The status and conservation of common hippopotamuses in Virunga National Park, Democratic Republic of Congo

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Abstract

Conservation is in crisis as most wildlife population have declined and wild lands have been degraded by human activities. Common hippopotamus (*Hippopotamus amphibius*) have declined by 30% in sub-Saharan Africa and especially more in the Albertine Rift region. The status of hippos in Virunga National Park (NP) requires particular conservation measures as the population has collapsed since the early 1990s and crashed in the early 2000s to <5% of the 1970 population. In order to estimate the current population accurately, this study used a combination of ground, water and aerial counts. Ground counts provide more accurate estimates of hippo numbers, but aerial counts are faster and can survey remote areas that are inaccessible on the ground.

The population of hippos in Virunga NP is estimated to be about 1,200 individuals, slightly higher than the previous count in 2005 (887 individuals). However, this apparent increase is probably due to a more comprehensive count in 2009. Hippo numbers remain <5% of the 1970 population size due to poaching and habitat destruction which are identified as the main causes of the decline both from past studies and our surveys of local households. The distribution of hippos in Virunga NP has also changed. In the past about two-thirds of the population occurred along the Rutshuru River and along the shores of Lake Edward whereas half of the current population is concentrated along the Ishasha River. In 2009, most hippos were located around ranger posts and legal fishing villages. Transfrontier cooperation between the Congolese and Ugandan conservation agencies including regular ranger patrols has contributed to the stability of the Ishasha River population.

Although local communities recognize the importance and the value of hippos in conservation, education and fisheries, bushmeat is sold and bought by communities in and around Virunga NP. Main actors of poaching are reported to be militias, soldiers and park staff (including rangers). The main reasons for poaching are reported to be the bushmeat trade

(including trophies) and meat for subsistence use. Apart from poaching, the lack of knowledge of conservation laws by communities and poor law enforcement, and a weak institutional policy have contributed to the decline of hippopotamus populations in Virunga NP.

If hippos are to persist in Virunga NP adaptive conservation measures are required such as to sustain the transboundary cooperation with the Uganda Wildlife Authority, to reinforce ranger patrols, to develop an intelligence network to limit the bushmeat trade, to enhance community awareness, and to initiate participatory activities that involve different stakeholders. Hippo population monitoring is needed to assess the effectiveness of these strategies and to advise decision makers on political measures to be taken, both at local and national levels.

Chapter 1. Introduction

1.1 Context of conservation of hippos in Virunga

Conservation of wildlife is in crisis as species are declining worldwide. The major causes of declines in wildlife in developing countries are human population growth, habitat fragmentation, inadequate land use practices and management, lack of economic alternatives, social and political conflicts, and unsustainable use of resources (Fitzgibbon et al. 1995; Burkey 1997; Myers et al. 2000; Kideghesho et al. 2007; Plumptre et al. 2008). The magnitude of these threats is greater in areas where a large proportion of human population relies directly on natural resources to sustain livelihoods (particularly protein intake) or for economic returns (e.g. trade of bushmeat, ivory or trophies) (Fitzgibbon et al. 1995; Kideghesho et al. 2007; Plumptre et al. 2008).

Although common hippopotamuses *(Hippopotamus amphibius)* were still abundant and widespread (*sensu* IUCN 2009) in the 1990s within their range of occurrence in sub-Saharan Africa (Lewison & Olivier 2008), local extinctions have occurred in some parts of their range since the 1800s, resulting in their current patchy distribution (Horwitz & Tchernov 1990). Hippo numbers have declined by 30% over the last three decades in sub-Saharan Africa and the species is now categorized as Vulnerable (Lewison & Olivier 2008). Hippo populations continue to decrease in some regions (e.g. Democratic Republic of Congo – DRC, Ivory Coast) but seemingly are stable or increasing in other areas such as Uganda, Zambia and Kenya (Lewison 2007, Lewison & Olivier 2008; Mapesa et al. 2007). In the Albertine Rift, large numbers of hippos were recorded in the eastern part of the DRC and in Uganda; especially in Lake Edward and its major tributaries, the Rutshuru, Rwindi, Semuliki and Ishasha Rivers (Mankoto 1989; Mackie 1989, 1991; Eltringham 1993; Languy et al. 1994). The population in the Albertine Rift was estimated at 50,000 individuals in the 1950s (Eltringham 1993; Verschuren 1993).

The greatest declines have been recorded in DRC, where populations have crashed dramatically even in protected areas (Languy 2006; Lewison & Olivier 2008). In Virunga NP for example, hippos decreased by 96% from about 30,000 in the 1970s to less than 1,000 in 2005 (Languy & de Merode 2006). Despite these declines, the conservation status of hippos has not changed under DRC law, which provides the species only partial protection (Arrêté n° 014/CAB/MIN/ENV/2004). In terms of this legislation, hippos can be hunted outside protected areas by any hunting permit holder, but hunting is prohibited in national parks and wildlife reserves.

Poaching for food and the bushmeat trade is the main cause of the decline of hippos in DRC, although items confiscated by wildlife authorities suggest that the trophy trade also may play a role (WCS unpublished data; Lewison 2007; Plumptre et al. 2008). Poaching of hippos has been exacerbated by the presence of armed groups (e.g. Mai-Mai, Rwandan rebels) as well as the DRC army and the population growth. Poaching in Virunga NP is also linked in part to the presence of the fishing villages in the park (Crawford & Bernstein 2008; Plumptre et al. 2008). There are about 14 fishing villages within the park boundaries (Fig. 1) with over 20,000 people in three "legal" fishing villages and more than 10,000 in illegal fishing villages (Petit 2006; Languy & Kujirakwinja 2006; Plumptre et al. 2008; WCS unpublished data 2008). Overfishing caused by weak enforcement of fishing regulations probably is the main driver of fishery collapse in Lake Edward (Vakily 1989; Languy & Kujirakwinja 2006; Petit 2006). Human activities in the park are not confined to fishing. Areas around some fishing villages have been developed for agriculture and human settlements causing habitat fragmentation and degradation with direct impact on the distribution of hippos (Verschuren 1993; Languy et al. 1994; Plumptre et al. 2008). With increased human interferences (insecurity, encroachment and settlements) on wildlife and their habitats, most species have restricted their ranges around ranger camps and limited movement into areas accessed by rangers (Verschuren 1993; Languy et al. 1994; ICCN 2008, 2009, Unpublished data). Large numbers of hippos occurred on the western shores of Lake Edward before human settlement and encroachment for farming in the early 1990s. This population decreased to fewer than 10 individuals by 2004 (ICCN 2005, unpublished data). With regular patrols and increased community awareness, the numbers of hippos in this area increased to about 60 individuals by 2006 (ICCN 2006, unpublished data), mainly due to migration from other sites in the lake (Verschuren 1993). Hence, the decline in hippos probably has impacted social, economic and ecological systems in Virunga National Park and surroundings areas.

1.2 The ecological importance of hippos

1.2.1 Niches and anthropogenic factors

Species distributions depend on various ecological factors including specific adaptations, habitat choice and quality, interaction with other members of the community and with external factors such as anthropogenic impacts (Hunter & Price 1992; Naiman & Rogers 1997; Olupot et al. 2009). Hippos require aquatic ecosystems known as their "daily living space" where they spend most of their time, and grazing pastures ashore (Delvingt 1974; Mackie 1989; Eltringham 1993; Naiman & Rogers 1997; Martin 2005). Thus, hippos can be affected by water quality and scarcity, and habitat change in areas adjacent to wetlands (Mankoto 1989; Martin 2005). Human interference (habitat degradation and fragmentation, human settlement) has an impact on their basic resources (grazing areas and wetlands) and probably has contributed to decreases in hippo numbers (Verschuren 1986, 1993; Burkey 1997; Languy 2006).

Anthropogenic threats are among the factors that drive the decline and ultimate extinction of species (Burkey 1997; Myers et al. 2000). Human beings have an impact on species directly (through extractive use), indirectly by destroying suitable habitat, converting lands for agriculture or pasture, or by overexploiting resources (Burkey 1997). Thus, anthropogenic activities can force a species to seek refuge in suboptimal habitats which might be unsuitable for their persistence (Lewison 2007). Three major threats are known to impact hippos in Africa: habitat loss, poaching (unregulated hunting) and environmental factors (climate variations, anthrax outbreaks and other diseases) (Eltringham 1993; Verschuren 1993; Post 2000; Lewison 2007). Efficient and specific management strategies are needed to stabilize hippo populations by minimizing interactions with humans (poaching, killing) and limiting degradation of suitable habitats (Decker et al. 2002; Riley et al. 2002; Lewison 2007).

1.2.2 Commonness and trophic cascades

Commonness refers to the relative abundance of a given species (Preston 1948; Gaston & Fuller 2007). The decline of a common species such as hippos can impact the ecological functioning of ecosystems through various feedback mechanisms (Power et al. 1996; Burkey 1997; Possingham et al. 2002). Common species shape the world and provide ecological services as keystone species or ecosystem engineers. They seldom are considered to be threatened because they occur in large numbers and their distribution is large (Hunter & Price 1992; Power et al. 1996; Naiman & Rogers 1997; Possingham et al. 2002; Gaston & Fuller 2007; Gaston 2008). Most conservation planning exercises and management policies thus focus on rare and threatened species for logistic and emergency reasons. By ignoring common species, their demise may be overlooked until the species falls below some threshold which makes them threatened and requires considerable management action to ensure their persistence (Naiman & Rogers 1992; Possingham et al. 2002; Gaston & Fuller 2007). Declines in common species can lead to trophic cascades and may impact the distributions and abundances of other species (Eltringham 1974; Hunter & Price 1992; Gaston & Fuller 2007). Hippos influence freshwater food chains, and may impact fishery yields. Although there have been no studies on hippos' contributions to the productivity of fisheries, they import nutrients (urine, excreta) into aquatic systems, promoting phytoplankton growth and enhancing the productivity of the system (Delvingt 1974; Naiman &Rogers 1992; Burkey 1997).

The abundance and wide distribution of hippos until the early 1990s led to complacency regarding their conservation status (Field 1970; Eltringham 1974). Hippos were so common that control programmes were needed to reduce their numbers in some countries. For example, culling programmes in 1957 and 1964 in Uganda targeted one third of the total hippo population, reducing the population from 21,000 to 14,000 and 7,000 individuals (Eltringham 1973, 1974; Mankoto 1989; Mapesa 2007; Lewison & Olivier 2008). This population decreased further between the late 1970s and early 1980s due to poaching under Idi Amin's regime. Since then the hippo population in Uganda has been increasing and the current estimate is around 7,000 individuals (Lewison & Olivier 2008; UWA 2008, unpublished data)

1.2.3 Interspecific competition, facilitation and mutualism

Although herbivores can compete for the same resource, feeding facilitation can happen when grazing activities by one species increase resource access to another or stimulate re-growth of grasses (Eltringham 1974; Olivier & Laurie 1974; Arsenault & Owen-Smith 2002). The grazing activities of hippos modify surrounding ecosystems (vegetation, riverbed and beaches), making them beneficial to other species like warthogs (*Phacochoerus aethiopicus*), bushpigs (*Potamochoerus larvatus*) which benefit from lawns created by grazing; and more than 14 birds such as Common Sandpipers (*Actitis hypoleucos*), Red-billed Oxpeckers (*Buphagus erythrorhynchus*) and African Pied Wagtails (*Motacilla aguimp)* which feed around and/or on hippos (Verheyen 1954; Rice 1963; Field 1970; Eltringham 1974). Thus, the abundance and diversity of the above species may vary with the size and distribution of hippo populations (Verheyen 1954; Rice 1963; Field 1970; Eltringham 1974; Olivier & Laurie 1974; Naiman & Rogers 1997; Martin 2005).

