available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/biocon

Transboundary conservation in the greater Virunga landscape: Its importance for landscape species

Andrew J. Plumptre[a,*], *Deo Kujirakwinja*[a], *Adrian Treves*[b], *Isaiah Owiunji*[a], *Helga Rainer*[c]

[a]*Wildlife Conservation Society, P.O. Box 7487, Kampala, Uganda*
[b]*Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, NY 10460, USA*
[c]*International Gorilla Conservation Programme, P.O. Box 10950, Kampala, Uganda*

ARTICLE INFO

Article history:
Received 16 June 2005
Received in revised form
30 November 2005
Accepted 8 August 2006
Available online 19 October 2006

Keywords:
Transboundary conservation
Landscape species
Large mammals
Large birds
Collaboration
War

ABSTRACT

Several of the protected areas within the Albertine Rift are contiguous with protected areas across international boundaries. This is particularly true for the Greater Virunga Landscape, which includes Virunga National Park in the Democratic Republic of Congo (DRC) and ten contiguous protected areas in Uganda and Rwanda. The larger bodied animal species that occur in this landscape have moved freely across what are now international borders for millennia and some species probably need this larger landscape if their populations are to remain viable. An analysis was carried out to identify these 'landscape species' and the importance of this cross-border movement is assessed in the light of civil wars in the region. For 13 years the International Gorilla Conservation Programme has been working in the Virunga Volcanoes and Bwindi Impenetrable National Park to foster transboundary collaboration. The results have shown that regular meetings and planning of activities by wardens can lead to better conservation even with countries at war with each other. More recently the Wildlife Conservation Society has started a programme to support transboundary collaboration further north in the landscape so that all contiguous protected areas are working together. The results show that mountain gorilla numbers have on the whole increased during the past 25 years despite civil wars in the region and this can largely be attributed to their ability to generate income from tourism but also to enhanced transboundary collaboration between Congo, Rwanda and Uganda. Ungulate numbers on the other hand have declined drastically since the 1960s but it is shown that the connectivity in the landscape has been important in reducing the impact of the civil war on elephants.

© 2006 Elsevier Ltd. All rights reserved.

1. Introduction

Conservation of protected areas that are contiguous with those in adjacent countries is both a challenge and a vehicle to foster greater international cooperation. Of the three sites being assessed in this symposium series, two straddle at least one international boundary; the Albertine Rift and the Cameroon-Nigeria highlands. While the Eastern Arc forests are primarily confined to Tanzania there are some forests in south-east Kenya but none of these actually straddle the international boundary between these two countries. This paper examines the history of conservation in the Greater

* *Corresponding author.*
E-mail address: aplumptre@wcs.org (A.J. Plumptre).
0006-3207/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biocon.2006.08.012

Virunga Landscape, the changes in large mammal populations and threats to their existence over time, and an assessment of species that require regional management in this landscape.

The Greater Virunga Landscape is an interconnected set of 11 protected areas that straddle the borders of Uganda, Rwanda and Democratic Republic of Congo (DRC) (Fig. 1). Bwindi Impenetrable National Park is sometimes considered together with this landscape but its connection to it was severed about 50 years ago. This landscape includes the Virunga Volcanoes, famous for their population of mountain gorillas (*Gorilla beringei beringei*), the savanna parks of Virunga and Queen Elizabeth, the Kibale National Park famous for its diversity and biomass of primates (Oates et al., 1990; Struhsaker, 1997) and the Rwenzori massif also known as the 'Mountains of the Moon'. Altitude ranges from 5100 m at the top of the Rwenzori massif to 600 m in the Semuliki park and consequently the landscape supports a wide variety of habitats. These habitats include, alpine moorland, giant heather, bamboo, montane and submontane forest, savanna woodland and grassland, high and low-altitude wetlands, lakes and vegetation types specific to lava colonisation and thermal pools around the active volcanoes of Nyamluagira and Nyriagongo in Virunga Park (Burtt, 1934; Robyns, 1948-1955; Mollaret, 1961; Lock, 1977; Howard, 1991). Virunga, Rwenzori Mountains and Bwindi Impenetrable national parks are World Heritage Sites, Queen Elizabeth Park is a Biosphere Reserve and Lake George is a Ramsar Site. This landscape contains more terrestrial vertebrate species and more endemic and threatened species than any other site in Africa (Table 1; Plumptre et al., 2003). As such it is a site of global importance for conservation.

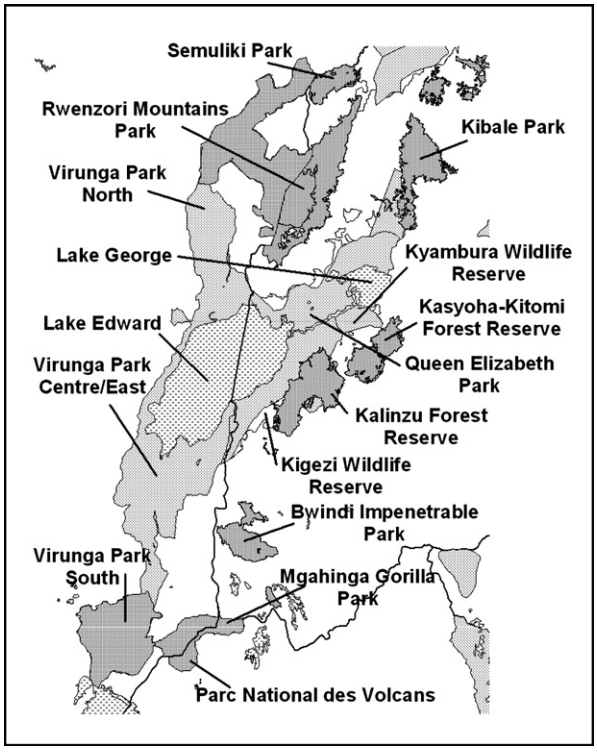

Fig. 1 – The protected areas that comprise the Greater Virunga Landscape. Darker shaded areas are forested and lighter shading indicates savanna grassland and woodland.

