The Impact of civil war on the Kahuzi-Biega National Park: Results of surveys between 2000-2008

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EXECUTIVE SUMMARY:

Kahuzi-Biega National Park was established in 1970 with the creation of an area of montane and alpine habitat to the west of Lake Kivu of about 600 km^2 (High altitude sector). In 1975 a much larger area in the lower altitudes to the west of this sector (Lowland sector) was added to create a park totaling about 6,000 km^2. Surveys were made of the high altitude sector to primarily census the population of Grauer's gorillas in 1978, 1990 and in 1996 and in the lowland sector in 1994-5. These surveys showed that the Kahuzi-Biega National Park probably held about 86% of the world population of Grauer's gorilla.

A civil war in Democratic Republic of Congo (DRC) erupted in 1996 which resulted in the overthrow of President Mobutu and the installation of President Laurent Kabila. In 1998 civil war broke out again with an attempt by Rwanda to oust Kabila which failed. Insecurity has however remained high in eastern DRC as a result of these two wars. In addition the presence of many of the *Interahamwe* who carried out the genocide in Rwanda in 1994 in the area in and around Kahuzi-Biega National Park has created over 10 years of insecurity.

This report summarises the results of a series of surveys that have taken place since 2000 in the Kahuzi-Biega National Park. Due to the insecurity it has been difficult to access the park and therefore surveys have had to make quick visits whenever it has been safe enough to do so. Teams have been attacked and robbed at times despite the efforts to ensure safety, highlighting the difficult nature of these surveys and the courage of the team members to obtain the data presented here.

The results show……

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Introduction

The Kahuzi-Biega National Park is one of five World Heritage sites in the Democratic Republic of Congo (DRC), designated in 1980 as such primarily because of its population of Grauer's gorillas (*Gorilla beringei graueri*). Research showed that this park contained about 85% of the world population of Grauer's gorillas in the mid 1990s (Hall et al. 1998a). Further surveys since then have discovered new populations of this subspecies of gorilla (P. Mehlman and J.Hart pers. comm.) between Maiko National Park and Kahuzi-Biega and also in the Itombwe Massif. However, despite these finds Kahuzi-Biega still is an important area for the conservation of this subspecies of gorilla.

Kahuzi-Biega National Park was established in 1970 with the creation of an area of montane and alpine habitat to the west of Lake Kivu of about 600 km^2 (High altitude sector). In 1975 a much larger area in the lower altitudes to the west of this sector (Lowland sector) was added to create a park totaling about 6,000 km^2. In the mid 1990s the Grauer's gorilla population was estimated at around 7,760 (4,180-10,830) gorillas for the park (Hall et al. 1998a). In addition about 1,900 elephants (Hall et al. 1997) and 2600 chimpanzees (Hall et al. 1998a) were estimated for the park at that time.

The park is also known for its exceptional biodiversity, ranking as one of the key sites within the Albertine Rift region, which itself is one of the most biodiverse ecoregions on the African continent (Plumptre et al. 2003, 2007). It contains more threatened mammal species than any other site within the Albertine rift and ranks as the second most important site in the rift for conservation of endemic species, third highest for conservation of threatened species and second for total species richness (Plumptre et al. 2003). Consequently this is one of the most important parks in the World for biodiversity conservation.

> In 1994 the genocide in Rwanda led to over 450,000 refugees fleeing Rwanda and settling around the Kahuzi Biega National Park (Yamagiwa, 2003). The presence of the ex military from Rwanda and the *Interahamwe* near the Rwandan border led to the invasion of Zaire (as DRC was known at that time) in 1996 which resulted in the overthrow of President Mobutu and the installation of President Laurent Kabila. In 1998 civil war broke out again with an attempt to oust Kabila which failed. Insecurity has however remained high in eastern DRC as a result of these two wars. Various militia groups have been created (usually lumped together as *Mai Mai*) that control small parts of territory in and around the park, which has led to very difficult working conditions for park staff. In addition the presence of many of the *Interahamwe* who carried out the genocide in Rwanda in 1994 in the area in and around Kahuzi-Biega National Park (calling themselves the FDLR – Forces Democratiques pour la Liberation de Rwanda) has created over 10 years of insecurity and led to major impacts on the park. As a result of these impacts Kahuzi-Biega is currently ascribed as a "World Heritage Site in Danger".

This report summarises the results of a series of surveys that have taken place since 2000 in the Kahuzi-Biega National Park. Due to the insecurity it has been difficult to access the park and therefore surveys have had to make timely visits whenever it has been safe enough to do so. Teams have been attacked and robbed at times despite the efforts to ensure safety, highlighting the difficult nature of these surveys and the courage of the team members to obtain the data presented here. The surveys have primarily assessed the impacts of the civil wars and presence of armed groups on the large mammal populations and human impacts and activities on the forest. However a smaller survey of the biodiversity of the highland sector was also undertaken and is also reported on here.

Kahuzi-Biega National Park geographic location

The park is located west of Bukavu town above Lake Kivu in Eastern Democratic Republic of Congo (Figure 1). The highland sector in the east ranges from 3,308 metres on the summit of Mt Kahuzi down to 600 metres in the west of the park. The high altitude sector (1,800-3,308 m) is connected to the lowland sector by a neck of land which has been severely degraded during the civil war between Ihembe and Kaniola. Most of the roads in the park have not been maintained and are fairly overgrown or are more paths than roads today. This was a process that started even before the civil war.