1.2.4 Human-wildlife conflict

Competition over common resources and space often results in conflicts between people and wildlife, and impacts both on wildlife and on human needs and assets (Fitzgibbon et al. 1995;

Decker et al. 2002; Madden 2004). These conflicts, termed human-wildlife conflicts (HWC), have been expanded to include conflicts between different stakeholders as they reflect different interests in uses of wildlife (conservation, source of meat, damages) (Madden 2004). In the context of national parks they are also termed park-people conflicts (Decker et al. 2002; Madden 2004). Communities neighbouring protected areas interact on a daily basis with wildlife and their habitat through conflict over crops, fishing, access to water, and firewood (Decker et al. 2002; Riley et al. 2002; Gusset et al. 2008). These interactions drive both positive and negative effects on human and wildlife which can influence the degree of tolerance of wildlife and their conservation in the area (Decker et al. 2002; Fall & Jackson 2002). Human-wildlife conflict is one of the current challenges facing conservation efforts in developing countries where wildlife is declining as a consequence of social factors such as human population pressure, food security, land use practices and poverty. It becomes acute when the local substitute resources become scarce for both humans and wildlife (Decker et al. 2002; Madden 2004; Packer et al. 2006; Marshall et al. 2007; Gusset et al. 2008). Apart from poaching, there are other interactions between hippos and humans where they live in close proximity and interfere on activities of one another (Post 2000). Hippos may damage crops and fishing equipment and endanger the lives of humans although the level of impact varies from one region to another (Eltringham 1993; Post 2000; Martin 2005; Lewison 2007).

The behaviour, cultural values and attitudes of people can influence and impact the success of conservation interventions, particularly in areas where wildlife may affect people's assets. Thus, conservation of biodiversity has to involve the assessment of people's attitudes to develop a site-based "conservation strategy" which involves multiple stakeholders to integrate wildlife needs and human livelihood aspects (Decker et al. 2002; Riley et al. 2002; Madden 2004; Kideghesho et al. 2007).

1.3 Research questions

The aim of this study is to assess the abundance and the persistence of hippos in Virunga NP despite the impact of anthropogenic activities and to understand the attitudes and perceptions related to the decline of hippos from communities living in Virunga NP.

Questions addressed in this study include:

- What is the current status (spatial distribution, abundance and threats) of hippopotamuses in Virunga NP compared to previous years?
- What factors allow the persistence of hippopotamuses in some habitats despite poaching and other threats?
- What are the drivers of population change in Virunga hippos?
- What are the attitudes and perceptions of people inhabiting fishing villages about the presence or decline of hippopotamuses and the implications of those attitudes for conservation?

Given the high level of poaching in Virunga NP, I expected that hippopotamuses would survive better in areas that are close to ranger posts and in areas with little human impact. The attitude of people towards hippopotamuses is expected to be a factor of how long they have lived in the park and their profession. People directly affected by hippos (e.g. crop raiding, damage to fishing equipment) are expected to be less tolerant of hippos.

Chapter 2. Study area and Methods

2.1. Study area

Virunga NP is located in the eastern DRC (00°56' N, 01°39' S) and part of the Albertine Rift valley. It was proclaimed in 1925, initially to protect mountain gorillas (*Gorilla gorilla beringei*) and covered about 200 km². It was subsequently extended between 1929 and 1950 to its current area of 7900 km² (Akeley 1931; Mankoto 1989; Languy & de Merode 2006). The goal of these extensions was to protect other large animals (elephant, hippo, buffalo) given concerns about the potential impacts of local communities on these species (Akeley 1931; Verschuren 1986; Mankoto 1989, Verschuren 1993). Virunga NP was recognized as a World Heritage Site (WHS) by the United Nations Educational, Scientific and Cultural Organisation in 1979 and has been listed as a WHS in danger since 1994 due to ongoing threats to its biodiversity (Languy & de Merode 2006). Covering a wide range of habitats, Virunga NP is amongst the most diverse protected areas in Africa, ranging from afromontane forest (4500 m) in the southern sector, through the savannas and lowland forest in the central and northern areas (750–1000 m) to alpine habitats on the Rwenzori Mountains in the north (maximum elevation 5119 m) (Mankoto 1989; Languy & de Merode 2006). As a result, it supports at least 196 species of mammals, 706 birds and 2,077 plants, of which 21 mammals, 23 birds and 230 plants are endemic to the Albertine Rift (Mankoto 1989; Plumptre et al. 2003). Major wetlands in Virunga NP include about 74% of Lake Edward, several ponds and four large rivers: Semuliki, Ishasha, Rwindi and Rutshuru which provide suitable habitat for hippos (Fig. 1).

It is usually assumed that human activities are strictly regulated or prohibited in protected areas categorized as national parks, but Virunga NP is an exception (Verschuren 1986, 1993; Mankoto 1989). The presence of humans in Virunga is related to the history behind its creation. Like most protected areas in Africa, it was occupied by local communities prior to its proclamation as a park (Akeley 1931; Verschuren 1993; Languy & de Merode 2006). These communities were displaced and resettled in other areas by the colonial authorities. Some of the displacements were for public interest reasons and others for health reasons as there were series of outbreaks of sleeping sickness in some areas (Akeley 1931; Mankoto 1989; Verschuren 1993). Although people were resettled in other areas or compensated through the traditional hierarchy in different villages, the access to Lake Edward for fishing was a critical issue for communities that depended on fishing (Akeley 1931; Vakily 1989; Verschuren 1986, 1993). Thus, fishing rights were granted to communities through the creation of a cooperative under the aegis of the twelve local traditional chiefs (as representatives of their communities) (Verschuren 1993). This led to the establishment of two sanctioned (legal) fishing villages in 1948 which are Vitshumbi and Kyavinyonge, and another (Nyakakoma) in 1964 (Vakily 1989; Verschuren 1993; Languy & Kujirakwinja 2006). With the outbreak of armed conflicts in the early 1990s and the absence of rangers in different surveillance posts; illegal settlements were established on the western coast of Lake Edward and different bays since the late 1990s (Verschuren 1993; Kalpers & Mushenzi 2006; Languy & Kujirakwinja 2006; Plumptre et al. 2008). The area occupied by these villages has been growing every year both in size (area occupied) and human population numbers (Petit 2006; Languy & Kujirakwinja 2006). The illegal extraction of resources is one of the major causes of conflict between protected area managers and local communities, and has become more acute as the populations in surrounding villages with limited access to land have increased (Akeley 1931; Verschuren 1993; Crawford & Bernstein 2008; Plumptre et al. 2008; Olupot et al. 2009).

This study covered the aquatic habitats suitable for hippos in Lake Edward and the Rwindi, Ishasha, Rutshuru and Semuliki Rivers (Fig. 1).

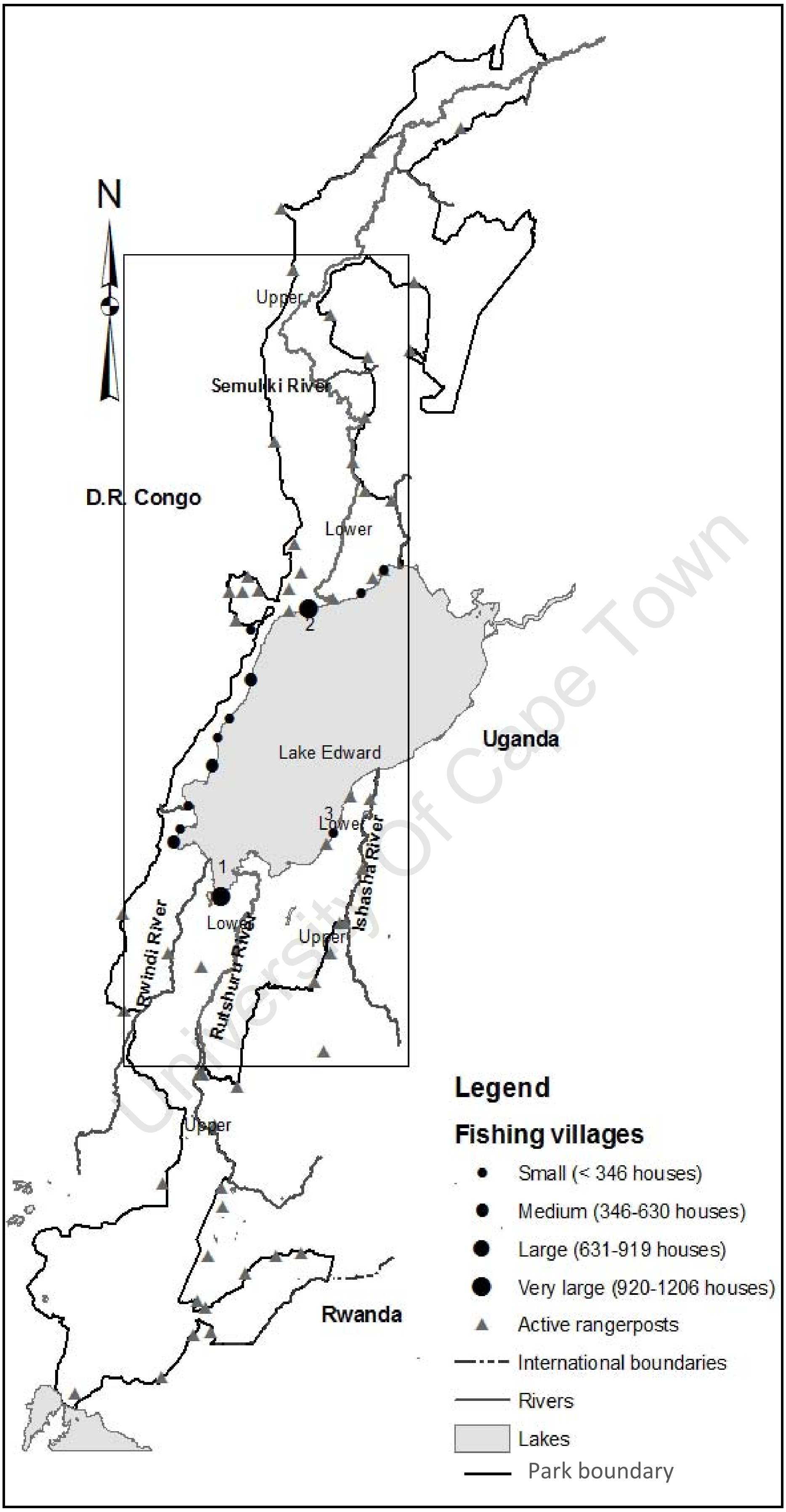


Figure 1. Map of study area in Virunga NP showing fishing villages and active ranger posts. Legal fishing villages are numbered 1 Vitshumbi, 2 Kyavinyonge and 3 Nyakakoma. Square denotes the count area, which encompasses most suitable habitat for hippos in Virunga NP.

2.2. Hippo counting techniques

Counts of large mammals can be performed using different techniques depending on the size of the species, the size of the area and the type of habitat (Jachmann 2001; Olupot et al. 2009). Aerial surveys are preferred for large animals and large areas in savannas (Caughley 1974; Caughley et al. 1976; Norton-Griffiths 1978; Jachmann 2001, 2002). Counts of hippos can be made either on foot, or from a boat or using small aircraft and helicopters. Each of these techniques has advantages and limitations (Caughley 1974; Norton-Griffiths 1978; Jachmann 2001). The combination of more than one technique probably is most valuable (Caughley et al. 1976). In this study, I used aerial counts and combined land and water counts to gain the best estimate of hippo numbers in Virunga NP.