Table 1 – Species richness and numbers of endemic and threatened species for the Greater Virunga Landscape (Data from Plumptre et al., 2003)

Taxon	Species richness	Endemic species	Threatened species
Mammals	278	30	22
Birds	871	31	16
Reptiles	134	12	1
Amphibians	84	21	10
Fish	81	56	?
Plants	3180	246	27

This paper reviews the history of the conservation of various components of this landscape, particularly the activities contributing to transboundary collaboration and coordination, and then assesses which species within the landscape are likely to require more active management and transboundary coordination in order to ensure their long term survival. We use this landscape as a primary example to emphasise the challenges, successes and future changes required for effective transboundary conservation, especially in a war-torn region of sub-Saharan Africa.

1.1. *History of conservation in the greater Virunga landscape*

Virunga National Park, in DRC, was established in 1925, encompassing the part of the Virunga Volcanoes [Volcanoes (Parc National des Volcans) and Mikeno sector of Virunga park]. In 1927 it was increased in size to its current extent and included a buffer zone that linked Virunga National Park to Bwindi Impenetrable National Park. In Uganda, Bwindi, Kibale, Kasyoha-Kitomi, Kalinzu-Maramagambo and Semuliki were established as forest reserves in 1932 and Rwenzori established as a forest reserve in 1941. Queen Elizabeth Park, Uganda, was established in 1952. Bwindi, and Rwenzori were made national parks in 1992 and Semuliki and Kibale in 1993. Mgahinga was established as a gorilla sanctuary in 1930 then became a game and forest reserve (managed jointly) in 1941 and finally became a national park in 1992. These protected areas were established for a variety of reasons. Initially it was to protect the mountain gorillas, and then later on the large concentrations of large mammals found in the savannas of Virunga and Queen Elizabeth parks. The forests were gazetted to protect watersheds and to provide firewood, timber and other materials for people living around them. In DRC the parks are managed by the Institut Congolais pour la Conservation de la Nature (ICCN), in Rwanda by the Office Rwandais pour Tourisme et Parcs Nationaux (ORTPN) and in Uganda by Uganda Wildlife Authority (UWA).

Following reasonable protection from the 1930s, the abundance of animals increased in the parks and in the 1960s numbers were at high levels. Some of this increase may have been due to a contraction of available habitat outside the protected areas, which was occurring at that time, forcing animals to move into them to escape poaching and habitat loss but this is not known for sure. At this time the savanna areas

of Virunga Park had one of the highest biomass density of wild mammals ever recorded on earth, at 314 tonnes/km^2 (Cornet d'Elzius, 1996). During the 1970s, poaching of wildlife for meat and ivory by the regime of Idi Amin and then civil war in Uganda led to a major decline in large mammals, particularly in Queen Elizabeth National Park. For instance, numbers of elephants for the park fell from 2500 in the late 1960s to 150 individuals in 1980 (Lamprey et al., 2003). Much of this decline was due to poaching (Malpas, 1980) but it is likely that animals escaped to Virunga Park across the Ishasha River to the south of Lake Edward and also through the corridor north of the lake. Since the current government took power in 1986 numbers of elephants have steadily increased in the park again, however, civil war in Rwanda and then DRC led to a large decline in large mammal numbers in the 1990s. Again there is some anecdotal evidence (R. Malpas pers. comm.) that species such as elephants fled to Uganda from DRC at this time. The importance of the linkages between these parks, in particular the savanna parks, is critical during periods of civil war.

During the early 1980s, tourism to see mountain gorillas was established in Rwanda by the Mountain Gorilla Project. The success of the Mountain Gorilla Project in Rwanda led to the establishment of the regional International Gorilla Conservation Programme (IGCP – a consortium of the African Wildlife Foundation, Fauna and Flora International and World Wide Fund for Nature) in 1991. IGCP started a process of regional collaboration between the three countries for the areas where mountain gorillas occur in the Virunga Volcanoes and then later between Bwindi Impenetrable National Park and Sarambwe Reserve (DRC).

1.2. *Transboundary collaboration in the greater Virunga landscape*

IGCP successfully developed a process of coordination and collaboration between the protected area authorities in the three countries (Rainer et al., 2003). A process of regular meetings between wardens of the three protected area authorities (ICCN, ORTPN and UWA) and of these authorities with their partners was established. This process led to the development of friendships and willingness to help each other out during various times of crisis since the early 1990s. While difficult to quantify, these relationships increased the ability to work across the international border and also helped tackle problems of poaching and trafficking of gorilla infants (Rainer et al., 2003). A measure of the success of this programme was that it continued even when the countries were at war with each other in the mid and late 1990s.

In 2003 the Wildlife Conservation Society expanded the geographical area in which this transboundary conservation programme was operating by supporting UWA and ICCN in a similar process further north in the Greater Virunga Landscape, where Queen Elizabeth, Rwenzori Mountains and Semuliki National Parks in Uganda meet Virunga Park in DRC. As such there are now transboundary conservation activities being supported throughout the Greater Virunga Landscape.