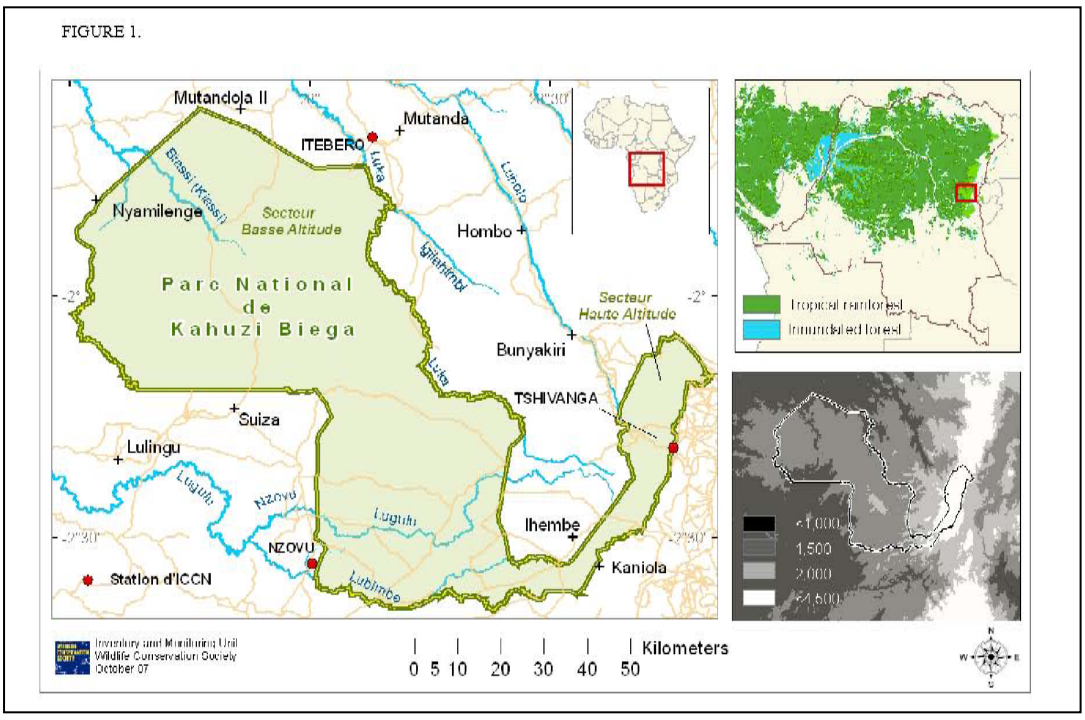

Figure 1. Map of Kahuzi-Biega National Park showing the locations of major settlements and minor roads. The location within the Democratic Republic of Congo (inset top right) and the range of elevations (inset bottom right) are also shown.

Previous surveys

The first surveys of this area were made by Emlen and Shaller (1960) who carried out a survey of Grauer's and mountain gorillas (at that time Grauer's gorillas were considered to be mountain gorillas). They identified the lowland area south west of Itebero as having the largest concentration of gorillas at that time.

Following the creation of Kahuzi Biega National park more detailed surveys were made of the high altitude sector using total count methods to estimate the total population of Grauer's gorillas. Gorillas were censused here in 1978, 1990 and in 1996 (Murnyak, 1981; Yamagiwa et al. 1993; Hall et al. 1998a; Inogwabini et al., 2000). Results showed that the population increased from 222 to 258 but dropped slightly in 1996 to 245 individuals (figure 2). The number of groups increased from 14 to 25 and remained at 25 in the 1996 census. Surveys were also made of chimpanzees and estimated about 0.13 chimpanzees per square kilometer (Yamagiwa et al. 1992). In 1996 a survey of the gorillas also recorded elephant sign and estimated there were about 771 elephants in the high altitude sector (Inogwabini et al. 2000).

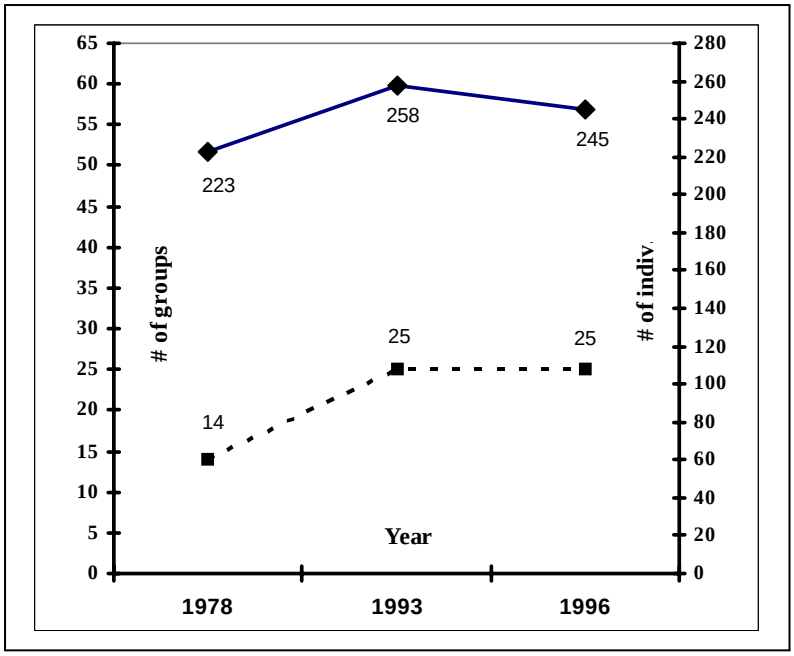

Figure 2. Numbers of individuals and groups of gorillas in the highland sector of Kahuzi-Biega.

No surveys of the lowland sector were made between 1959 and 1994 (Hall et al. 1998b). The surveys of the lowland sector in the early and mid 1990s showed that most gorillas occurred in the central-west area of the lowland sector of the park (figure 3). Few occurred in the lowland sector immediately to the west of the high altitude sector.