2.2.1. Aerial counts

Aerial counts rapidly cover large and remote areas, but they are expensive and their accuracy is questionable because some hippos are overlooked in thickets, under water and under fallen trees (Mankoto 1989; Mackie 1991). They are also easily biased by changes in visibility (e.g. with water turbidity and weather conditions), the speed of the aircraft and differences in observer experience (Caughley 1974; Norton-Griffiths 1978; Mackie 1989; Jachmann 2002). For example, riparian vegetation and the turbid nature of most rivers and lakes in east and central Africa make it hard to spot all hippos from the air (Delvingt 1974; Mackie 1989). Despite these limitations, most hippo surveys in Virunga NP used aerial counts, while ground counts were used to calibrate aerial estimates (Delvingt 1974; Mankoto 1989; Mackie 1989, 1991; Languy 2006). A detailed methodology for aerial counts of hippos in Virunga NP was developed by Mackie (1989, 1991). To ensure that my data were almost comparable with previous counts I followed the same methodology for aerial counts but used large areas covered by ground counts to derive correction factors (Mackie 1989, 1991). Counts were made from a small aircraft (Cessna 208) by a team composed of two pilots (one flying the plane and the other monitoring speed, altitude and GPS position), and three observers (two observers on either side of the plane and one photographer). Altitude was kept as close as possible to 100 m above the ground at an air speed of 160 $km.h^{-1}$. The count was made from the right side of the plane to allow the main observer to count hippos (≤5 individuals) and the assistant observer to photograph large groups (>5 individuals). The left side observer had to count small groups of hippos seen on his side. If the group was large; the pilot circled the area to enable a better count or to allow a photograph to be taken. The doors of the plane on the right side were removed to enhance visibility. During the flight; GPS coordinates, picture number from the camera and individuals in small groups were recorded (Mackie 1989, 1991).

For counts along rivers the plane followed river courses, including circling meanders, ensuring that they remained on the right side of the plane. For Lake Edward, the right side of the plane was positioned to face the shoreline while the left observer checked for groups farther offshore. The same strategy was used for marshes and ponds but with at least two checks to ensure that they were completely covered.

The aerial count was completed in about ten hours over two days (7-8 December 2009). For the lake, the count was conducted between 9:30 and 11:00 while for rivers the counts were made between 11:00 and 14:00. It was hard to start the counts before 9:00 as recommended by Mackie (1989, 1991) as it is was necessary to have a permit issued each day by the civil aviation authority. Fortunately, during our flight over Lake Edward, the water was relatively clear allowing hippos to be seen easily.

2.2.2. Land- and boat-based counts

Land- and boat-based counts (referred to as ground counts) of hippos are relatively accurate but are labour-intensive and are restricted to accessible sites with some biases related to observer experience and the behaviour of animals (Norton-Griffiths 1978; Mackie 1989; Jachmann 2001). Ground counts were used to record changes in hippo numbers and habitat after culling and cropping programs in Uganda and Zambia (Eltringham 1974; Marshall & Sayer 1976; Martin 2005) and to assess the distribution of hippos in Benin (Amoussou et al.

2006, unpublished data). Paths along the rivers were walked and all individuals encountered were counted from >40 m (if possible) to limit observer disturbance (Eltringham 1973; Eltringham 1974; Marshall & Sayer 1976; Jachmann 2001; Martin 2005). Counts along the lake shore were performed from a motorized boat (20 – 40 Horsepower) at an average speed of 11 km.h^{-1} (range 1-14), keeping within 100 m of the shore where possible. The distance to the shore was constrained in some areas by low lake levels, sedimentation and emergent vegetation. For both land- and boat-based counts, the team was composed of 4 to 8 members (depending on the security constraints in different sectors), each of whom independently counted each group of hippos. Counts were compared and repeated until the team agreed on a count (Jachmann 2001, 2002).

In some areas where it was difficult to cover the whole area in one day and with the aim of minimizing errors, the count was done by segments to avoid double counting (Caughley 1974). In order to map the distribution of hippos, a hand-held Global Positioning System (GPS) unit (Garmin GPSmap 60CSx) was used to record locations of groups and the area surveyed. Binoculars (10 x 43) were used to count hippos in areas where observers could not make the count with the naked eye (Jachmann 2001, 2002).

Data were collected from 29 September to 27 November into three periods: from 29 September to 04 October 2009 (the Rwindi sector covering part of the lower Rutshuru River and the south-western coast of Lake Edward), 21 - 27 October 2009 (the Ishasha River and eastern Lake Edward) and from 23 - 27 November 2009 (the lower Semuliki River and the northern Lake Edward). Most counts were performed in the mornings (6:00 to 11:00) when hippos are most easily seen as they are active and clumped in groups, usually in shallow water. As winds pick up during the day, hippos tend to move into deeper waters where they are more easily overlooked (Delvingt 1974; Mackie 1989; Martin 2005).

The ground counts included only a subset of areas covered by the aerial counts while the latter covered almost all areas where hippos occur. In areas where both techniques were used, the ground counts were used to derive correction factors to get better estimates of the overall population from the aerial counts (Caughley 1974; Delvingt 1974; Mackie 1989, 1991; Jachmann 2002).

2.2.3. Hippo counting sites

Virunga NP is divided into four different management sectors (Mutsora in the north; Rwindi in the central, Lulimbi in the eastern and Rumangabo in the southern sector of the park), of which the first three sectors support hippos (Languy & de Merode 2006). For the hippo counts; the park was divided into six zones (Fig. 1) (Delvingt 1974; Mankoto 1989; Mackie 1989, 1991):

1) Lake Edward covers 224 km² of which 166.8 km² is part of Virunga NP (Languy & de Merode 2006). For ground counts I counted hippos along the northern shores (from the DRC – Uganda border in the north to Muramba at the northern edge of the western shores of the lake) and southern shores (from the delta of the Ishasha River at the Ugandan border to Mwigha Bay: the southern end of the western shores) of the lake. The entire lakeshore was covered by the aerial counts (176 km) while the western coast (85 km) was not covered by water based counts due to security constraints. The local communities in this area oppose conservation activities as they fear they may lose their "encroached" lands.
2) The Ishasha River runs along the border between the DRC and Uganda, with about 49.5 km in the park. This is a complex wetland system comprising several small rivers and marshes. This area was entirely covered by both aerial and ground counts. Due to the habitat type and the timing constraint to counting hippos, the area was covered in three days by ground count and once off by aerial count. The three segments were divided based on the knowledge of rangers about gaps in the distribution of hippos along the river.

3) The Rwindi River drains part of the western side of the park where it borders some villages. Some 56.5 km of the river runs through the park. This site was inaccessible by foot, thus hippos were aerial counted.

4) The floodplain of the Semuliki River crosses the savanna in the northern sector of the park and the lowland forest in the upper north. Some areas are inhabited by hippos and others are not because of the width of the river and the water regime. The river was covered both by aerial count (60.2 km out of 90.3 km) and water counts (10 km) due to security constrains. Although the aerial counts covered most of the area, one group of hippos was encountered by the ground count north of the area not covered by plane (Fig. 2).

5) The Rutshuru River crosses the central sector and the savanna habitats where it forms marshes and ponds. The river (109 km) was covered by aerial counts, and some accessible sections were visited by foot (9.1 km).

6) Marshes and interior ponds (lakes) were covered by plane because all the previous counts reported hippos in different ponds and marshes (e.g. Kizi, Chabuganga and Kikere in the central and eastern sectors of the park) (Delvingt 1974; Mackie 1989, 1991; Languy et al. 1994). These marshes and ponds were covered by the aerial counts only.

2.3. Questionnaire to assess the attitudes of local communities

A questionnaire (Appendix 1) was administered to 346 households living in the fishing villages and around ranger stations along the shores of Lake Edward (88 in Kyavinyonge, 97 in Nyakakoma, 26 in Ishasha; 50 along the western coast and 85 in Vitshumbi). Questionnaires were printed and handed to interviewees if they are comfortable with writing while explanations were given by the interviewer (Fitzgibbon et al. 1995; Kideghesho et al 2007). For other people, questions were translated in Swahili and responses were written by the interviewer. The interview was stratified to select people from different professions (fishermen, police, army, small businessmen, and other public services). Given the "sensitivity" of some professions (soldiers, police and rangers), it was difficult to have a representative sample from these groups. Another limitation was linked to the movements of local people from legal villages to illegal fishing settlements currently established by soldiers. Illegal sites were difficult to access for security reason. The data were collected from 29 September to 10 December.

The household was considered as the unit of the study and defined as a social or domestic unit living together and consisting of the members of a family and any other people sharing a residence (Fitzgibbon et al. 1995; Kideghesho et al. 2007). Households were selected randomly from different streets of fishing villages and ranger stations. The questionnaire had 23 questions related to sociodemographic information on respondents without recording their names, conservation status of hippos, human-hippo conflict, poaching and the bushmeat trade, and possible conservation measures to restore hippos. Bushmeat referred to meat and trophies or ivories collected from wildlife (Fitzgibbon et al. 1995; Olupot et al. 2009). The questionnaire was designed to assess the perceptions of local stakeholders towards the decline of hippos.

2.4. Data analysis and mapping

Estimating large mammal numbers from aerial counts suffers from several biases (Caughley 1974; Caughley et al. 1976; Norton-Griffiths 1978; Jachmann 2001, 2002). Thus, correction factors (CF) are needed to minimize errors and give acceptable estimates of study populations (Caughley 1974; Caughley et al. 1976; Jachmann 2002). In areas which were covered by both ground and aerial counts, simple correction factors were derived from the ratio of ground: aerial counts, given that ground counts invariably were greater than aerial counts (see Results) (Mankoto 1989; Mackie 1989, 1991; Jachmann 2002). Thus, hippos seen during aerial counts in areas not covered by ground counts were not considered to derive CF. The CF were used to extrapolate the hippo population size for Virunga NP from numbers seen during aerial counts (Caughley et al. 1976; Mackie 1991; Jachmann 2002). Estimates are conservative because I assumed that ground counts were accurate and located all groups of hippos (Mackie 1989, 1991; Jachmann 2001, 2002). Three different estimates were produced: the minimum estimate, the best estimate and the extrapolated estimate by zone (Mackie 1991). The minimum estimate is the sum of hippo numbers from ground counts and numbers seen from aerial counts in areas not covered by ground counts. This estimate assumes that ground counts are accurate and aerial counts are seen as complementary techniques for remote areas (Mankoto 1989; Mackie 1991; Jachmann 2001, 2002). The best estimate was derived from the sum of hippo numbers from the ground counts and the extrapolated numbers from aerial counts in areas not covered by ground counts. The extrapolated estimate by zone was derived from hippo numbers seen during aerial counts corrected by CF by zone. Average group size and standard deviation (SD) by sector was derived. The range (hippo numbers and groups, or social parameters) is hereby considered as the interval between the minimum and maximum figures for specific parameter or variable. The CF for the groups was calculated following the same procedures as for hippo numbers. Hippos seen in areas not covered by ground were identified by geographic coordinates taken for each observation.

Data on distribution and abundance of hippos from ground and water counts were compared to aerial counts to get the better estimate of hippos in Virunga NP (Caughley 1974; Jachmann 2002). The abundance and distribution of the population were mapped using ArcGIS 9.3.1. Proportions of respondents were calculated for social parameters to compare different variables related to different questions. Chi-squared goodness of fit tests were used to test the significance of some sociological parameters.

Chapter 3. Results

3.1. Distribution and abundance of hippopotamuses

3.1.1. Comparison of hippo counts using different techniques

The population counted from the land/water counts and the aerial count give different numbers. For areas covered by both techniques (see 2.2), the ground counts recorded 990 individuals found in 108 groups compared to the aerial counts where 603 individuals were recorded in 57 groups (Table 1). The overall correction factor for aerial counts for individual hippos was therefore 1.64 (990/603). The CF varied by zone depending on habitat types and length of area covered (Table 1). In areas covered by both the ground count and the aerial count, the ground counts had a higher number for both total population and group size regardless the type of habitat (Table 1, 2, 3).

Table 1. Hippo groups and numbers seen during ground and aerial counts by zones. The CF for groups and individuals were derived from the ratio number seen from ground/number seen from aerial count for area covered by both techniques and hippos seen by aerial counts only were excluded.