Activities that take place under the transboundary collaboration include; joint planning, coordinated patrols that work to trap poachers that flee across the international boundary to escape capture, coordinated tackling of threats to the parks, collaborative information gathering on illegal activities (e.g. ivory trade), regular meetings of wardens to share what is happening in their region, joint training, joint monitoring of wildlife and illegal activities and coordinating with the military to avoid problems with parks staff.

1.3. *Landscape species of the greater Virunga landscape*

The Wildlife Conservation Society has developed a method to analyse species that require management at a landscape scale under their Living Landscapes Program (Sanderson et al., 2002). The aim of the process is to identify which species may need additional conservation management action to ensure their populations survive in the long term. These are usually species that require large ranges, occur at low density and have low reproductive rates. The needs of these species are assessed and management actions recommended based upon these assessments. In some landscapes where the method is applied it leads to conservation of one or more species outside as well as inside a protected area (e.g. elephants and bongos in logging concessions adjacent to parks in the Republic of Congo).

In the case of the Greater Virunga Landscape the landscape species that occur here are likely to need coordinated management between protected areas, both across international borders and also between institutions in the same country (UWA and the National Forest Authority in Uganda) for contiguous parks and forest reserves respectively. A process of landscape species selection for the Greater Virunga Landscape was made with both scientists and protected area managers and this paper describes the process and the species selected. It then analyses how populations have changed for several of these species within the landscape since the 1960s and looks at two, the elephant (Loxodonta africana) and the mountain gorilla (Gorilla beringei beringei) in more detail.

2. Methods

2.1. *Landscape species identification*

WCS has identified six criteria/characteristics that can help select species that may need more detailed management and whose management can help capture the needs of other species. These are

1. area needs (species that would require relatively large areas to maintain a minimum population of 100–200 breeding individuals);
2. distribution (species endemic to the Albertine Rift or listed as threatened in the IUCN Red Data Book listings);
3. functionality (species that act as important pollinators, seed dispersers, ecological engineers, keystone prey or keystone predators);
4. habitat heterogeneity (species that depend on more than one habitat for breeding, raising young, sheltering and foraging);

5. socioeconomic significance (species that have strong positive or negative value to local residents or national and international stakeholders); and
6. vulnerability (species that either suffered many threats Vm or were particularly sensitive to a single threat so they could serve as an indicator species, Vi).

The process used to identify the landscape species for the Greater Virunga Landscape was less data intensive than those that have been published earlier (Sanderson et al., 2002; Coppolillo et al., 2003). This was because in this part of the world insufficient data existed to be able to plan in the same way. A workshop comprising protected area managers and biologists was held to use these criteria to identify landscape species. Armed with a list of vertebrate species (mammals, birds, reptiles, and amphibians) present in the Greater Virunga Landscape, participants were split into three groups to identify candidate species that displayed key biological criteria deemed important to management and conservation. Each group included a facilitator to help clarify the characteristics. Many species were listed under each criterion but the groups were asked to select the 8–10 species that best represented the group and represented the variety of habitats that the species use and the variety of their functional roles (e.g. Hippos fertilize the lakes and increase the productivity of the fisheries as a result; elephants change woodland into grassland when at high density) in the landscape. The need to reduce the number is evident when it comes to identifying specific management actions following the identification of species. Then all three working groups collated their lists and these were ranked by the total number of key biological characteristics (1–6) identified for each species.

2.2. *Compilation of population numbers*

We compiled all the old census records for the various protected areas within the Greater Virunga Landscape to assess population changes of large mammals in the landscape since the late 1950s/early 1960s (when the earliest records were available). Much of the early information that was available was for the savannas as these were more easily surveyed by aircraft. Surveys of large mammals on the savannas in Virunga Park were made in 1958–1960 (Verschuren, 1993), 1981 (Mertens, 1983) and 2003 (Mushenzi et al., 2003). Regular aerial surveys in Queen Elizabeth National Park were made from 1963 up to the 1980s (Malpas, 1980), sometimes of large mammals and sometimes focused upon elephant numbers. Two surveys were made in the 1980s (Olivier et al., 1989; Douglas-Hamilton et al., 1980) and then several in the 1990s and early 2000s (Lamprey et al., 2003). Forest surveys did take place for elephants in Kibale Forest in the 1960s (Wing and Buss, 1970) and for mountain gorillas in Bwindi Impenetrable National Park and the Virunga Volcanoes in 1959–1960 (Schaller, 1963) but we could not find any other surveys of forests. While census methods did vary (particularly total counts of some species such as elephant and buffalo vs sample counts to calculate densities) the great changes that occurred in animal numbers between the 1960s and the present cannot be attributed to differences in the census methods. Since the late 1960s fairly standard aerial survey methods were used for either the total or the sample counts and the variability between the different counts are unlikely to be just due to sampling methods.