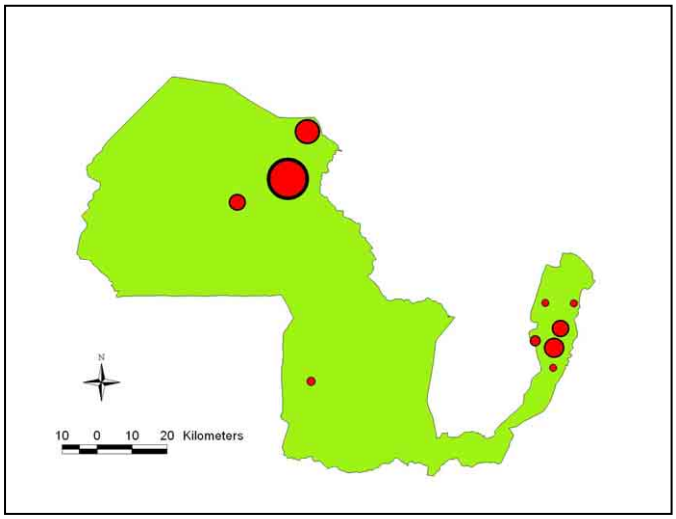

Figure 3. Relative abundance of gorillas in the areas surveyed in the early and mid 1990s.

The surveys of the lowland sector also estimated elephant numbers to be around 3,720 (2300-5000) (Hall et al. 1997) and chimpanzee numbers to be around 2,600 (1,620-4,500) (Hall et al. 1998a).

Surveys of taxa other than large mammals have also been made for birds (Wilson and Catsis, 1990), Reptiles and amphibians (Hinkel and Fischer, 1996) and plants (Fischer, 1996). These data have been summarized to show that Kahuzi-Biega has 136 mammal species, 335 birds, 69 reptiles, 44 amphibian and 1,171 plant species recorded from the park (Plumptre et al. 2003; 2007). More species probably occur here but have yet to be found and recorded.

Survey Methods

The surveys of Kahuzi-Biega since 2000 have used several methods depending on the goals of the surveys and the security situation at the time of the survey. These are summarized in different sections here so that the differences are clear.

High Altitude Sector surveys of Large Mammals

Sweep census surveys were made in the high altitude sector to estimate the gorilla population in 2000 and in 2004.

2000 survey:

Between June and August 2000 these surveys used reconnaissance (recce) walks to access the park and enter every 500 x 500 m block of forest where security was ok. When fresh gorilla trail was encountered (1-5 days old) it was followed until the previous nesting site where nests were counted and faeces in the nest measured to allocate them to age classes, a method used for mountain gorillas (McNeilage et al. 2001). Signs of other mammals were recorded along the recce walks but not once the field teams started to follow gorilla trail. A Hipchain and topofil thread was used to measure the distance walked on the recce walks. Not all of the highland sector was safe to survey but the main areas where gorillas and elephants had been recorded in 1996 were visited.

2004 survey:

The 2004 survey was not able to cover as much ground as the 2000 survey although initially it had hoped to do so. During this survey data on plants and birds were also collected (see below). A similar method was used as in 2000 except that transects were mainly used with some recce walks. Transects were oriented in a NW-SE direction within a 2km grid. Each transect was 1km long and then recce walks were made between the end of one transect and the next transect. Where fresh gorilla trail was encountered the transects or recces were halted and the trail followed to count the gorilla nests as in the 2000 survey.

Figure 4 shows the coverage of the recces or transects for the two surveys in the highland sector.

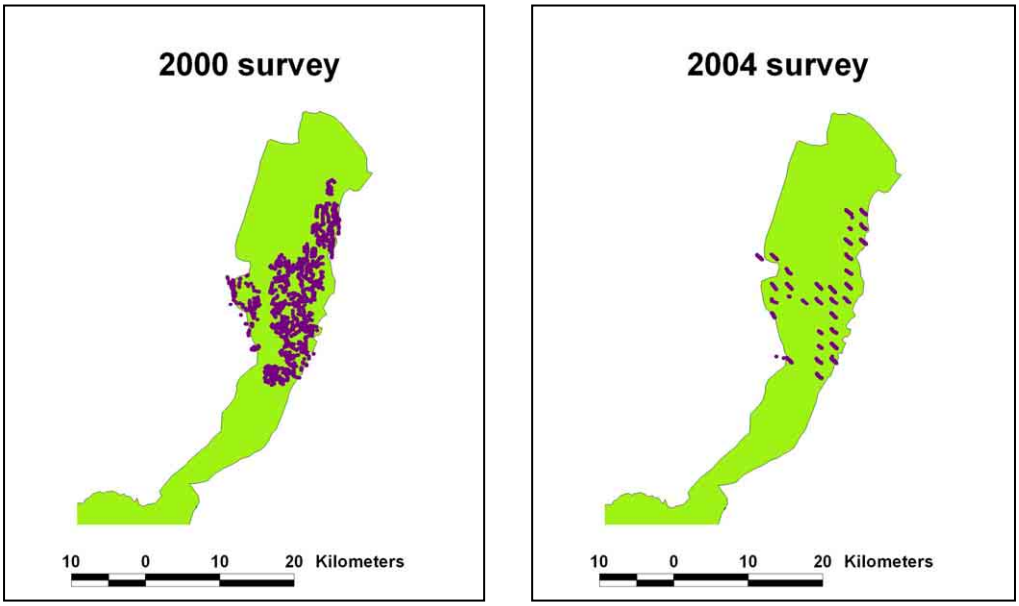

Figure 4. Maps showing coverage of the highland sector in 2000 and 2004 surveys.

Lowland Sector surveys of Large Mammals

An interim report summarized the results of the surveys between 2004-2007 (Hart et al. 2007) for 5x5 km blocks in the lowland sector of the park. We revised the methods of analysis in this report because of the variability in encounter rates in a recce or transect across 5km for many sightings and instead selected sites for which at least 15km was walked to reduce the effects of such variance. The methods used to collect the data were the same however and are summarized here.