	Hippo groups			Hippo numbers*		
	Ground counts	Aerial count	CF Groups	Ground counts	Aerial counts	CF individuals
Lake Edward North	13	7	1.86	55	28	1.96
Lake Edward South	45	20	2.25	327	142	2.30
Lower Semuliki River	15	8	1.88	93	85	1.09
Lower Rutshuru River	4	4	1.00	15	6	2.50
Lower Ishasha River	14	10	1.40	185	128	1.45
Upper Ishasha River	17	8	2.13	315	214	1.47
Grand Total	108	57	1.89	990	603	1.64

*hippos counted in areas covered by one technique were not considered to derive CF

In total, for the whole area covered by aerial counts 733 and 995 hippos were counted by air and on the ground respectively (Table 2). The ground counts still gave the higher number despite the limited survey coverage compared to aerial counts.

3.1.2. Distribution and abundance of hippos

By applying the average correction factor on hippos seen during aerial counts (733 x 1.64), the extrapolated population was 1,202 hippos (Table 2). An additional 130 hippos were counted during the aerial counts in areas not covered by ground counts. Extrapolating these aerial counts with the average CF suggested these areas support some 213 hippos.

Table 2. Hippo numbers from the ground and aerial counts for all zones and hippo numbers extrapolated from aerial count using the average correction factor of 1.64. The percentage (%) cover refers to area covered by ground counts compared to the total distance of zones in the study area.

	Ground count	% cover	Aerial count (total)	Extrapolated population (aerial)
Lake Edward North	55	23	30	49
Lake Edward South	327	58	156	256
Pond			30	49
River Rwindi			4	7
Lower Semuliki River	93	33	86	141
Upper Semuliki River	5	0*	28	46
Lower Ishasha River	185	100	128	210
Upper Ishasha River	315	100	214	351
Lower Rutshuru River	15	8.3	17	28
Upper Rutshuru River			40	66
Grand Total	995		733	1202

* the aerial count did not cover the whole Semuliki River while one group of hippos was counted from the ground.

The minimum population was 1,125 and the best estimate (ground counts numbers + extrapolated aerial counts outside ground count areas) was 1,209 hippos (Table 3). Using zones specific CF (aerial counts * CF by zone), the population was 1,197 hippos (Table 3). Hippos were still present in most of the aquatic habitats of the park, but some sectors support more individuals than others (Fig. 2). Both counts showed the same patterns for the distribution of hippos in different sectors: more hippos were located along the Ishasha River and the south eastern shores of Lake Edward. The Ishasha River supported almost half of the current hippo population in Virunga NP (500 animals) while Lake Edward had almost 400 animals (Table 3). The spatial distribution of hippos along the lake shore was not uniform as the south eastern shores had more hippos compared to the rest of the lake. The western coast of the lake had very few hippos, with only a few in the extreme north and south where there was less human settlement. The Rwindi River had almost no hippos compared to the other major rivers (Table 3). The density of hippos was higher along the Ishasha River (10.1 hippos.km^{-1}) than other areas (0.1, 0.9 and 2.2 for Rwindi and Rutshuru and Semuliki Rivers, 2.4 for the lake).

Hippo populations in Virunga were about 148 groups (Table 3) derived from the best estimates when the groups seen from the ground were combined with groups seen from aerial count in areas not covered by ground count. The ground count recorded more groups while the aerial counts recorded larger group sizes.

Table 3. Estimates of hippo population in Virunga NP from minimum estimate numbers (ground counts + aerial counts in areas not covered by ground counts), extrapolated estimates using CF by zone and best estimates (ground counts + extrapolated population in areas not covered by ground counts. The number of groups was related to the best estimate numbers in different zones.

	Total population			
	Minimum estimate	Extrapolated by zone	Best estimate	No of Groups
Lake Edward North	57	59	58	15
Lake Edward South	341	359	350	53
Pond	30	42	49	1
River Rwindi	4	6	7	1
Lower Semuliki River	94	94	95	18
Upper Semuliki River	33	39	51	14
Lower Ishasha River	185	186	185	14
Upper Ishasha River	315	315	315	17
Lower Rutshuru River	26	43	33	6
Upper Rutshuru River	40	56	66	9
Grand Total	1125	1197	1209	148

There were no records of hippos in three main ponds (sometimes referred to as interior lakes) compared to the previous counts. Two ponds were dry (although we visited the area during the short rainy season) and the other had decreased in size to such an extent that it can no longer support hippos. The pond reported in Table 2 was neither part of the main ponds identified nor its population reported in previous counts. It is located in the eastern sector* of the park (west side of the Ishasha River) and supported 49 hippos.

The average group size from the ground/water counts was 9.2 and the size of the hippo group ranged from 2 to 91 individuals (Table 3) although there were some solitary individuals. The average group size from the aerial counts ranged from 8.2 (using CF) to 10.5 (counts not corrected). The size of the group ranged from 2 to 98 individuals. Lake Edward (especially the southern shores) had more groups than other zones because of the length of its shores while Ishasha River had the largest group of hippos (Table 3) because of presence of rangers and its contiguity to Queen Elizabeth NP. The high numbers of groups along the lake shores can be explained by the total distance of shores of the lake (see 2.2.3).

* sector refers to the management sectors of the park which is different from zones under this study

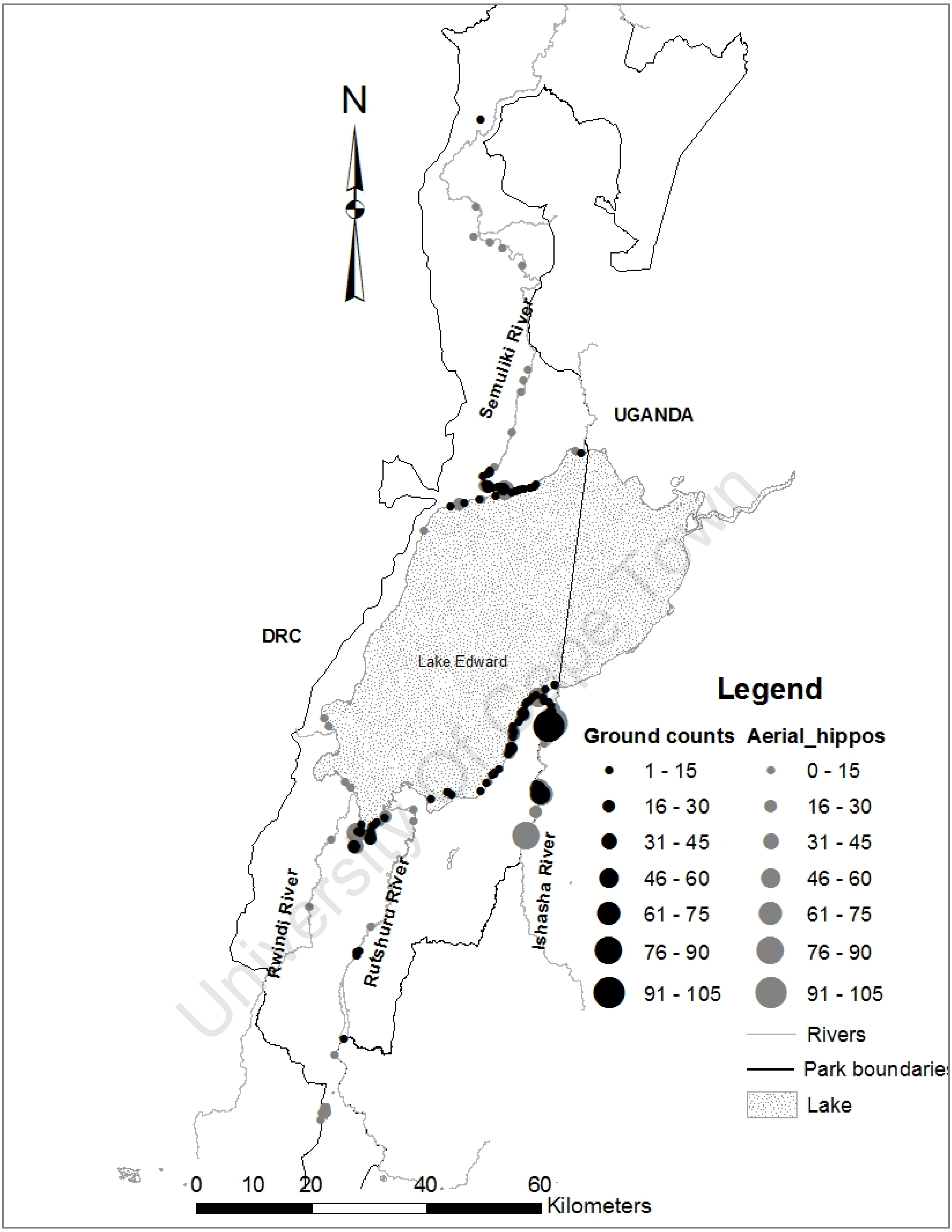


Figure 2. Distribution of hippo groups in Virunga NP as counted from ground and aerial counts (interval of 15) in different zones of the study area

Both counts show almost the same distribution pattern among sites: Lake Edward supported more groups than other sites although these are small groups followed by the Ishasha and

Semuliki Rivers (which supported more than 15 groups each based on the ground counts) while the Rutshuru River supported 4 groups (Table 4).

Table 4. Group numbers, mean group size and ranges of hippos in Virunga NP based on ground and aerial counts

	Ground counts			Aerial counts		
	Groups	Mean group size (±SD)	Range	Groups	Mean group size (±SD)	Range
Lake Edward North	13	3 (±4)	1-9	7	7 (±6)	3-18
Lake Edward South	45	7 (±7)	1-30	20	13 (±12)	2-49
Marsh				1	49	49
River Rwindi				1	7	7
Lower Semuliki River	15	6 (±6)	1-21	8	18 (±18)	2-56
Upper Semuliki River	1	5		7	7 (±3)	2-11
Lower Ishasha River	14	14 (±13)	1-42	10	21 (±29)	2-98
Upper Ishasha River	17	23 (±19)	1-91	8	44 (±28)	7-89
Lower Rutshuru River	4	2 (±4)	2-6	4	7 (±3)	3-10
Upper Rutshuru River				5	13 (±3)	10-18

Hippo group size was related to the distance from a protection point (ranger post), decreasing with the distance from their "daily space" to the ranger post (Fig. 3).

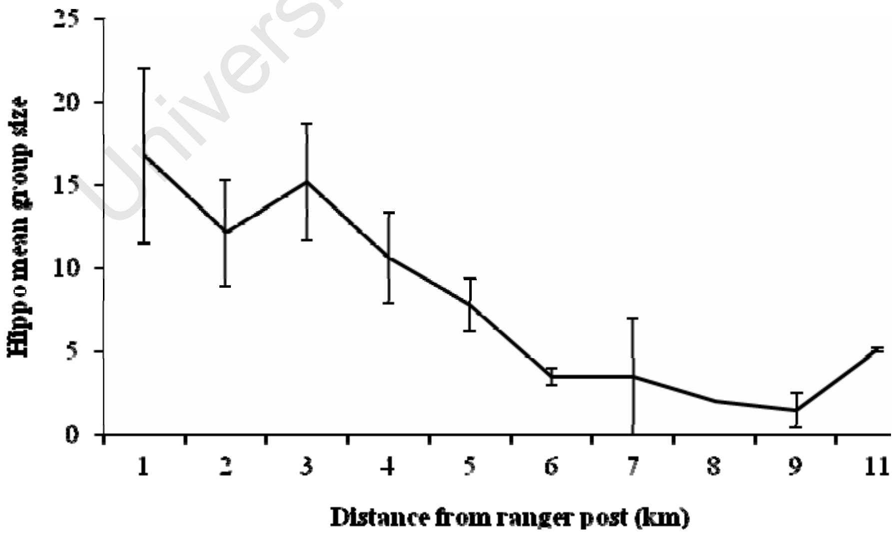


Figure 3. Mean group size of hippos in relation to the distance from ranger posts. Value for groups 5-6 and 10 km from a ranger post excluded two isolated large groups of >60 hippos on the Ishasha River.