3. Results

3.1. *Landscape species selection*

The resulting draft list of Landscape Species contained 32 species including several different guilds. Eleven species (lion, *Pathera leo*, leopard, *Panthera pardus*, golden cat, *Felis aurata*, chimpanzee, *Pan troglodytes*, gorilla, *Gorilla gorilla*, buffalo, *Syncerus caffer*, hippopotamus, *Hippopotamus amphibius*, elephant, *Loxodonta africana*, crowned eagle, *Stephanoaetus coronatus*, lappet-faced vulture, *Torgos tracheliotus*, lesser flamingo, *Phoeniconaias minor*) appeared under more than one criterion and these were reviewed to see how well they 'captured' all habitats. It was identified that afroalpine and swamp habitat was not included so the Rwenzori duiker (*Cephalophus rubidus*) and sitatunga (*Tragelaphus spekei*) were added to include these two habitats, respectively. The process and list produced was reviewed and some changes made based on the input of other biologists after the meeting. The result was 13 Landscape Species (Table 2). These are key species that probably need some additional management in addition to law enforcement if their populations are to survive in the Greater Virunga

Table 2 – The 13 Landscape species selected with the six criteria and total score (summed across the criteria)

Species	Area	Distribution	Functionality	Habitat Heterogeneity	Socioeconomic	Vulnerability	Total score
Lion	1	1	1		1	1	5
Chimpanzee		1	1		1	1	4
Elephant	1		1		1	1	4
Hippopotamus			1	1	1	1	4
Leopard	1	1	1			1	4
Gorilla		1			1	1	3
Golden cat	1	1	1				3
Crowned Eagle	1		1				2
Buffalo	1			1			2
Lesser Flamingo	1					1	2
Vulture (lappet faced)	1		1				2
Rwenzori Duiker		1					1
Sitatunga				1			1

Landscape. In particular they are the species for which the conservation of corridors and maintenance of connectivity is likely to be important.

3.2. *Changes in large mammal population numbers*

Overall there has been a marked decrease in numbers of large mammals in the savannas of the Greater Virunga Landscape (Table 3). Distribution maps of buffalo and topi have shown declines across the landscape since the 1960s (Fig. 2b and c), with initial declines in Queen Elizabeth during the 1980s and then in Virunga Park by 2000s. This is a direct result of civil wars in both Uganda and DRC, which has led to rampant poaching. However, the fact that wars have affected the countries at different times has meant that poaching occurred in Uganda in the late 1970s and early 1980s and then DRC in the 1990s and 2000s. As a result it is possible that animals fled across the international border between Uganda and DRC. We tested this by examining the elephant populations in more detail.

Elephant numbers in Queen Elizabeth declined to 150 individuals in 1981 but by 2002 there were about 1000 individuals in the same park and recently in 2004 the number had increased to 2300. However, elephant populations have been recorded to increase at a maximum of about 6% per year (Owen-Smith, 1988). If the Queen Elizabeth population had increased at this rate since 1981 you would expect a population of 510 by 2002. It is therefore clear that immigration as well as reproduction has led to the increased population. It is most probable that this immigration was from DRC, as the only other option would be Kibale forest. Examination of the distribution of elephants in the landscape show that there has been an increase in elephant numbers in the southern part of Queen Elizabeth park near the border with DRC since the 1980s (Fig. 2a). Elephant numbers in Kibale forest were estimated in the late 1960s to be around 1700 (Wing and Buss, 1970). A survey carried out by the Wildlife Conservation Society (WCS) in 2001 estimated the population to be 260 individuals. It is possible the survey in the 1960s was an overestimate and with several correction factors it could be reduced to a minimum count of 460 (Wing and Buss, 1970), yet even with this correction it indicates a decline in numbers up to the present day. This is likely to be a decline in the population rather than an emigration to Queen Elizabeth Park because people living near the corridor that links Kibale Park to Queen Elizabeth west of Lake George indicate that there have been few movements of elephants in this area in the 15 years. Additionally park rangers in the south of Queen Elizabeth report that elephants have been crossing the Ishasha river from Virunga Park because of shooting in the DRC. We are fairly confident therefore that the recent increase in elephant numbers in Queen Elizabeth is due to immigration from the Virunga Park in the south of the park.

Table 3 – Average number of large mammals in the savannas of the Greater Virunga Landscape from aerial surveys between 1960 and 2003. Results are given for 20-year periods from the 1960s[a]

Species	1960s	1980s	2000s
Elephant	5390	750	1310
Buffalo	45,170	11,490	9200
Hippo	47,080	25,810	5330
Topi	9200	4970	1010
Waterbuck	5610	2580	2410
Uganda Kob	41,060	29,300	15,020
Total	155,470	76,880	36,280

a Data from Malpas (1980), Lamprey et al. (2003), Mertens (1983), Cornet d'Elzius (1996).

Mountain gorillas have been fairly well studied and have been censused regularly since the early 1960s. They have also been the focus of the IGCP transboundary collaboration programme. Their numbers were estimated at 450 in the 1960s in the Virunga Volcanoes and at about 120–180 individuals in what is now called the Bwindi Impenetrable National Park (Schaller, 1963). Mountain gorillas decreased to about 230 in the Virunga Volcanoes in the late 1970s through hunting and loss of habitat (Weber and Vedder, 1983). Numbers have since increased to 380 in 2003 despite killings of individuals in DRC during the civil war (A. McNeilage pers. comm.). The cross-border nature of the Virunga Volcanoes has protected gorillas because armies and rangers from the three countries have been willing to collaborate to guard the forest and reduce the numbers of poachers willing to risk entering the forest. In the highland sector of the Kahuzi Biega National Park in DRC about half the Grauer's gorillas were killed during the same time. In Bwindi, numbers were around 290 in 1997 (McNeilage et al., 1998) and 320 in 2002 (A. McNeilage pers. comm.). Mountain gorillas are one of the few species surveyed in this landscape that have shown an increase in numbers since the early 1980s. This is probably a result of both the economic value they have through their ability to generate revenue from tourism and the transboundary coordination between the countries. It is interesting that the gorillas in Kahuzi Biega fared much worse than those in the Virunga Volcanoes. This may in part have been due to the fact that fewer tourists visited Kahuzi Biega prior to the conflict and hence the income potential was lower and that people tend to eat primate meat in DRC while they don't in Rwanda and Uganda but we would argue that the transboundary nature of the Virunga Volcanoes and the collaboration that existed before the conflict helped the gorillas here. The fact that people from Uganda and Rwanda were lobbying their governments who were invading DRC and the fact that ICCN in DRC was able to influence the invading armies through these lobbying efforts probably contributed to the lower deaths in the gorillas in the Virunga Volcanoes.