The lowland sector has been even harder to access because of the presence of various armed groups. Teams have been able to enter in the south more readily than the north, particularly around the ICCN patrol post in Nzovu. Surveys were made between 2006-2008 in the lowland sector using recce walks. These involved long recces and it was not possible to use a hipchain and thread as used in the high altitude surveys. Instead GPS points were taken at all sightings and every 30 minutes if no sighting was made and the distance of each recce walk calculated from these in ARCVIEW using a points to line extension. However this method measures horizontal distance but does not incorporate the variation because of topography. In order to correct for topography we calculated the horizontal distance from ARCVIEW for transects and recce walks which had used a hipchain and thread where we knew the true distance walked. We plotted these two measures and fitted a regression line (forced through the origin) to an equation that could be used to correct the ARCVIEW calculated distances (figure 5). These plots showed that the correlation was very good for the high altitude sector where we had many lines (R^2=0.906) but also reasonable for the lowland sector where we only seven lines for comparison (R^2=0.607). Hipchain distances are 7.2% longer in the high altitude sector and 1.9% longer in the lowland sector. Arcview measured distances were therefore corrected by these values for each recce walk and encounter rates calculated using these revised distances. These values are lower than the 12.4% that was used in surveys in Bwindi Impenetrable National Park (McNeilage et al. 2001).

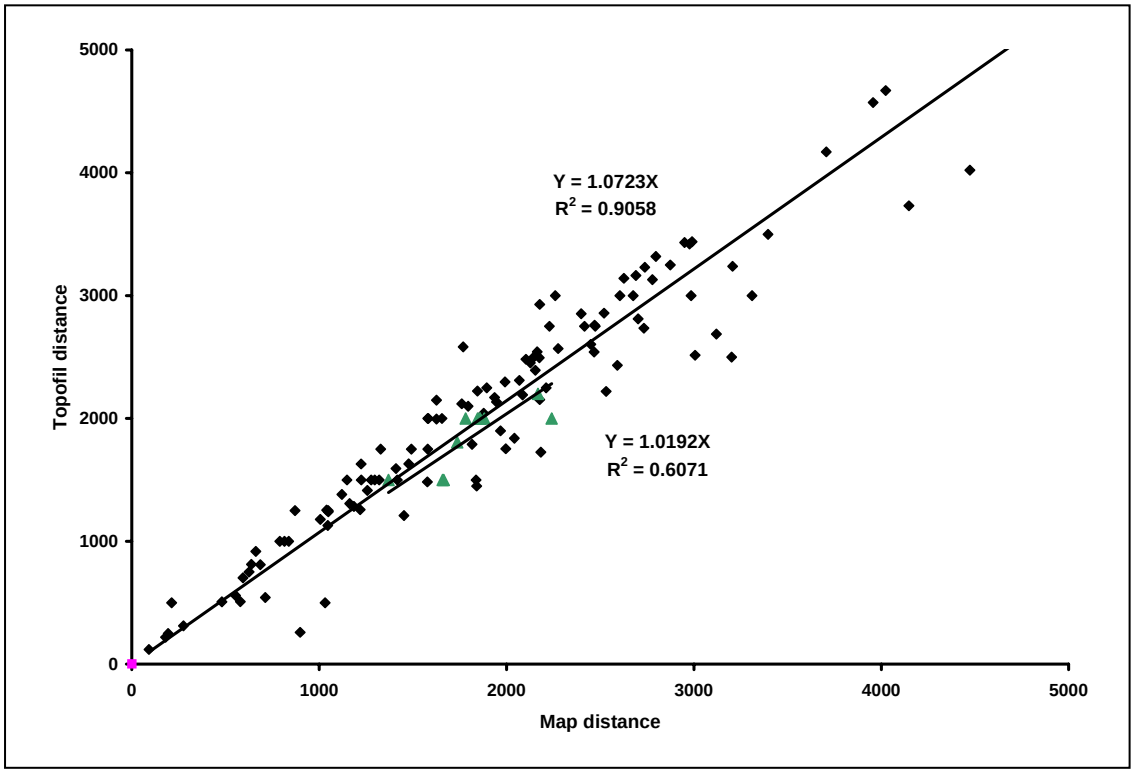

Figure 5. Plots of arcview measured distance (map distance) against hipchain and topofil thread measured distances for high altitude sector (diamonds) and lowland sector (green triangles).

Most recces in the lowland sector tried to follow compass directions and tried to avoid using human trails too much. However one recce walk from the south to the north through the centre of the park did use a human trail and as a result the encounter rates from this walk may be lower than what might be found further away from the trail in this part of the park.

Figure 6 shows the survey coverage of the whole park (both high altitude and lowland) from all the surveys reported upon here.

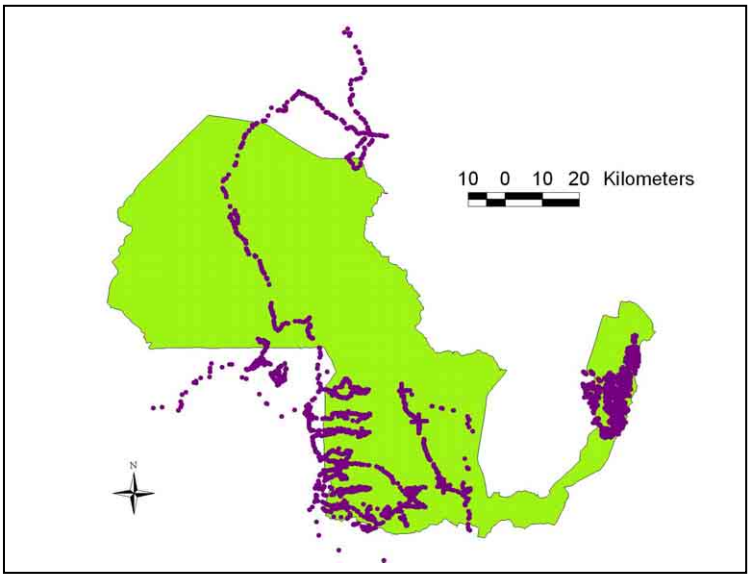

Figure 6. GPS points of all surveys made between 2000 and 2008 by WCS survey teams.

Encounter rates of all large mammals (feeding sign, dung, calls and sightings) and any sign of human use were calculated for different sites of the park in both the high altitude and lowland sectors. The sites were selected to give a reasonable geographical spread to allow for comparisons between different parts of the park (figure 7) but also to ensure that a reasonable distance of recce was walked (at least 15 km) to dampen the variance that occurs in sightings over short distances. Most distances walked were considerably larger than this (Table 1) with an average distance per site of 50.38 km. The total distance walked was 1,056.88 kilometres for all recces and transects combined. Only the 2000 survey data were used for the highland sector because the total distance walked in 2004 was much lower (12.85 km vs 307,346 km) because it focused on transects instead of recce walks.