3.1.3. Trends in hippo numbers in Virunga NP

Previous surveys of hippos and other mammals were conducted in Virunga NP since the 1950s. The hippo population in Virunga declined drastically since the 1990s (Fig. 4). I used data from previous censuses to show the trend of hippo population (1959, 1974, 1981, 1989, 1991, 1994, 2003 and 2005). Although my results suggest a modest increase compared to 2005 where the population was 827 (Fig. 5b), there were some variations among sectors (Fig. 5 and appendix 3). I did not consider results from the 2006 hippo counts (Muir 2006) because there is no detailed report on spatial distribution and the techniques used and only total numbers (629 hippos) were reported.

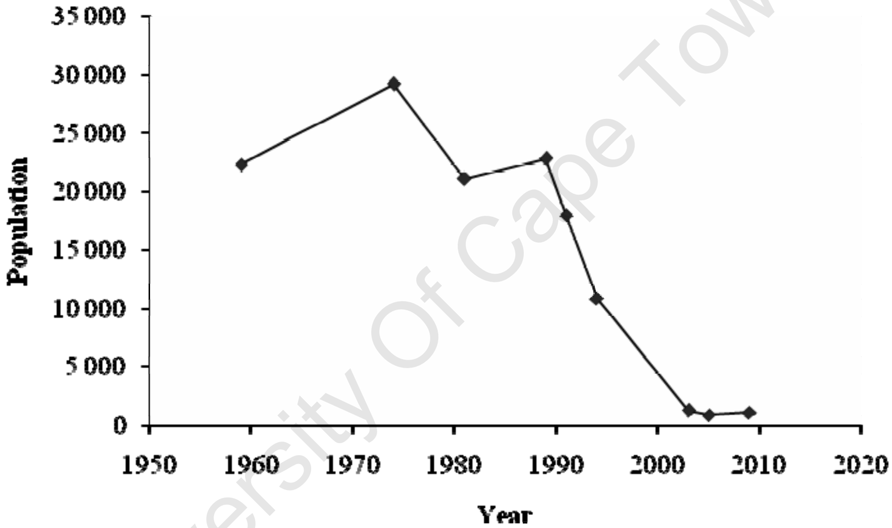


Figure 4. Hippopotamus population size in Virunga NP from 1959 to 2009 (based on data from Bourlière & Verschuren 1960; Delvingt 1974; Mertens 1983; Mackie 1989, 1991; Languy et al. 1994; Mushenzi et al. 2003)

The decline in hippo numbers was accompanied by a change in the distribution of hippos in different sectors compared to the past (Fig. 5). Lake Edward and, the Rutshuru and Rwindi Rivers were home to around 15,000 hippos until the 1990s, but numbers in these zones have now declined to hundreds (Fig. 5). There has been a slight increase for most of the zones apart from the Rwindi River and the northern sector of Lake Edward.

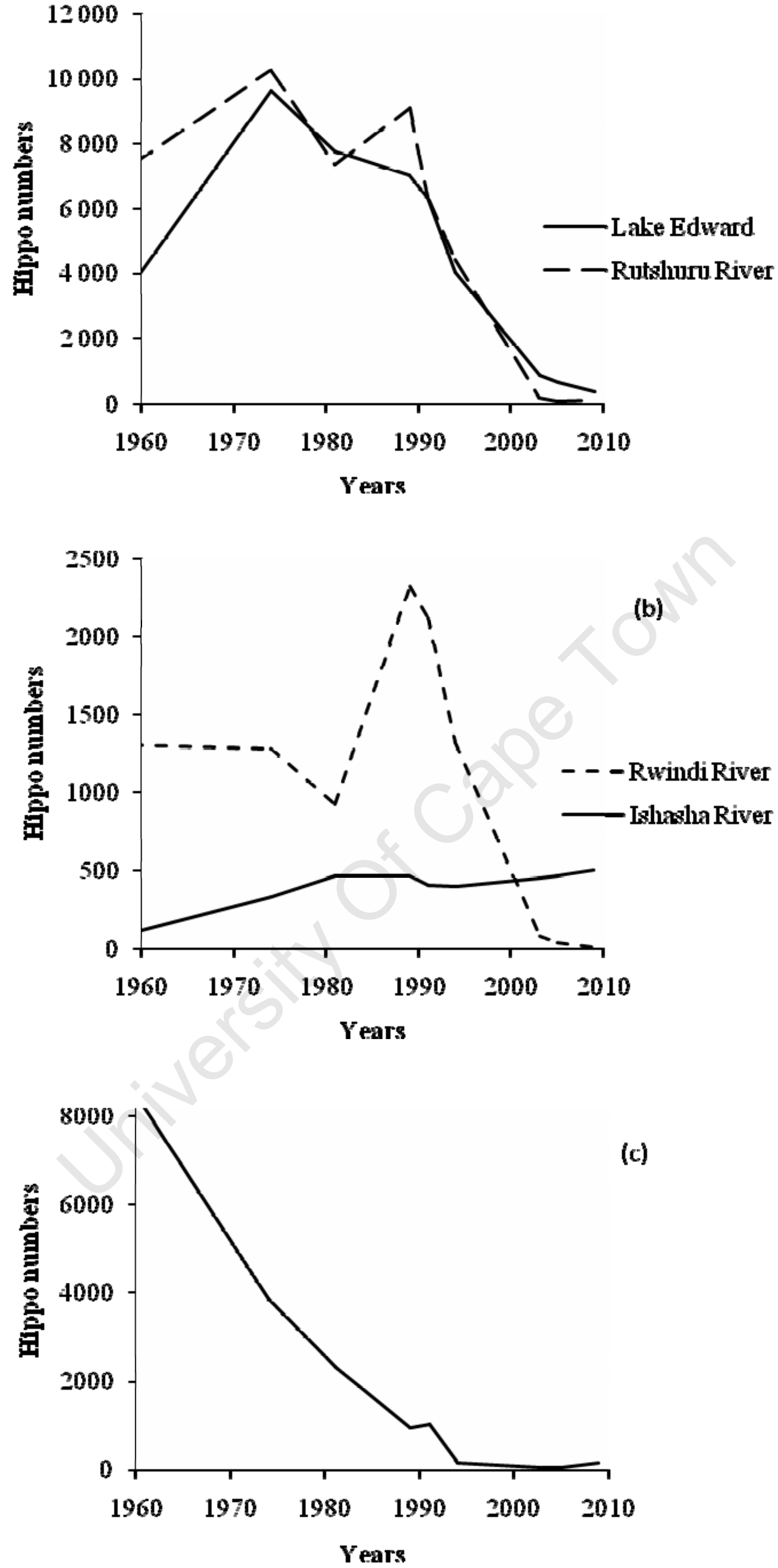


Figure 5. Hippo population trend in different sectors of Virunga National Park: (a) Lake Edward and Rutshuru River, (b) Ishasha and Rwindi Rivers and, (c) Semuliki River

3.2. Social attitudes and hippos

3.2.1. Household composition and activities

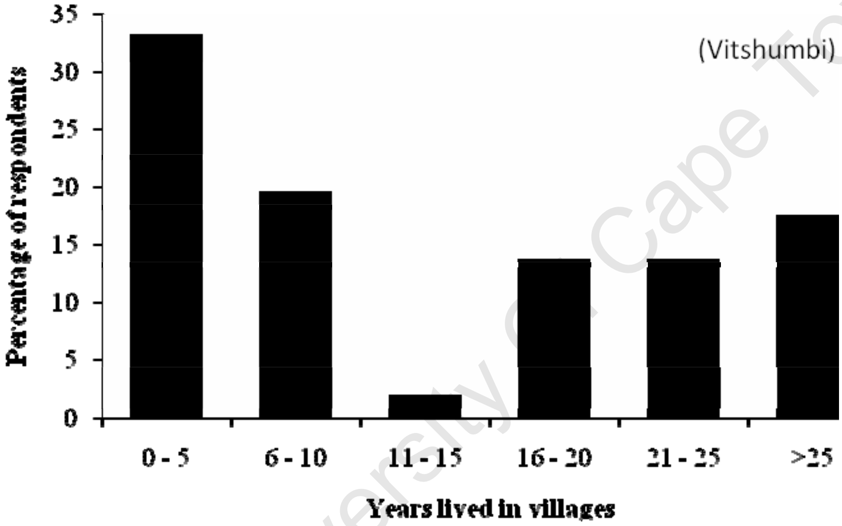
Questions related to household composition, the occupation of the respondent and their level of education were asked to collect the socio-demographic information in different villages. Kyavinyonge, Nyakakoma and Vitshumbi are the three legal fishing villages and Muramba, Mubana and Kavuavua were three out of ten villages on the western lakeshores that were visited, others were not visited due to security constrains (Fig. 1). Ishasha village is located at the DRC-Uganda boarder and near Nyakakoma fishing village where local communities conduct different activities including local trade (fish, manufactured products and food items). The mean household size was 6 people (SD: 3.2, range: 1-15) although the size varied in different villages (Table 5). Fishing (25%) and public services (25%) were the main occupations in fishing villages while farming was the main activity for communities along the western shores of the lake (Table 5). Farming was largely confined to Kyavinyonge and the western coast of the park where 15% respondents were involved in agriculture. Other professions include students, civil society professionals and unemployed people.

Table 5. Percentage of respondents showing profile of communities in Virunga NP by profession categories by village, the average household size and average years spent in villages (n= number of respondents)

		Kyavinyonge (n=86)	Nyakakoma (n= 81)	Ishasha (n=25)	Vitshumbi (n= 68)	West coast (n= 50)	Total%
Profession	Fisherman	36.7		29.1	21.5	12.7	25
	Farmer	29.8	8.5			61.7	15
	Others	22.4	6.5	36.4	29.9	4.7	35
	Public service		12.0	76.0	12.0		25
Mean household size		6	4	6	5	6	
Mean years in villages		20.0	8.5	10.5	14.1	15.3	

People have lived in the fishing villages for 14.5 (SD: 11.3) years on average ranging from <1 to 50 years (Fig. 6).

The Kyavinyonge community seems to have been more stable compared to other fishing villages, as about 31% of respondents had been resident for more than 25 years compared to other villages where this category (resident for >25 years) represented only 7-10%. Most of the villages have experienced migration (immigration and emigration) as indicated by the number of people who have lived in these villages for less than ten years. Immigration was most evident at Nyakakoma where about two thirds of respondents have been resident for less than 10 years, only 7% have been resident for more than 25 years (Fig. 6). Ishasha village showed a similar pattern. Respondents from the western coast have been in the area for 6 – 15 years (62%) and there are some people still immigrating to this village (6%).