Ungulates have suffered heavily as a result of poaching in the GVL (Table 2 and Fig. 2c) since the 1960s. Buffalo and hippopotamus are species that are particularly targeted by hunters because they yield much meat for a single shot. Buffalo declined to low numbers in Queen Elizabeth in the 1980s but have gradually increased since then. Only recently has there been a drop in numbers indicating that poaching may be increasing again. Topi (*Damaliscus lunatus*) on the other hand had declined by the early 1980s but have continued to decline since then. This may be partly due to hunting pressure but may have ecological reasons as well. Topi generally like fairly open habitat in which they can detect predators

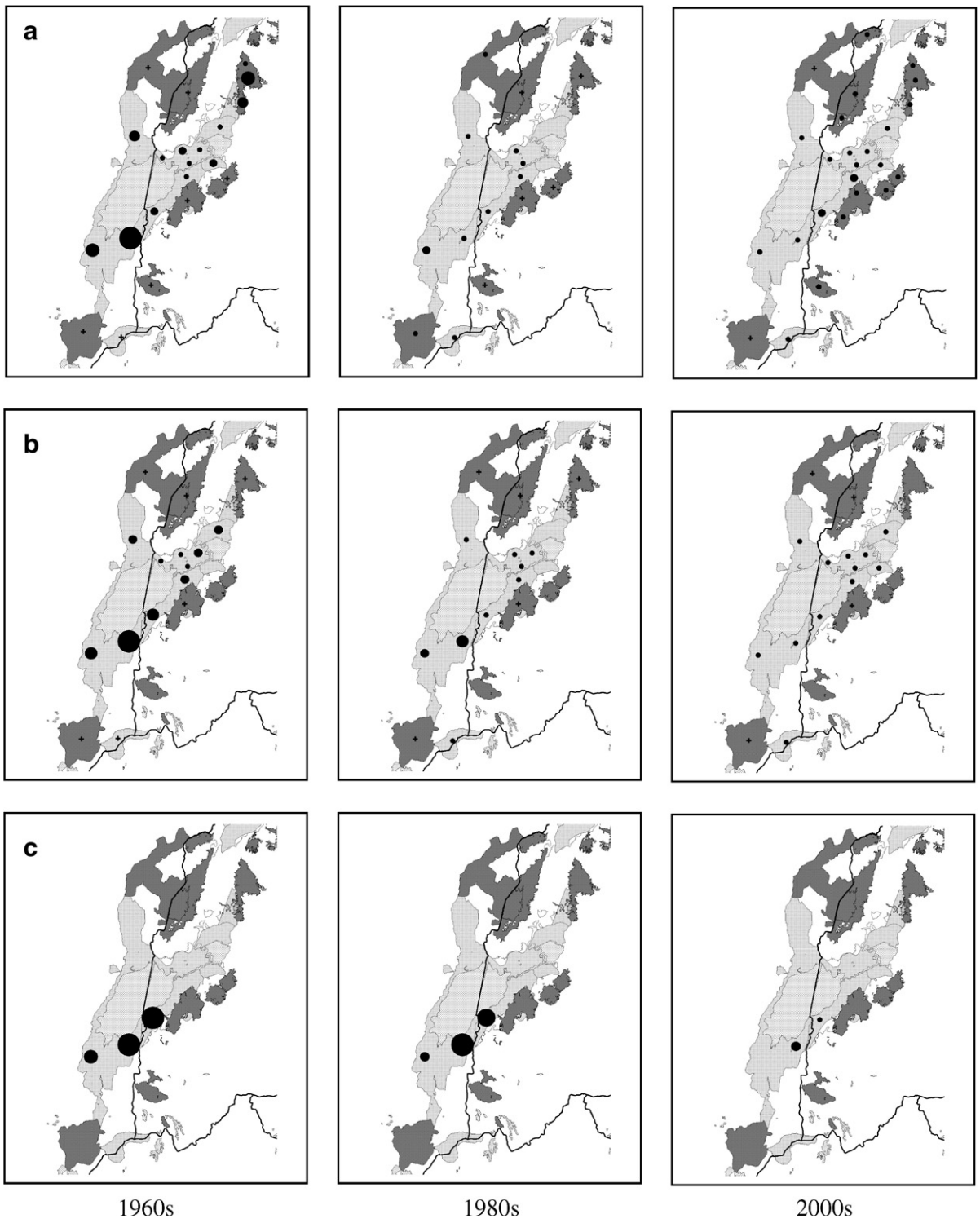

Fig. 2 – Changes in (a) elephant, (b) buffalo and (c) topi numbers since the 1960s. Circle size represent relative numbers of animals and locations within the landscape. Darker shaded areas are forested. + – indicates presence of a species but unknown numbers.

and flee. With the decline in elephants in the GVL there has been an increase in woody vegetation and areas that were once grassland in the region and where topi were found have now become woodland. It is possible this change in habitat has increased the decline in this species. Uganda Kob (*Kobus kob*) have increased since the early 1980s and have reached numbers approaching those in the 1960s in parts of the park (R.Lamprey pers. comm.). These data show that ungulates

have the potential to recover their populations relatively quickly if allowed to, provided hunting is curtailed and other ecological factors do not prevent population growth.