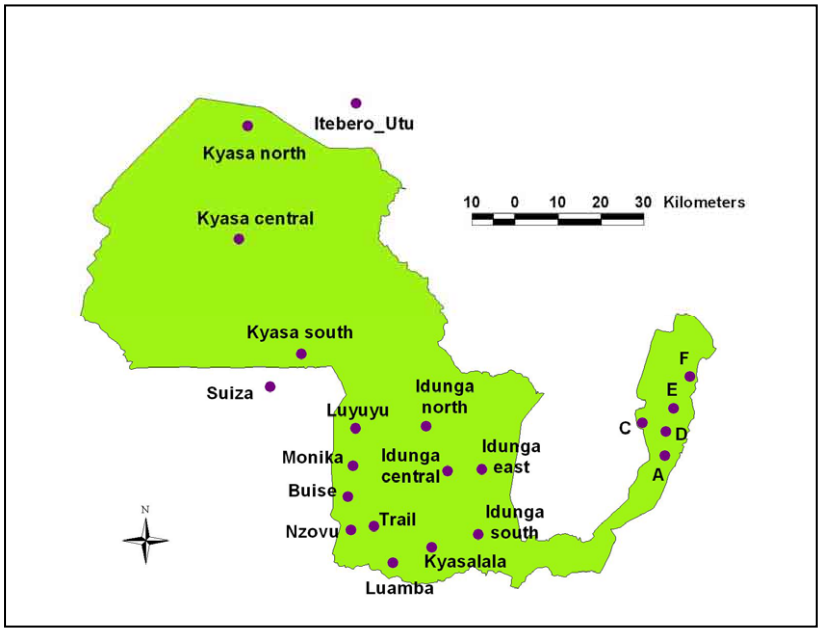

Figure 7. Survey sites for which encounter rates were calculated.

Table 1. Total distance walked and mean GPS coordinate for the 21 survey sites.

Site	Distance walked (m)	Longditude	Latitude
High altitude sector (2000) survey			
A	70,208	28.71046	-2.37563
C	72,881	28.66292	-2.30675
D	42,094	28.71277	-2.32480
E	78,342	28.72866	-2.27639
F	43,821	28.76294	-2.21090
Lowland Sector			
Buise	31,276	28.04719	-2.46104
Idunga central	22,657	28.25589	-2.40755
Idunga east	45,456	28.32719	-2.40444
Idunga north	13,692	28.21150	-2.31461
Idunga south	19,677	28.31978	-2.53930
Kyasa central	41,417	27.82028	-1.92169
Kyasalala	46,097	28.22296	-2.56661
Kyasa north	31,068	27.83772	-1.68522
Kyasa south	49,237	27.95071	-2.16383
Luamba	36,474	28.14208	-2.59883
Luyuyu	74,496	28.06364	-2.31845
Monika	38,469	28.05831	-2.39660
Nzovu	82,947	28.05357	-2.52964
Suiza	56,007	27.88474	-2.23234
Trail	59,328	28.10236	-2.52302
Itebero_Utu	101,236	28.06431	-1.63851

Biodiversity surveys

Bird surveys

Birds were surveyed in the high altitude sector in 2004. A combination of ad lib. observations, mistnetting and point counts were used to obtain a species list and relative abundances of species in six sites. Bird survey teams followed the transects used by the large mammal and human impact survey teams and made a point count every 250 metres along the transects. For each site a total list of bird species was also generated from the three methods to give an estimate of the number of bird species per site. Counts were made in April and November 2004.

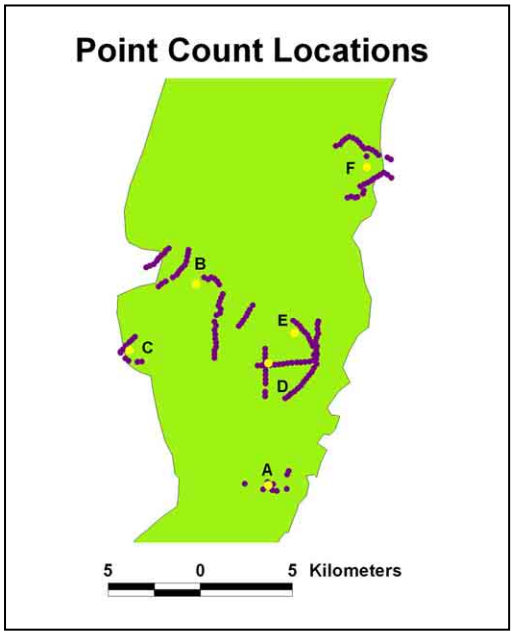

Figure 8. Point count locations for both the April and November surveys showing also the central points for each survey site.

Species accumulation curves were calculated using rarefaction for each site using the point count data. Similarity indices were also computed using the Bray-Curtis method. The Shannon-Wiener and Alpha diversity indices were also calculated.

Plant surveys

Plants were studied along the same transects and recce's used for the large mammal and bird surveys. Collections were made of any species encountered that were thought to be new to generate total species lists for each site within the high altitude sector in 2004. In addition quantitative data were collected from plots at the same locations as the point counts for the birds. Concentric plots of varying radius were used to sample, trees, shrubs, lianas and herbs as follows:

1. Trees and shrubs: 20 m radius circular plot centered at each 250 metre interval mark on the recce/transect line walked by the mammal team. Number of trees in DBH interval classes (2.5-10cm, 10-30 cm, 30-50 cm, >50 cm) were recorded.
2. Lianas >1cm diameter: 10 m radius plot nested within the larger plot above centered at the same point. Numbers of stems were recorded per plot.
3. Herbs/ferns: 2 m radius plot centered at same site. Presence/absence of species were recorded per plot.