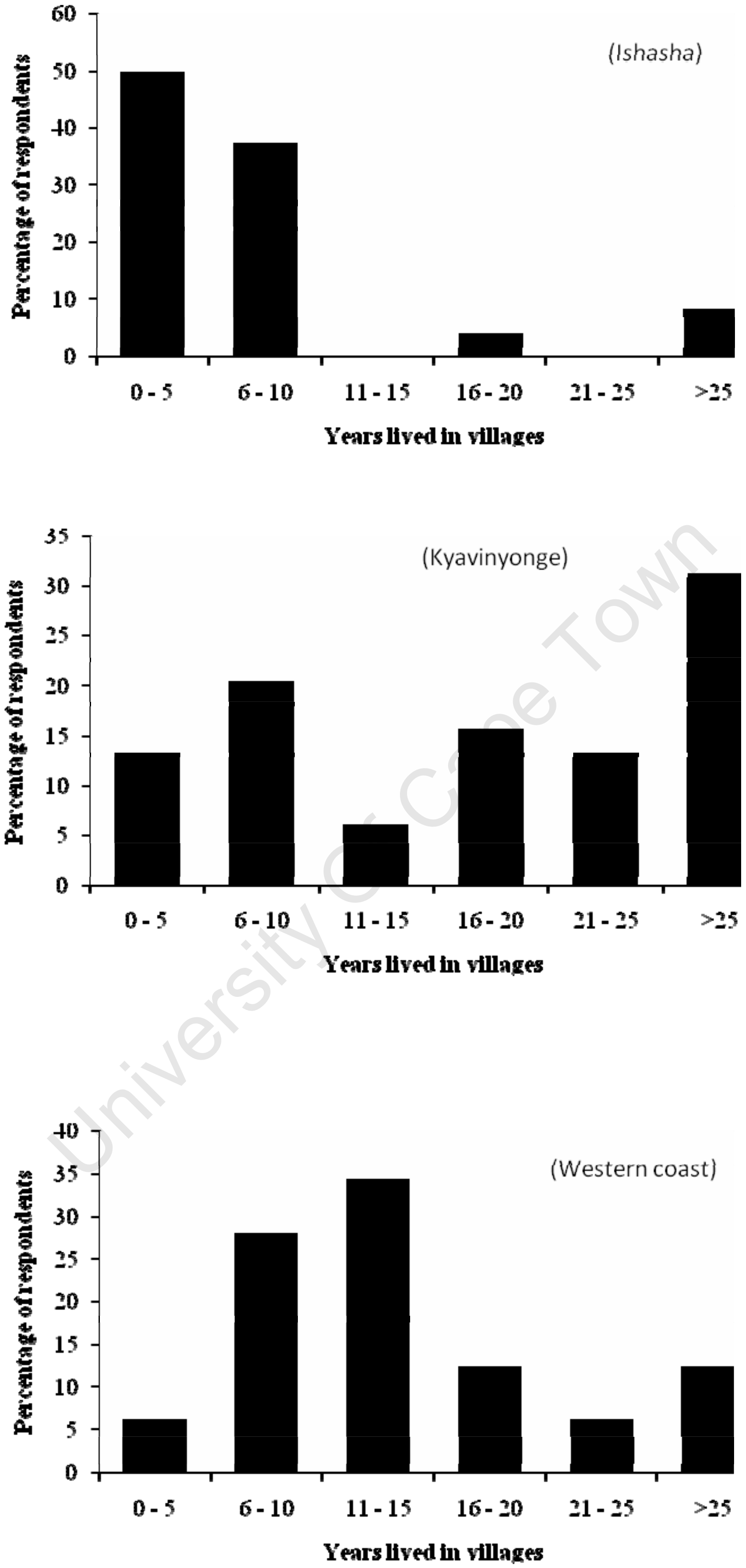


Figure 6. Percentage of respondents and number of years people lived in fishing villages (Vitshumbi, Nyakakoma, Ishasha, Kyavinyonge and West coast) from <1 to >25 years.

Most respondents (53%) had high school education (secondary level), followed by primary level education (24%) with only 7% having any tertiary-level training (Table 6). The education level differed from one village to another. The western coast villages had the highest percentage of people with no education while the primary level education was high in Nyakakoma while Vitshumbi had more respondents with a secondary education, and Kyavinyonge more respondents with a tertiary education.

Table 6. Percentage of respondents by village and education level from primary to university levels

	Ishasha	Kyavinyonge	Nyakakoma	Vitshumbi	Western coast	Total %
None		20.9	5.1	10.3	36.2	15
Primary	33.3	20.9	44.3	2.9	25.5	25
Secondary	58.3	46.5	46.8	77.9	38.3	53
University	8.3	11.6	3.8	8.8		7

3.2.2. Value and importance of hippos

Most respondents recognized the importance of hippos in Virunga NP. More than half (56%) of them perceived hippos to be beneficial for fisheries in terms of food and source of economic revenue, but 22% perceived no benefits (Table 7). Most people in the latter category were farmers (64%). Local communities also reported that hippos help to reduce livestock theft (looting), by providing an alternative source of meat for armed militias.

Table 7. Perceived benefits of hippos by categories reported by respondents and by professions based on the questionnaire (n= number of respondent by category).

	Farmer (n=47)	Fisherman (n=77)	Public service (n=25)	Others (n=102)	Total (%)
None	63.8	26.0		11.8	22
Fisheries	8.5	57.1	96.0	68.6	56
Conservation	4.3	1.3		2.9	4
Tourism	4.3	9.1	4.0	11.8	11
Education	2.1	5.2		2.0	3
Bushmeat		1.3		2.0	1
Substitute (looting)	17.0			1.0	3

Respondents valued hippos for their contribution to the local economy (37%), education (19%), culture (13%) and conservation (7%). The conservation value for communities was explained in terms of job and tourism revenue opportunities. The economic value was linked to monetary benefits that communities derive from fishing and/or the bushmeat trade. The education value of hippos was linked to the opportunity of students to get to know hippos and their habitats. Respondents perceived hippos as part of their cultural package.

Local communities identified seven sites that support hippos in Virunga NP (of which five were covered by this study) with Lake Edward (71%) chosen most often, followed by the Semuliki River (11%). The other three rivers; Ishasha (5%) , Rutshuru (3%) and Rwindi (1%) known to support high number of hippos in Virunga NP were least recognised by respondents as important sites supporting hippos. Apart from the four primary rivers which support hippos in Virunga NP (Table 3), various small rivers (tributaries of the lake and main rivers) thatwere identified by respondents (6%) as potential sites that support hippos. The perception of local communities was that those tributaries support more hippos than some of the big rivers, even though this had never been reported in the past. These small rivers were not covered by this study given the timeframe for this study, security constrains in some of these areas but also no hippos have ever been reported in thepast. Most respondents (97%) identified at least one site where hippos were found; 51% knew two sites and only 21% knew more than two sites.

Most respondents (89%) recognized that the distribution of hippos had changed. They also reported changes in distribution and abundance of fish (27%), large mammals (25%), bird communities (24%) and habitat (24%). The decline of hippos was perceived to have started in the 1990s with the population estimated to be only 1% (2006) and 0.3% (2009) of the population of the 1950s. The perceived decline has occurred since the 1980s. The main reasons for the decline of the hippo population were reported to be political instability caused by armed conflict (66%), the resultant presence of armed groups and poaching in the park

(24%), poor institutional capacities (3.5%), presence of soldiers in the park (1%), hippo diseases (0.9%), human encroachment (0.7%) and human population growth (0.6%). Only 3.1% of respondents failed to identify a reason to explain the decline.

3.2.3. Poaching and bushmeat

Bushmeat as a result of poaching is illegal under the DRC conservation law if conducted in a protected area, or without a hunting permit in other areas. Such illegal hunting is uses fire arms or traditional weapons such as spears, snares and pitfall traps. Almost all respondents (97%) acknowledged the existence of poaching and the bushmeat trade in Virunga NP, mainly in Nyakakoma (20%) and Vitshumbi (20%), with a lower reporting rate in Kyavinyonge (9%). Respondents perceived that the decline of hippopotamus population in Virunga NP was due mainly to traditional and armed poaching for the bushmeat trade and trophies for sale (64%) and subsistence use (24%) (Fig. 7). The bushmeat trade category includes a group of activities such as trophy trade and the barter of bushmeat in exchange for ammunition between armed groups and stakeholders. It is difficult to separate activities related to bushmeat trade from trophy trade because poachers take both meat and trophies. Weak institutional capacity and unemployment were low reported as reasons for poaching.

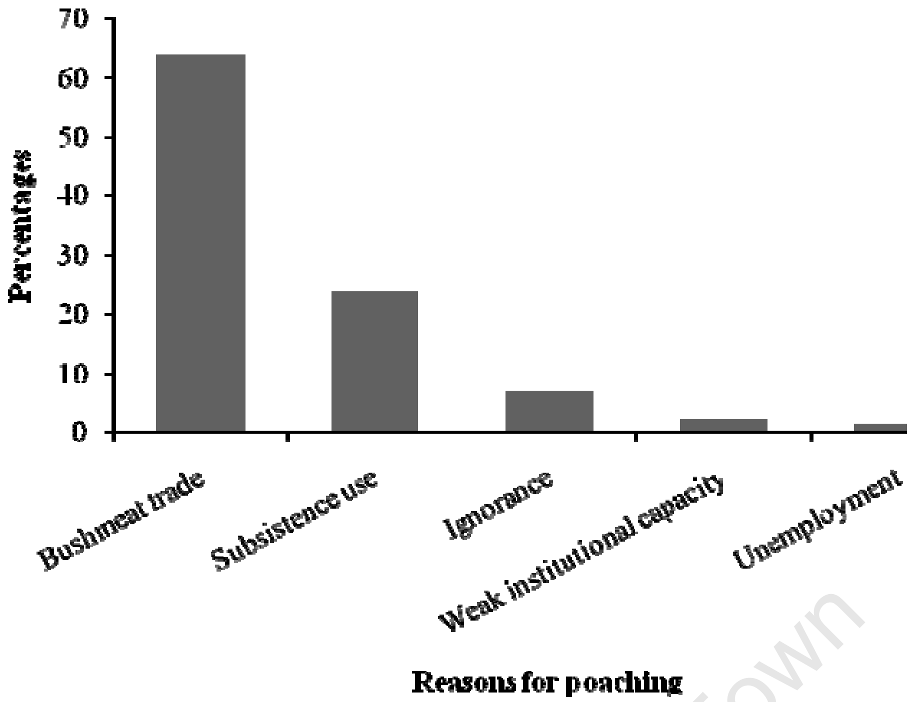


Figure 7. Percentages of respondents perceiving bushmeat trade, subsistence use, ignorance, weak institutional capacity, and unemployment as reasons for poaching of wildlife in Virunga NP.

Poaching in Virunga NP targeted almost all large mammals but with different intensities (Fig. 8): respondents identified hippos, elephant (*Loxodonta africana*), warthog and buffalo (*Syncerus caffer*) as the most targeted animals. Hippos and elephants were most frequently selected by poachers for the quantity of meat, and the ivories or trophies which generate more money than other species.

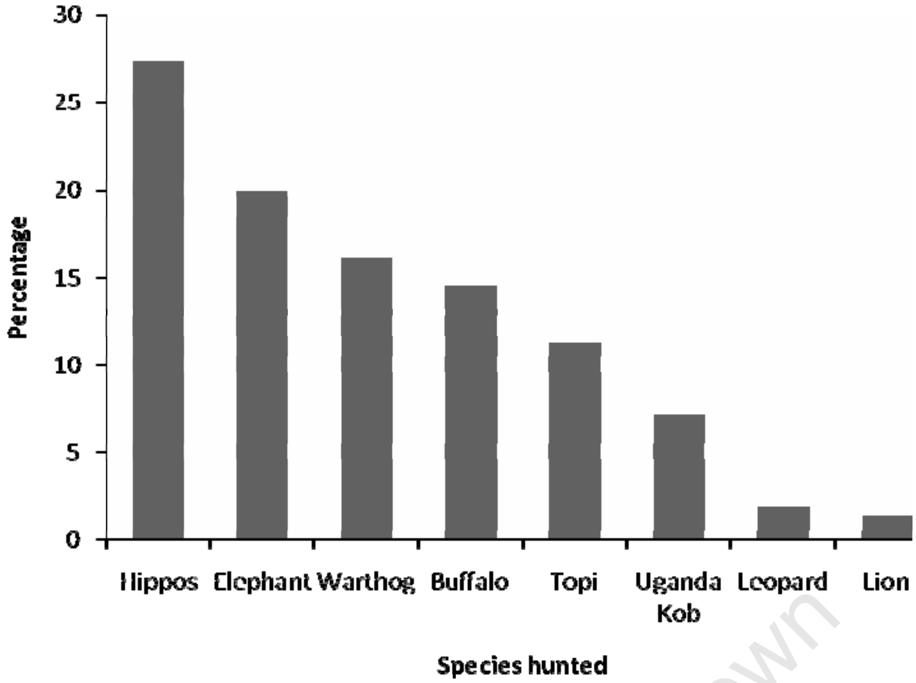


Figure 8. Percentage of respondents admitting the existence of poaching of different species in Virunga NP

Respondents reported that poaching is mainly carried out by militias, soldiers and rangers although some poaching was conducted by people from Uganda as well as members of the resident communities and people from villages outside the park (Fig. 9).