4. Discussion

The Greater Virunga Landscape is of global conservation value both for its species diversity but also its abundance of large mammals. Management of this landscape cannot rely solely on individual management of the 12 protected areas that occur in the landscape. Management plans developed at the scale of the protected area have not considered the linkages between the protected areas and the importance of maintaining corridors that currently link them. The ecological requirements of landscape species needs assessing and as a first step a suite of 13 species have been identified which will require regional management if they are to survive and play their functional roles within the landscape. The importance of the linkages between countries during civil war and a breakdown in law enforcement in any one country has been assessed here and there is some evidence that the ability to move across borders has been important during civil war for certain of these landscape species. The initiatives that IGCP and WCS have developed are aiming to reduce illegal activities through better collaboration between the protected area authorities (Lanjouw et al., 2001). Increasing support from the Protected Area authorities of these countries towards supporting transboundary collaboration is evident in their desire to acquire further formalisation. Further formalisation of transboundary protected area management has the potential to increase support for conservation through improved management and economic returns (Kalpers, 2001; Wilkie et al., 2001; van der Linde et al., 2001).

It is probable that the 13 landscape species will require regional management if their populations are to remain viable in the long term. For example, the lion population in Queen Elizabeth National Park is estimated at between 150 and 200 individuals (L. Siefert pers. comm.). The lion population in the neighbouring Virunga Park is unknown at present but is likely to be low as the prey available has been drastically reduced. As a result it is unlikely to exceed about 200 individuals also. If lions are to remain viable in this landscape, and play their important role in reducing disease in ungulates by weeding out the sick animals, then this species will need some specific management actions to promote regional management. The next steps in the management of these landscape species will be to study them in more detail and understand their ecological requirements and movements within the landscape and then to develop regional action plans with the three protected area authorities,ICCN and UWA and where appropriate ORTPN. These could be developed as part of the transboundary collaboration process.

A major step towards formalizing the transboundary collaboration was achieved in January 2004 when the protected area authorities of Uganda, Rwanda and the Democratic Republic of Congo signed a memorandum of understanding (MoU) which underscored their desire to extend, maintain and protect the unique ecosystem of the Greater Virunga Landscape. This included the habitat of the mountain gorillas and also further north in the Rift, to include all protected areas contiguous with the Virunga Park. This MoU outlines the desire of the Protected Area Authorities to collaboratively manage eight protected areas shared between them, these being Parc National des Volcans and Virunga, Mgahinga Gorilla, Bwindi Impenetrable, Queen Elizabeth, Rwenzori Mountains, Semuliki and Kibale National Parks. The Protected Area Authorities continued to fully support transboundary collaboration and worked to bring together the Ministries in charge of the Environment in the three countries to sign a tripartite agreement (signed on October 14th 2005) that agrees to recognize the transboundary nature of the landscape and to work together to ensure its conservation. By formalizing transboundary conservation through the increased use of treaties and MoUs throughout the landscape the following additional contributions to conservation could be made:

1. Strengthened park management
   Currently, certain park management activities are restricted by the international boundaries. By formally designating transboundary protected areas, the park authorities would be able to obtain a single radio frequency, which would enhance communication, develop one overall management plan and further integrate joint activities (Lanjouw et al., 2001). Although the countries involved are anglophone and francophone communication is possible through the use of Swahili.
2. Increased tourism revenue
   Developing regional tourism circuits within and outside the protected areas would encourage visitors to the region to spend longer and thereby contribute to the economics of these countries. For example, allowing visitors to follow gorilla groups as they cross into neighboring countries would ensure that refunds for permits are no longer necessary as per the current practice, developing hiking trips that traverse the Virunga Volcano Range. Gorillas are not the only attractions though and there is a need to promote the active volcanoes, the large mammals of the savannas, Africa's largest hippo population, the primate diversity of Kibale Forest and its chimpanzee viewing and the Rwenzori Mountains. If animal numbers ever reach the levels of the 1960s again this landscape will provide a huge attraction and will strongly compete with Kenya and Tanzania as a result.
3. Promotion of a culture of peace and cooperation
   The collaboration that occurs as a result of working together for a common goal (in this case conservation) breaks down animosity and suspicion between those involved. The ability to work together can help build a culture of peace and cooperation in a transboundary area (Lanjouw et al., 2001; Sandwith et al., 2001), particularly if the collaboration is widened to include other stakeholders involved in policing and law enforcement. We have seen in the GVL a reduction in suspicions between the parks authorities in Uganda and DRC simply through regular meetings held every quarter. This culture of peace probably encourages better management of protected areas and reduces the number of illegal activities, particu-

larly poaching, and hence contributes to conservation. It is difficult to quantify the impacts of transboundary conservation on peace and to date this has not been measured. However the International Institute for Sustainable Development (IISD) is starting a program to try to measure this in the GVL region (Hammill and Besangon, in press).

4. Improved law enforcement
   Improved law enforcement would occur with a formalised agreement because it would allow joint ranger patrols to take place, allow one radio frequency so that wardens and rangers can effectively communicate, and ensure that laws are harmonized between countries thereby allowing offenders to be prosecuted in their own countries if caught in another.
5. Improved species management
   Currently the only species managed in a regional manner is the mountain gorilla. Coordinated censuses have taken place and the management of health programs and tackling the trade in gorilla infants are all handled in a regional manner. Other species that need regional management are the landscape species identified here. Formal agreements between DRC, Rwanda and Uganda will improve the ability to manage some of these species, particularly those that are hunted such as elephants, leopards and hippos. Tackling the trade in ivory, skins and meat needs to have strong agreements in all countries and the ability to enforce the policies that exist.