Heights and crown cover were estimated for each size class within the plot. The GPS position, altitude and vegetation type were taken at each plot provided satellites could be found by the GPS unit such that maps of the locations of the plots could be produced.

Voucher specimens were collected for most species encountered in each forest (occasionally some trees which were common and easily identified were omitted). Specimens were collected in triplicate to allow for further confirmation at Makerere University herbarium. Those species that have not been identified at the herbarium have been sent to the Royal Botanic Gardens at Kew and Missouri Botanical Gardens for identification. Those that have not had a name given yet have been given voucher numbers and recorded as separate species where we are certain they differ from other unidentified plants collected.

Analyses

The following analyses were made of the data for this report at the scale of each site:

1. Total species list: The plant and bird species lists (species richness) were compiled from the plot/point count data and daily observations.
2. Species diversity: The Shannon-Wiener index and Alpha Index were calculated from the plot/point count data.
3. Rarefaction curves: Rarefaction curves were calculated from the plot/point count data, calculating the species accumulation rate per number of plants present per plot sampled or number of birds observed.
4. Similarity indices: The Bray Curtis linked cluster analysis was used to calculate similarity between sites. Similarity indices for the forests were presented as dendrograms.
5. Mapping richness and endemism: Plant/bird species richness and the number of endemic species in the Albertine Rift per sector was mapped in Arcview 3.2a using the total lists obtained per sector. Circles of varying size were used to depict the relative abundance to allow comparison between sectors and between forests. Endemic species were identified in a previous assessment for the Albertine Rift (Plumptre *et al.* 2003).

Results

Large mammal distributions

The locations of signs (dung, feeding, nests, trails) of apes or elephants was plotted on the map of the park and indicates that elephants have disappeared from most of the park. The only signs observed for elephants were in the high altitude sector of the park (figure 9).

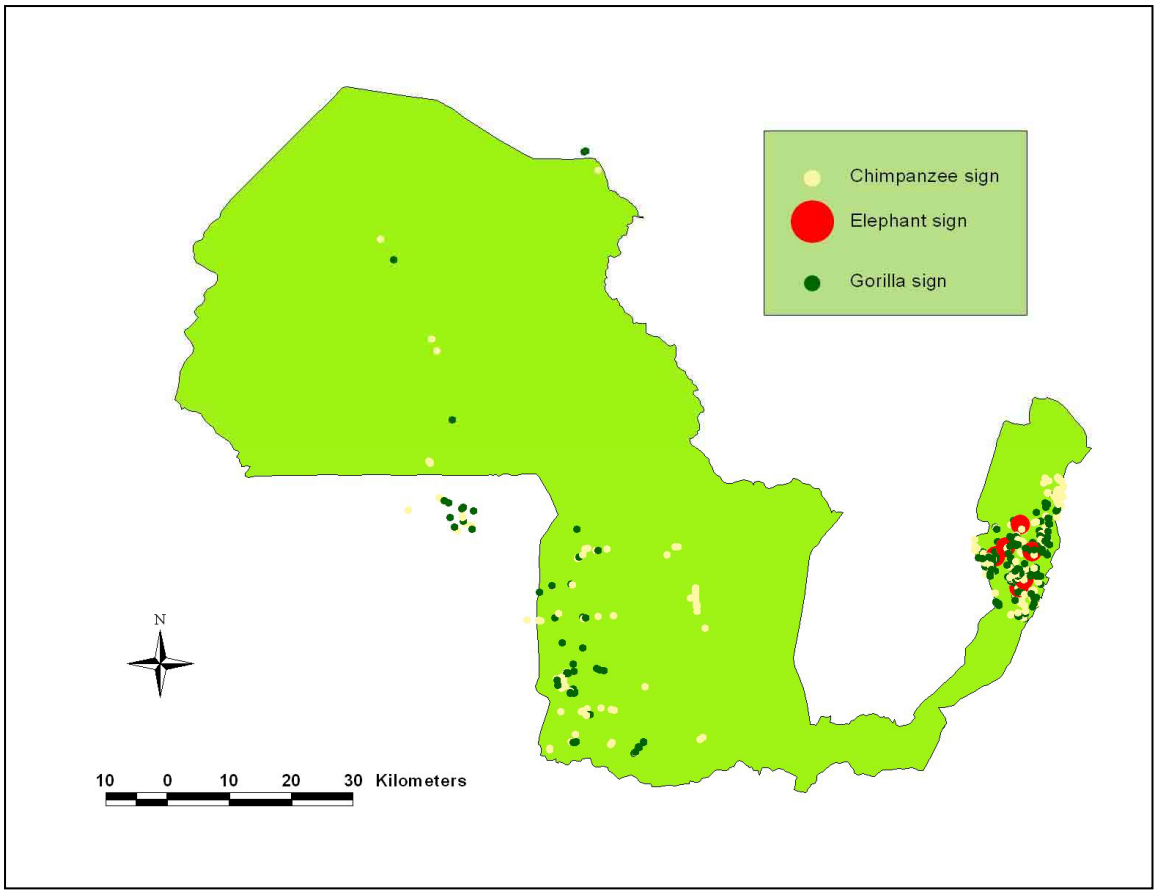

Figure 9. Locations of all signs of gorillas, chimpanzees and elephants. These signs include dung, nests, tracks and feeding sign. The highest density of sign are in the high altitude sector.

Encounter rates of different species varied widely between sites (figure 10). In general there tended to be higher encounter rates in the high altitude sector of the park but for some species such as gorilla and owl-faced monkey there were reasonably high encounter rates in the Ndunga-Luamba-Buise region of the park in the south. Encounter rates in the central part of the lowland sector (Kyasa) were consistently low but it is here that the teams followed a relatively major human trail because of insecurity and therefore these results for this part of the park should be treated with caution. More surveys are needed in this region together with the area in the furthest west of the park.

Ungulates were not always distinguished to species and the signs are all combined here to obtain a picture of relative abundance of ungulates. A more detailed survey would be needed to assess particular species and should probably focus on dung sightings.