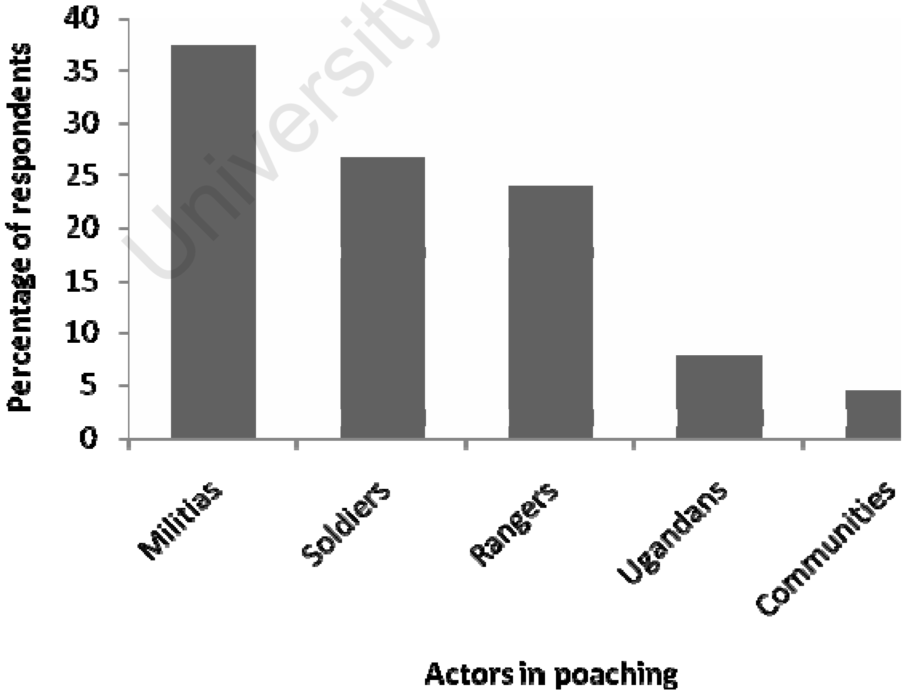


Figure 9. Percentage of respondents identifying actors responsible for poaching according to park residents

Bushmeat is sold to local communities as well as being transported to neighbouring towns (Goma, Butembo and Beni). Villages around the park (Ishasha, Nyamirima, Kiwanja, Butembo) have been used as routes for bushmeat as well as for fish trade. Prices varied among villages, and were higher outside fishing villages than within villages (Table 8). Bushmeat transactions have been less reported by respondents from the western coast villages as there is no more wildlife remaining in the area. The bushmeat trade was made through informal (black) markets (82%) via a network composed of buyers, sellers, and intermediaries.

Table 8. Reported average prices (US$) for bushmeat (±SD) in and outside of fishing villages. Numbers in parentheses represent the sample size

Fishing villages	Bushmeat in villages		Bushmeat outside villages	
	Mean price (kg^{-1})	Maximum price (kg^{-1})	Mean price (kg^{-1})	Maximum price (kg^{-1})
Ishasha	2.1±0.7(17)	2.9	3.3±2.7(4)	5.9
Kyavinyonge	0.2±0.8(5)	5.0	2.6±1.3(5)	4.2
Nyakakoma	1.5±1.4(60)	5.9	4.1±3.1(36)	18.8
Vitshumbi	1.0±0.7(64)	3.5	2.5±1.4(53)	5.9
Western coast			1.8 (1)	
Mean	1.2+0.8	5.9	2.9±0.9	18.8

The main facilitators of the bushmeat trade (i.e. who assisted with transport from the poaching site to markets) were reported to be army soldiers (34%), militias (24%) or both (16%). Their intermediaries included members of fishing villages (42%), spouses of soldiers (20%) and small businessmen (19%). Most respondents (58%) claimed that they did not eat bushmeat to supplement their diet but, 27% stated they ate bushmeat monthly, and 9% ate bushmeat twice a week. Public servants were identified by respondents as frequent consumers of bushmeat in their villages presumably because of their limited income and their social relationship with poachers and intermediaries.

3.2.4. Impact of the decline of hippos and human-wildlife conflict

Only 30% of respondents were affected by hippos and only 20% could relate the incidents that had occurred. Most respondents (60%) reported interactions with hippos in terms of crop raiding (25%), killing (23%) poaching (23%) and theatening people (22%).

Poaching was listed as a source of conflict because some poachers were killed or threatened by hippos. A respondent's profession had no influence on their perception of human-hippo conflicts (χ= 6.5, df = 7, $p > .05$).

Incidents included threatening people (44%), crop raiding (32%), injuries (8%) and killing (3%) since the 1970s. Conflicts occur mainly in the rainy season when hippos were easily overlooked because of high water levels and increased turbidity. Most incidents occurred in bays where either illegal fishing and/or encroachment of park land occurred. In most cases, there were no retaliation actions against hippos (69%). However, some people did call for assistance from rangers and/or soldiers to scare animals, or people guarded their crops and scared the animals in case of crop damages. Most perceived that the decline of hippos had no impact on their activities (65%), although 35% recognized an impact on fisheries (45%).

3.2.5. Conservation measures

Most respondents believed that the protection of hippos is very important (90%) because of their value to the community (see 3.2.2). Different activities were suggested by respondents as measures to conserve hippos in Virunga and main conservation actions can be summarized as follow:

a) Increased community awareness and involvement in conservation activities (28%). Such a programme should include integrated conservation-development projects, education activities, animal scaring programs and a park revenue sharing scheme;
b) Improving the security of the park (20%) which targets the removal of armed groups;
c) Reinforcing conservation patrols (20%) to limit poaching activities, illegal collection of other resources such as firewood and charcoal making. This should be strengthened by institutional support (11%), including the provision of field equipments to rangers, adequate salaries, more training, recruiting additional rangers, and effective disciplining of rangers who break conservation rules.

Subsets of measures suggested by respondents included:

a) Political support for conservation (7%). The government should increase salaries for soldiers and public servants to limit poaching and their interference in conservation activities, and should support law enforcement in the park by giving rangers more rations and ammunitions;
b) Improved enforcement of fishing regulations (6%). This included the regulation of immigrants into the park as well as effective control of fisheries through limits on fishing mesh sizes, restricting number of public services that should operate in fishing villages and restricting fishing to specific areas;
c) Removing soldiers from the park to limit their impacts on wildlife and reduce the bushmeat trade (4%);
d) Participatory boundary demarcation (0.7%). Large parts of Virunga NP boundaries are not marked, leading to conflict between park staff and people;
e) Manage crocodile population (0.3%). Some respondents suggested that the crocodiles chase hippos in some open habitat (e.g. beaches) and sometimes attack hippo calves.

Chapter 4. Discussion

Most surveys of hippos in Virunga NP used either ground or aerial counts, but more often the ground/water counts were restricted to short sections (3 km) per sector to derive correction factors for aerial counts (Delvingt 1974; Mankoto 1989; Mackie 1989, 1991). Ground and water counts give better results for rivers and the lake shores, while aerial counts allow coverage of remote areas where access is limited and areas where it is unsafe to enter due to security issues (Norton-Griffiths 1978; Mankoto 1989; Jachmann 2002). For this study, The use of a combination of ground, water and aerial counts conceivably allowed a more robust estimate of hippo numbers.

Numbers and groups of hippos in ground counts were higher than aerial counts in all areas where both methods were employed (Mankoto 1989; Jachmann 2002) perhaps through the ability of observers to detect most of the groups as the observer can spend more time at each site to get "accurate" numbers. Given that there were more than two observers individually counted the same group, so counting errors are minimized (Caughley et al. 1976; Eltringham 1974; Amoussou et al. 2006, unpublished data). Aerial counts underestimate hippo numbers due to various biases that include the speed of the aircraft and the consequently reduced ability of observers to detect hippos either in groups or individuals (Caughley 1976; Mankoto 1989; Jachmann 2002). A combination of techniques gives better results than using only one technique for different areas (Languy 1994; Jachmann 2002; this study). The 2003 counts, for example, used an arbitrary correction factor of 1.25 for all sectors to estimate hippo population without correcting for different biases. This may have resulted in an underestimate of the hippo population in Virunga NP (Jachmann 2002; Mushenzi et al. 2003). Using the average correction factor from my study, the 2003 population would be around 1,700 compared to 1,300 hippos. The limitations of aerial surveys are well demonstrated by the 2005 count of hippos in Virunga NP where only 141 animals on the Ishasha River whereas water counts made by rangers from Uganda (along the same river) were 461 in 2006 and 497 in 2008 (Languy 2006; UWA 2008, unpublished data).

Differences in count techniques and, to a lesser extent, areas covered, make it difficult to compare hippo populations between time periods for Virunga NP (Mackie 1989, 1991; Jachmann 2002; Mushenzi et al. 2003; Languy 2006). This study is more comprehensive and integrative as the estimates from ground counts were "supplemented" by the aerial counts, and the results should be used as baseline for future counts in Virunga NP. Regular counts of hippos using both techniques should be conducted to monitor any changes in the populations, at least once every two years. Also, there is need to standardize counting techniques between Virunga NP and Queen Elizabeth NP to update and report hippo numbers.

The current estimated population of hippos in Virunga NP is around 1,200 individuals in 148 groups. Though using three different estimate calculations results show almost no differences between numbers: 1,197 hippos from the minimum estimates, 1,202 from the zone-based estimates and 1,209 hippos from the optimal estimates. Although this is a modest increase compared to the 2005 population, the population is still lower than the 2003 estimates and represents less than 5% of the 1970s population (Delvingt 1974; Languy 2006). The hippo population in Virunga NP has therefore declined since the 1970s (Figure 4), from around 20,000 to barely 1,000 animals between the early 1990s and 2000 (Delvingt 1974; Mushenzi et al. 2003; Languy 2006; Muir 2006). Part of this decline in hippo numbers can be explained by an anthrax outbreak in 1990-91 that killed an estimated 1,000 hippos (Mackie 1991; Verschuren 1993; Languy et al. 1994). However most of the decrease was due to poaching since the 1970s in different sectors according to political and regional specific contexts, but the last two decades, characterized by armed conflict, have seen dramatic decreases in hippo numbers (Fig. 4) (Verheyen 1954; Delvingt 1974; Mankoto 1989; Verschuren 1993; Languy et al. 1994; Kalpers & Mushenzi 2006; Crawford & Bernstein 2008; Plumptre et al. 2008). These dramatic decreases were accompanied by changes in hippo distribution (Fig. 5). Lake Edward and River Rutshuru supported almost two thirds of the population and had a high population compared to other sectors while the Ishasha River supported only 100 individuals (Verschuren 1986; Mankoto 1989; Mackie 1989, 1991). The Ishasha River is the only area that supported a stable hippo population in Virunga NP over the last 20-30 years and hippos have increased there since the 1950s (Fig. 5) (Verschuren 1986; Languy et al. 1994). This river borders Uganda's Queen Elizabeth National Park, where the hippos benefit from transfrontier conservation efforts that include regular patrols and security collaboration between the DRC and the Ugandan conservation and security agencies (Plumptre et al. 2007; Plumptre et al. 2008; UWA 2008, unpublished data). Thus, law enforcement activities and involvement of targeted stakeholders can help to stabilize fishing villages, as this was reported in a study in Kyavinyonge, and reduce the impact of both fishing and human on resources in Virunga NP (Madden 2004; Nele 2008; Olupot et al. 2009).