Several benefits can be cited from the collaboration at field level even prior to these formal agreements and emphasise the value of building up such collaborations from the field (Lanjouw et al., 2001; Rainer et al., 2003). Some of the lessons learned include:

1. Breaking down suspicions between wardens
   Regular meetings of the wardens break down suspicion between groups and builds friendships. The development of friendships between the wardens is one of the most valuable aspects of these regular meetings and yet is difficult to measure in any quantifiable way. As such they are much more ready to support each other when problems occur. These meetings also improve communication between the protected area authorities.
2. Collaboration and information sharing leading to better action
   By working together it has been possible to share information about threats that have a cross-border component much more effectively. These include the trade in infant gorillas, the ivory trade, illegal timber movements, fire control and illegal fishing on Lake Edward. Prior to the support provided by IGCP and WCS parks staff were unable to follow up on their intelligence of such illegal activities in the adjacent country. Often they would be shown permits but had no means of confirming if they were valid or not. An ability to tackle regional threats is also more feasible as a result of collaboration. A particular case in point here is that recent threats (such as encroachment of park for land) have occurred in DRC caused by Rwanda and Uganda and given the political nature of the war in the region it has been impossible for ICCN staff to tackle these threats. However, by working with ORTPN and UWA they have been able to lobby the military and stopped the threats.
3. Planning with stakeholders for the landscape leading to political will to act
   Joint planning leads to a better appreciation of the regional needs and the need to manage the landscape as a whole. The identification of landscape species had the input of all wardens because they will be the ones to manage these species and they need the understanding for the conservation of these species. Similarly other regional meetings that have been held have tackled various issues concerning the management of the landscape with a wider group of stakeholders and obtained improved political will to work with the protected area authorities.
4. Regional training helps equalize skills level
   Joint meetings that involve an aspect of regional training helps build the capacity of parks staff regionally and tends to equalize the level of knowledge between countries, bringing up those that have had less chance of further education.
5. Coordinated patrolling can reduce poaching levels
   Coordinated patrolling can be very effective. Although in most patrols parks staff do not cross country borders, by coordinating patrols along the boundary it is possible to capture people involved in illegal activities. Prior to the transboundary collaboration anyone caught outside their country involved in illegal activities would be deported and could be back in the park the next day. Now they are handed over to the park counterparts at the border and can be prosecuted in their own country. As such illegal activities have been reduced greatly at the borders.

The importance of maintaining the corridors that link Virunga Park to the adjacent parks in Uganda and Rwanda are clear. Civil war in this region has led to major declines in mammals but these would probably have been greater without these linkages, particularly for the larger species that can move between the parks such as elephants. The importance of maintaining support for conservation activities during times of war has been made by several authors (Kalpers, 2001; Plumptre and Williamson, 2001; Plumptre et al., 2001) and the development of a network of relationships across international borders can facilitate the provision of such support (Sandwith et al., 2001). Transboundary collaboration has helped protect species such as the mountain gorilla, which receive the focus of attention due to their ability to raise income from tourism. There is a need to broaden this focus to other species in the Greater Virunga landscape, particularly the landscape species identified here.

Acknowledgements

This paper is a product of many years of conservation work in the region of the Greater Virunga Landscape. This work has been funded by many different grants to both the Wildlife Conservation Society and the International Gorilla Conservation Programme, particularly The Daniel K. Thorne Foundation, European Union, International Gorilla Conservation Pro-

gramme (African Wildlife Foundation, Fauna and Flora International and World Wide Fund for Nature), the John D. and Catherine T. MacArthur Foundation, United States Agency for International Development (USAID), and Wildlife Conservation Society. Comments were kindly made on initial drafts of this paper by Neil Burgess and Norbert Cordeiro.

REFERENCES

Burtt, B.D., 1934. A botanical reconnaissance in the Virunga volcanoes of Kigezi RuandaKivu. Bulletin of Miscellaneous Information, Vol. 4. Royal Botanic Gardens, Kew. pp. 145–165.

Coppolillo, P., Gomez, H., Maisels, F., Wallace, R., 2003. Selection criteria for suites of landscape species as a basis for site-based conservation. Biological Conservation 115, 419–443.

Cornet d'Elzius, C. 1996. Ecologie, Structure et evolution des Populations des Grands Mammiferes du Secteur Central du Parc National des Virunga(Parc National Albert) Zaire (Congo Belge). Fondation pour Favoriser les Recherches Scientifiques en Afrique, Belgium, pp. 231.

Douglas-Hamilton, I., Malpas, R., Edroma, E., Holt, P., Laker-Ajok, G., Weyerhauser, R. 1980. Uganda Elephant and Wildlife Survey. Unpublished UIE report to IUCN.

Hammill, A., Besangon, C. in press. Measuring Peace Park performance: Transboundary mountain gorilla conservation in central Africa. In: Ali, S. (Ed.), Peace Parks: Conservation and Conflict Resolution. MIT Press, Cambridge MA.

Howard, P.C 1991. Nature Conservation in Uganda's Tropical Forest Reserves. 313pp IUCN, Gland, Switzerland.

Kalpers, J. 2001. Volcanoes under siege: impact of a decade of armed conflict in the Virungas. Biodiversity Support Program, Washington, DC.

Lamprey, R., Buhanga, E., Omoding, J. 2003. A study of Wildlife Distributions, Wildlife Management Systems and Options for Wildlife-based Livelihoods in Uganda. Unpublished report to IFPRI/USAID. pp. 145.