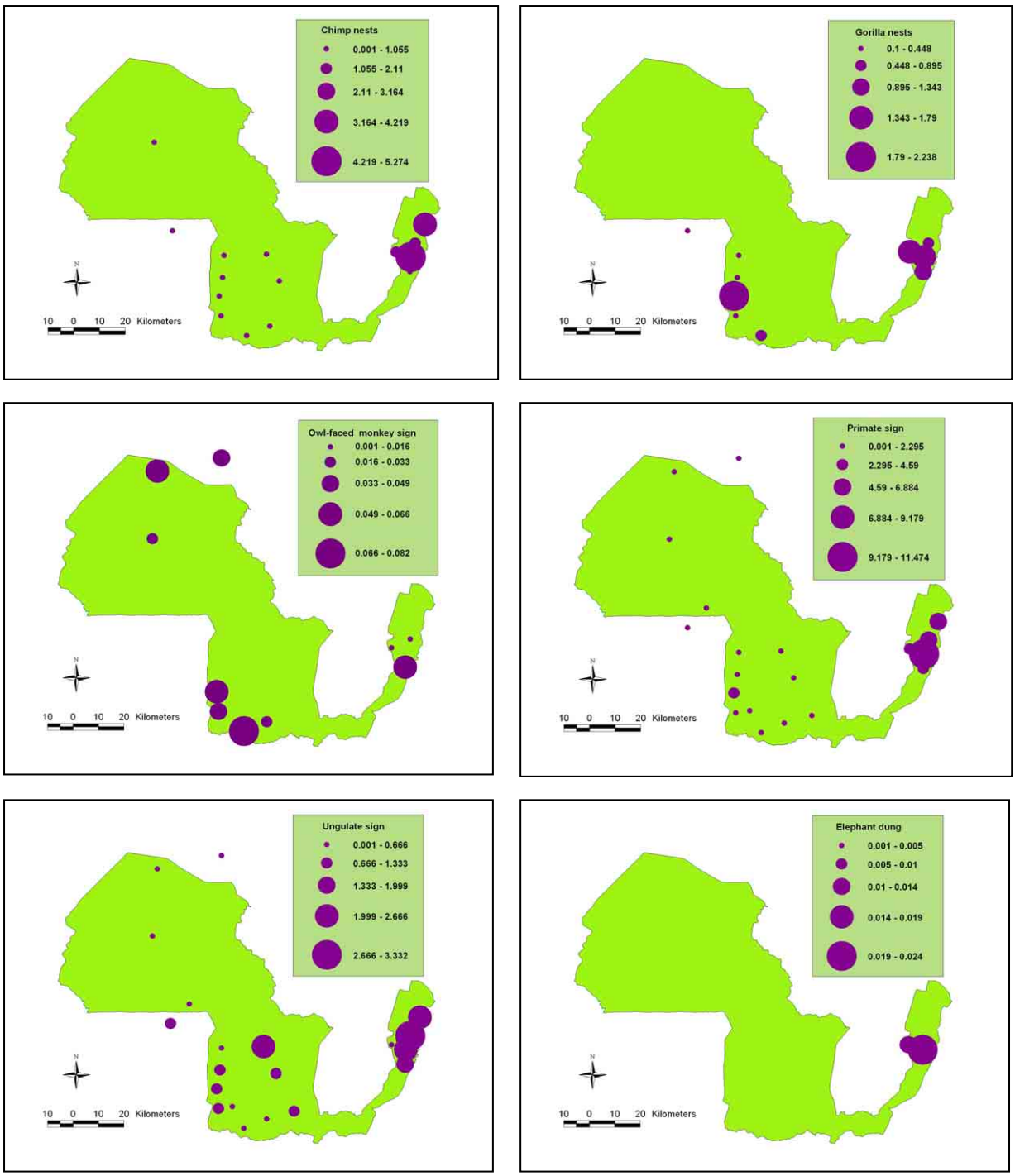

Figure 10. Encounter rates per km walked for various species and groups of species for each site surveyed. Clockwise from top left: Chimp nests, gorilla nests, all primate sign, elephant dung, ungulate sign and owl-faced monkey sign.

The encounter rates per km walked are summarized for each site labeled in figure 7 for primates (Table 2) and ungulates (Table 3).

Table 2. Encounter rates of primates (no per km walked) for each site surveyed in Kahuzi-Biega. Signs of primates included sightings, calls and feeding sign where it could be attributed to a particular species.

Site	No. Gorilla nests	No. Chimp nests	Gorilla nest groups	Chimp nest groups	Owl-faced sign	Redtail monkey sightings	Blue monkey sightings	All Primate sign
High altitude sector (2000) survey								
A	0.969	0.869	0.214	0.342	0.057	0.000	0.228	3.675
C	1.358	1.880	0.261	0.563	0.014	0.000	0.082	4.432
D	1.402	5.274	0.309	1.615	0.000	0.000	0.285	11.474
E	0.740	1.519	0.243	0.562	0.013	0.000	1.213	6.574
F	0.000	3.491	0.000	0.776	0.000	0.000	1.278	6.778
Average	**0.894**	**2.607**	**0.205**	**0.771**	**0.017**	**0.000**	**0.617**	**6.586**
Lowland Sector								
Buise	2.238	0.959	0.288	0.192	0.064	0.032	0.000	3.997
Idunga central	0.000	0.530	0.000	0.485	0.000	1.015	0.000	2.030
Idunga east	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Idunga north	0.000	0.365	0.000	0.365	0.000	0.803	0.000	1.315
Idunga south	0.000	0.000	0.000	0.000	0.000	0.051	0.000	0.051
Kyasa central	0.000	0.048	0.000	0.024	0.024	0.193	0.000	1.183
Kyasalala	0.000	0.065	0.000	0.043	0.022	0.456	0.000	0.868
Kyasa north	0.000	0.000	0.000	0.000	0.064	1.352	0.000	1.770
Kyasa south	0.000	0.000	0.000	0.000	0.000	0.203	0.000	0.325
Luamba	0.740	0.165	0.192	0.055	0.082	0.027	0.000	1.261
Luyuyu	0.107	0.242	0.027	0.107	0.000	0.000	0.000	0.725
Monika	0.208	1.040	0.026	0.078	0.000	0.000	0.000	1.612
Nzovu	0.241	0.265	0.036	0.145	0.048	0.072	0.000	1.218
Suiza	0.321	0.357	0.089	0.196	0.000	0.000	0.000	1.893
Trail	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.152
Itebero_Utu	0.000	0.000	0.000	0.000	0.049	0.168	0.000	0.267
Average	**0.241**	**0.252**	**0.041**	**0.106**	**0.022**	**0.273**	**0.000**	**1.167**

Table 3. Encounter rates of ungulates (no per km walked) for each site surveyed in Kahuzi-Biega. Signs of ungulates included sightings, dung and feeding sign where it could be attributed to a particular species.

