorillas.

There has been a reduction in human-related disease outbreaks in the gorillas, with no scabies outbreaks since 2002, and reduced exposure of gorillas to human and livestock diseases such as giardia, which lowered to non-detectable levels in the mountain gorillas (Kalema-Zikusoka et al. 2018). This outcome is attributed to a combination of increased referrals of people with infectious diseases such as tuberculosis, and improved health and hygiene in homes bordering park boundaries. Data collected from CTPH has revealed a three to seven fold increase in handwashing facilities outside the pit latrine, from 10% to between 30 and 75%, as well as an increase in homes with pit latrines, clean water storage containers, and drying racks (Ainerukundo et al. 2019).

Additionally, CTPH's family planning program has contributed to a significant increase in women who are using modern contraceptives from 22 to 67% of women in the communities of Mukono and Bujengwe parishes. This increase falls above the national Ugandan average in rural areas from 30 to 47% in the same time period (National Population Council 2019). Behaviour Change Communication has resulted in an increase in the inter-birth interval, contraceptive prevalence rate, and a reduction in the rate of conception in the number of children for each woman in Kanungu District from 6.7 to 4.2, which is now among the lowest in Uganda (National Population Council 2019). When a family reduces their number of children, they are better able to provide good health care and

education, thus reducing the threat of disease transmission between people and gorillas, and helping to break the poverty cycle. An unintended positive outcome has been the reduction of gender disparity, as women are more involved in conservation, and men are more involved in family planning and health care.

CTPH has seen similar gains within the marginalized Batwa pygmy community, where data has shown that when the program began 1% of households had hand-washing facilities compared to 10% among the majority Bakiga community, and overall hygiene and sanitation measures are poor at best. Batwa communities rely heavily on natural resources from within Bwindi Impenetrable National Park, and efforts by CTPH to support this community may contribute to a decrease in such dependence, and subsequent drain on gorilla habitat.

CTPH's One Health program has resulted in a better quality of life for Bwindi local communities, which in turn has led to more positive attitudes toward conservation. Examples include: the local community protecting an aged silverback gorilla from Mubare gorilla group who could not keep up with the rest of his family group, and chose to settle in community lands rather than the forest (Kalema-Zikusoka 2019) and the VHCT community volunteers promoting sustainable agriculture, which utilizes less land, and adhering to improved soil and water conservation methods, resulting in less pressure on fragile gorilla habitat.

Future Recommendations for Model Sustainability and Scalability

CTPH has established one of the first One Health field programs in the world, in communities surrounding Bwindi Impenetrable National Park. This program is also being scaled up to Virunga National Park in the Democratic Republic of Congo (DRC) in order to serve communities surrounding the DRC populations of mountain and eastern lowland or Grauer's gorillas (*Gorilla beringei graueri*) in DRC. This One Health model is being sustained through alternative livelihoods at the community level, which have been expanded to include reformed poachers, who are being given similar group income-generating projects as the VHCTs and HUGOs. The One Health model is also being supported externally through a social enterprise, Gorilla Conservation Coffee, that provides above-market prices for coffee farmers in the Bwindi community, reducing their dependence on gorilla habitat for food and fuelwood. The farmers are trained in sustainable agricultural practices that conserve soil and water, enabling ecological sustainability. Additionally, a portion of the proceeds from coffee sales is funneled into CTPH's community health, gorilla health, and conservation education programs.

CTPH's programs embody a One Health or integrated Population Health and Environment (PHE) approach that addresses human, animal, and ecosystem health together in order to reduce threats to wildlife and fragile ecosystems. This is accomplished through the prevention and control of cross-species disease transmission, as well as the promotion of: family planning, hygiene and sanitation, nutrition, sustainable agriculture, wildlife and forest conservation, agribusiness, ecotourism, and the reduction of conflict between people and wildlife. An analysis by CTPH has revealed that this work began at Bwindi Impenetrable National Park, home to 43% of the world's remaining mountain gorillas, addresses 10 of the 17 UN Sustainable Development Goals (United Nations 2015). The SDGs are important in bringing countries together to holistically achieve shared goals where the work of CTPH is mainly contributing to the goals of conservation, health, development, gender, and sustainable consumption. The model of CTPH can be extrapolated to other species, ecosystems, or areas of concern, by addressing the human side of the equation in conservation, namely by addressing the needs of the people in order to indirectly support conservation and biodiversity. The 10 UNDP sustainable development goals that CTPH contributed to are:

SDG 1. No Poverty
SDG 2. Zero Hunger
SDG 3. Good health and well-being
SDG 5. Gender equality

SDG 6. Clean water and sanitation
SDG 8. Decent work and economic growth
SDG 10. Reduced inequalities
SDG 12. Responsible consumption and production
SDG 15. Life on land
SDG 17. Partnerships for the goals

A One Health model has the potential to help reverse the negative growth trend of other gorilla subspecies, including eastern lowland gorillas (*Gorilla beringei graueri)* western lowland gorillas (*Gorilla gorilla gorilla)* and cross river gorillas (*Gorilla gorilla diehli*).

CTPH has also tested this One Health model in savannah ecosystems such as Queen Elizabeth National Park and Pian Upe Wildlife Reserve, where the primary threat to conservation is disease transmission at the interface between wildlife and livestock. Many of these diseases are zoonotic, including brucellosis, tuberculosis, and Rift Valley Fever. This work has helped to improve community attitudes toward park management by focussing on improving livestock health and husbandry through facilitating the formation of Community Conservation Animal Health Workers. CTPH has also tested this model in a non-great ape mountainous ecosystem, Mount Elgon National Park, where the primary threat to conservation is habitat encroachment through planting of crops and cattle grazing leading to cracks in the mountain and landslides (UWA 2019). The model has reduced conflict between local communities and park management by focusing on improving community health and family planning. Finally, this model has been implemented in a freshwater ecosystem at Lake Victoria Basin through Ecological Christian Organization, Osienala and Pathfinder International to reduce overfishing while improving community health, and to slow the region's high human population growth rates.

Donors

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