Lanjouw, A., Kayitare, A., Rainer, H., Rutagarama, E., Sivha, M., Asuma, S., Kalpers, J. 2001. Beyond Boundaries: Transboundary Natural Resource Management for Mountain Gorillas in the Virunga-Bwindi Region. Biodiversity Support Program, Washington, DC, USA.

Lock, J.M., 1977. The vegetation of Rwenzori National Park, Uganda. Botanisches Jahrbucher und Systematiks 98, 372–448.

Malpas, R. 1980. Wildlife in Uganda 1980. A survey. Unpublished report to Ministry of Tourism Trade and Industry, Uganda. pp. 118.

McNeilage, A., Plumptre, A.J., Brock-Doyle, A., Vedder, A. 1998. Bwindi Impenetrable National Park, Uganda Gorilla and Large Mammal Census, 1997. WCS Working Paper, 14. pp. 52.

Mertens, H., 1983. Recensements aériens des principaux ongulés du Parc National des Virunga, Zaire. Revue Ecologie Terre et Vie 38, 51–64.

Mollaret, H.H. 1961. Biotopes de Haute Altitude: Rwenzori II et Virunga. Exploration du Parc National Albert, Institut des parcs Nationaux du Congo et du Ruanda-Urundi, Bruxelles.

Mushenzi, N., DeMerode, E., Smith, F., Hillman-Smith, K., Banza, P., Ndey, A., Bro-Jorgensen, J., Gray, M., Mboma, G., Watkin, J. 2003. Aerial Sample Count of Virunga National Park, Democratic Republic of Congo. Unpublished Report to USFWS and ICCN.

Oates, J.F., Whitesides, G.H., Davies, A.G., Waterman, P.G., Green, S.M., DaSilva, G.L., Mole, S., 1990. Determinants of variation in tropical forest primate biomass:new evidence from West Africa. Ecology 71, 328–343.

Olivier, R.C.D., Edroma, E.L., Campbell, K.L.I. 1989. Aerial monitoring of large mammal Populations in Queen Elizabeth National Park, Uganda. Unpublished report, Uganda National Parks.

Owen-Smith, N., 1988. Megaherbivores: the influence of very large body size on ecology. Cambridge University Press.

Plumptre, A.J., Williamson, E.A., 2001. Conservation-oriented Research in the Virunga Region. In: Robbins, M.M., Sicotte, P., Stewart, K.J. (Eds.), Mountain Gorillas: Three Decades of Research at Karisoke. Cambridge University Press, Cambridge, pp. 361–389.

Plumptre, Masozera, Vedder, 2001. The impact of civil war on the conservation of protected areas in Rwanda. In: The Trampled Grass. Biodiversity Support Program, Washington DC. www.worldwildlife.org/bsp/publications/africa/145/pdf/Rwanda.pdf.

Plumptre, A.J., Behangana, M., Davenport, T., Kahindo, C., Kityo, R., Ndomba, E., Nkuutu, D., Owiunji, I., Ssegawa, P., Eilu, G. 2003. The Biodiversity of the Albertine Rift. Albertine Rift Technical Reports No. 3, pp105. www.albertinerift.org.

Rainer, H., Asuma, S., Gray, M., Kalpers, J., Kayitare, A., Rutagarama, E., Sivha, M., Lanjouw, A., 2003. Regional conservation in the Virunga-Bwindi region: the impact of transfrontier collaboration through the experiences of the International Gorilla Conservation Programme. Journal of Sustainable Forestry 17, 189–204.

Robyns, W. 1948–1955. Flore des Spermatophytes du Parc National Albert: Vols 1–3. Institut des Parcs Nationaux du Congo Belge, Bruxelles.

Sanderson, E.W., Redford, K.H., Vedder, A., Coppolillo, P.B., Ward, S.E., 2002. A conceptual model for conservation planning based on landscape species requirements. Landscape and Urban Planning 58, 41–56.

Sandwith, T., Shine, C., Hamilton, L., Sheppard, D. 2001. Transboundary Protected Areas for Peace and Cooperation. IUCN Gland, Switzerland & Cambridge. pp. 111.

Schaller, G.B., 1963. The Mountain Gorilla: Ecology & Behavior. University of Chicago Press, Chicago.

Struhsaker, T.T., 1997. Ecology of an African Rainforest:Logging in Kibale and the Conflict between Conservation and Exploitation. University Press of Florida, Florida. pp. 434.

van der Linde, H., J. Oglethorpe, T. Sandwith, D. Snelson, Y. Tessema (with contributions from Anada Tiéga and Thomas Price). 2001. Beyond Boundaries: Transboundary Natural Resource Management in Sub-Saharan Africa. Washington, DC, USA: Biodiversity Support Program.

Verschuren, J. 1993. Les Habitats et la Grande Faune: Évolution et Situation Récente. Exploration du Parc National des Virunga (Zaire), Fascicule 29. pp. 133.

Weber, A.W., Vedder, A.L., 1983. Population dynamics of the Virunga gorillas 1959–1978. Biological Conservation 26, 341–366.

Wilkie, D.S., Hakizumwami, E., Gami, N., Difara, B., 2001. Beyond Boundaries: Regional Overview of Transboundary Natural Resource Management in Central Africa. In Biodiversity Support Program, Beyond Boundaries: Transboundary Natural Resource Management in Central Africa. Biodiversity Support Program., Washington, DC, USA.

Wing, L.D., Buss, I.O., 1970. Elephants and Forests. Wildlife Monographs 19, 1–92.