The presence of rangers is crucial for the persistence of hippos in Virunga NP. Most recent changes in distribution and abundance depend more on ranger post locations than on habitat availability and suitability (Verschuren 1986). For example, the "stable" trend of hippos along the Semuliki River (141 in 1994 and 146 in 2009) is probably the result of the presence of a ranger training camp and ranger post at Ishango which enables rangers to secure the extreme north shores of the lake (Kalpers & Mushenzi 2006; Languy 2006). Hippo groups were larger closer to ranger stations (Fig. 3) and they still persist around legal fishing villages, but have disappeared close to illegal human settlements where poaching and habitat degradation due to agriculture and new fishing village settlements are rife (Mankoto 1989; Verschuren 1986, 1993; Languy & Kujirakwinja 2006; Plumptre et al. 2008). The invasion of the western shores of Lake Edward by farmers had apparently a catastrophic impact on hippo populations, as has the formation of illegal fishing villages established by armed groups in bays such as Kagezi, Mutimatsanga, Birwa, Chondo, Kibahari (Verschuren 1993; Languy 2006; Languy & Kujirakwinja 2006).

Hippos are valuable and important for people living in fishing villages and others surrounding the park. This perception of local communities regardless of their profession was based on the economic returns people get from fishing and safety because armed groups pull down on poaching hippos (bushmeat for trade and consumption) thus they did not loot or threaten local communities for food or money. Although this would be perceived as unsustainable aspect for conservation, communities perceived it as positive (Fitzgibbon et al. 1995; Decker et al. 2002; Madden 2004). One of the challenges faced by conservationists and park managers is limiting the interactions between humans and wildlife as people encroach on wildlife habitat (Riley et al. 2002; Decker et al. 2002; Gusset et al. 2008). Large mammals may be especially problematic if they threaten human lives and their socioeconomic base but they are seen also as a source of income and cultural benefits (Fitzgibbon et al. 1995; Madden 2004; Gusset et al. 2008; Kideghesho et al. 2007; Olupot et al. 2009). Unfortunately, local communities perceive hippo damage in Virunga NP to be greater than the actual incidents on the ground (ICCN 2008, unpublished data). Although hippos are identified among dangerous animals in other areas (Post 2000), they were reported to have killed few people in Virunga NP. Crop raiding by hippos is also less reported. The impacts of humans in Virunga NP on hippos can be inferred from their current distribution in Virunga NP where the current densities are lower in areas where people have settled (e.g. the western coast) than those where settlement is low or absent (e.g. Ishasha River and the south eastern coast of Lake Edward) (ICCN, unpublished data 2008).

Fishing is the main activity in fishing villages, but the villages also promote poaching and exploitation of other wildlife resources (Nele 2008; Olupot et al. 2009). Thus, fishing-related activities may have facilitated the decline of the hippo population in Virunga NP, either by degrading wetland shores where hippos graze, by covering poaching and allowing people to settle in new fishing villages (Languy & Kujirakwinja 2006; Olupot et al. 2009). This study has shown that there is ongoing immigration to fishing villages, implying that increased pressure on local resources will take place (Zaoual 2007). Although poaching and the bushmeat trade occurred in different fishing villages, Kyavinyonge had the lowest reported frequency of bushmeat and the most stable human population (years spent in village) either due to the value attached to their lands/territories or as a result of previous law enforcement activities against illegal settlement and grazing (ICCN 2008, unpublished data; Nele 2008). Most bushmeat trade occurs in Nyakakoma and Vitshumbi, which are close to where wildlife is concentrated at present (ICCN 2009, unpublished data). The main reasons for poaching are bushmeat and trophies for local markets, although there have been some cases of cross-border poaching and bushmeat trade between the DRC and Uganda (WCS 2008, unpublished data; Olupot et al. 2009). Interestingly, the routes for the bushmeat trade identified by local communities coincide with the routes used to trade fish. This was also found in a study on bushmeat in Uganda where the traders and poachers used fishing trade and timber trade routes (Olupot et al. 2009). Local communities are aware of the ongoing poaching and the declining trend in hippos and different social groups were identified to be involved. Poaching was most reportedly conducted by militia groups living in the park as well as law enforcement agencies (legal army and park staff) (Crawford & Bernstein 2008; Olupot et al. 2009). Some cases of poaching by rangers and involvement of other park staff were reported, and were often linked to inadequate salaries. Although rangers were reported among poachers, they also were identified by respondents as key players if hippos are to be protected.

Due to intensive poaching, hippos have apparently adapted their behaviour: they gather around ranger posts in case of any attempt, or during or after any poaching incident, they move towards ranger stations for their safety (Verschuren 1993; Languy 2006).

Chapter 5. Conclusions and management implications

The status of hippos in Virunga NP is still critical and it is likely to continue to decline due to poaching and human settlement unless effective conservation strategies are planned and implemented. The population in 2009 is 1,200 individuals less than 5% of the population from 40 years ago, with no unequivocal evidence of a recovery. The apparent slight increase from 2005 to 2009 is probably the result of greater count effort in 2009. Future counts should use a combination of aerial and ground counts to minimize biases (Jachmann 2002). The persistence of hippos in Virunga NP relies on their proximity to ranger posts. The transboundary conservation effort with Uganda is particularly important (Plumptre et al. 2007, 2008). Thus, areas in the vicinity of ranger posts in adjacent protected areas may provide a refuge for hippos threatened elsewhere in the park and strategic patrolling can prevent hippos from continuous poaching.

Different factors determined the vulnerability of hippos in Virunga NP. These factors are mostly related to their behaviour and to the political and institutional contexts (Lewinson 2007; Olupot et al. 2009). These include:

a) easy access of poachers to hippo pools: most poaching occurs near human settlements or human activities (fishing and farming) or through paths created by hippos to reach their grazing sites (Delvingt 1974; Verschuren 1986; Mankoto 1989; Muir 2006);
b) the large quantity of meat obtained from a hippo;
c) a ready market for hippo meat in and around the park. Local communities prefer hippo meat to that from other species due to different beliefs and qualities such as taste, healing abilities and high priced meat or little efforts involved compared to farmed meats (Olupot et al. 2007);

d) the limited mobility of hippos compared to other large mammals: they spend most of their time in the same location and in groups. For example; Delvingt (1974) reported how hippos clump together when threatened, rather than fleeing, making them easy targets;

e) limited defensive capabilities: compared to other big mammals (e.g. buffalos and elephants); hippos have limited capabilities of threatening poachers or killing them. Traditional hunters are able to kill hippos with spears.

Anthropogenic factors (poaching and habitat change) have impacted the distribution of hippos in Virunga NP through the removal or displacement of hippos from some areas (Verschuren 1986; Mankoto 1989; Languy et al. 1994; Languy 2006). Because poaching has been largely responsible for the decline of hippos, measures to ensure their persistence and possible recovery must aim to reduce poaching and related human disturbances (Verheyen 1954; Delvingt 1974; Verschuren 1986, 1993; Languy et al. 1994).

The recovery of hippos in Virunga NP will require the implementation of effective management strategies. Conservation actions include:

a) maintaining cross border law enforcement activities (patrols and information exchange)

b) developing an intelligence network to enable a proactive strategy to mitigate the bushmeat trade in the area;

c) intensifying overnight patrols in areas with high concentrations of hippopotamuses to minimize human interference;

d) developing community programmes related to large mammal conservation in fishing villages and surrounding communities, focussing on education, awareness and support to local economic development activities to persuade local communities to support conservation and act as partners;

e) reinforcing the management structures and regulations of fishing villages because they harbour poachers and act as transit points for bushmeat.

A monitoring plan should be developed to assess the relative success of conservation actions and to allow adaptive management. Monitoring activities should include regular counting of hippopotamuses. If complete counts are not possible, regular surveys should focus on some key areas: the Ishasha and Semuliki Rivers, south and north-eastern sectors of Lake Edward to enable a quick detection of changes in abundance.

Although this study focussed on hippo population in Virunga NP, there is need to develop a nation-wide monitoring plan for hippos, to carry out hippo counts in different protected areas to establish baseline data and then detect trends and, to lobby decision makers to amend the current hunting policy to place the hippos on the Appendix 1 (fully protected species) of the DRC hunting law.

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Dedication

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Appendix 1. Social attitude questionnaire (translated from French)

Interviewer: .... Date..................... Location................. Sector.....................

Household size: .... Profession............................. Age........................ Time living in the area........years. Education............. Origin.........................

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1. Where are hippos located in Virunga? ....
   ....(give numbers if possible)
2. What have changed in those areas (Q.1)? habitat☐ birds☐ fish☐ mammals☐
3. What are the benefits of hippos in your area?
4. What is the value of hippos in the area?

   Cultural ☐ Economic ☐ Commercial ☐ Education ☐ Conservation ☐
5. How would you rate the hippo population has changed over the years in Virunga? 1=more abundant 2=abundant 3=less abundant 4= depleted

   1960 ☐ 1970 ☐ 1980 ☐ 1990 ☐ 2000 ☐ 2003 ☐ 2006 ☐ 2009 ☐
   Explain changes...
6. Have changes in hippo numbers and distribution affected your activities? Y ☐N ☐
7. How/Why not?...
8. Are there conflicts between hippos and people? Y ☐ N ☐
9. Have you (household) ever been affected by the presence of hippos Y ☐ N ☐
   When ... …………… Season .... where.............
10. How: crop raiding ☐ killing ☐ threatened ☐ Other specify…………………….
11. What did you do?
12. Estimates of losses (if products)
13. Are you aware of poaching in Virunga? Y ☐ N ☐

14. Why do you think people kill animals?

15. How would you rank poaching of the species below in the area: 1:less and 5 the most

Elephant	☐	☐	☐	☐	☐
Hippo	☐	☐	☐	☐	☐
Buffalo	☐	☐	☐	☐	☐
Uganda kob	☐	☐	☐	☐	☐
Topi	☐	☐	☐	☐	☐
Warthog	☐	☐	☐	☐	☐
Lion	☐	☐	☐	☐	☐
Leopard	☐	☐	☐	☐	☐

16. Who is involved in poaching (rank): 1: main actor 2: intermediate 3: less involved

Armed groups	☐	☐	☐
Soldiers	☐	☐	☐
Rangers	☐	☐	☐
People from your community	☐	☐	☐
People from outside the community	☐	☐	☐
People from Uganda	☐	☐	☐
Park Staff	☐	☐	☐

17. Is bushmeat sold in your community? .... How much ....FC/....... unit)? In other places and countries? Y ☐ N ☐ Where...............? How much......... FC/unit?

18. How is the market organized and who is involved?

Poaching site --- Village..

Poaching site --- Village --- Cities...

Poaching site --- Village --- Cities --- Towns..

19. How often do you buy bushmeat? ☐daily☐twice a week☐weekly☐monthly☐N/A

20. Is it important to protect hippos?

21. Why?

22. How can hippos be protected effectively?

Appendix 2. Hippo population estimates from censuses from 1959 to 2009 in Virunga NP

	1959	1974	1981	1989	1991	1994	2003	2005	2009
Lake Edward	3 630	9 638	7 769	7 019	6 326	4 011	892	683	408
River Rutshuru	7 340	10 262	7 337	9 121	6 369	4 417	164	58	99
River Rwindi	1 300	1 278	920	2 324	2 121	1 314	78	35	7
River Ishasha	100	335	462	467	407	400	141	61	500
Ponds	1 175	3 813	2 282	2 949	1 705	566			49
River Semuliki	8 811	3 852	2 325	945	1 038	141	34	50	146
Total	22 356	29 178	21 095	22 825	17 966	10 849	1 309	887	1 209