Site	Blue duiker dung	Bongo tracks	Elephant dung	Buffalo track	Bushpig track	Duiker tracks	Ungulate sign
High altitude sector (2000) survey							
A	0.000	0.000	0.000	0.000	0.427	1.026	1.951
C	0.000	0.000	0.014	0.000	0.069	0.274	0.412
D	0.000	0.000	0.024	0.000	0.428	1.378	2.613
E	0.000	0.000	0.000	0.000	0.868	1.838	3.332
F	0.000	0.000	0.000	0.000	0.434	1.164	2.031
Average	**0.000**	**0.000**	**0.007**	**0.000**	**0.445**	**1.136**	**2.068**
Lowland Sector							
Buise	0.000	0.032	0.000	0.000	0.096	0.384	0.767
Idunga central	0.044	0.000	0.000	0.000	0.000	0.132	1.103
Idunga east	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Idunga north	0.803	0.000	0.000	0.000	0.000	0.000	2.410
Idunga south	0.000	0.000	0.000	0.000	0.356	0.152	1.016
Kyasa central	0.072	0.000	0.000	0.072	0.000	0.000	0.531
Kyasalala	0.000	0.000	0.000	0.000	0.347	0.000	0.456
Kyasa north	0.000	0.000	0.000	0.000	0.000	0.000	0.064
Kyasa south	0.000	0.000	0.000	0.000	0.000	0.000	0.020
Luamba	0.000	0.000	0.000	0.000	0.110	0.000	0.356
Luyuyu	0.000	0.000	0.000	0.000	0.013	0.403	0.470
Monika	0.000	0.026	0.000	0.000	0.208	0.806	1.118
Nzovu	0.012	0.000	0.000	0.036	0.205	0.012	0.808
Suiza	0.018	0.071	0.000	0.000	0.089	0.464	0.786
Trail	0.000	0.000	0.000	0.000	0.067	0.034	0.118
Itebero_Utu	0.000	0.000	0.000	0.000	0.000	0.010	0.020
Average	**0.059**	**0.008**	**0.000**	**0.007**	**0.093**	**0.150**	**0.628**

The number of gorillas counted in nest counts in the high altitude sector totaled 130 in 13 groups, 4 lone males in 2000, and 168 animals in 15 groups, 2 lone males in 2004, down from 245 in 1996 (figure 11). Group size in 2000 ranged between 2 to 38 individuals with a mean group size of 9.7. At this time the proportion of immature individuals was 42% of the population (table 4). In 2004 group size ranged between 3 and 17 with a mean group size of 9.6. The data on group composition for 2004 were not available except for infants (26 counted in 163 – estimated that 5 additional infants were missed – table 5).

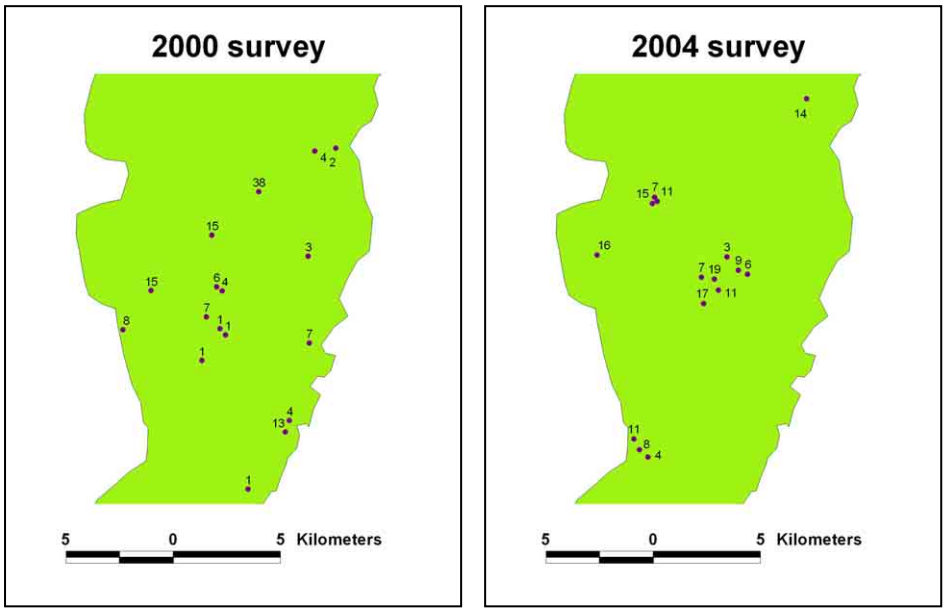

Figure 11. Gorilla groups and their sizes from the 2000 and 2004 censuses of the high altitude sector.

Table 4. Gorilla group composition in 2000

Group	Sector	Silverback	Female	Other Adult	Sub adult	Juv.	Infant	unknown	Total
A1	**A**	1							**1**
A2	**A**	1	2	1	4	3	2		**13**
B1	**A**	1	1	1			1		**4**
C1	**C**	1		4	4	2		4	**15**
C2	**C**	1		2	1	1		3	**8**
C3	**C**	1							**1**
D1	**D**	2		3	2				**7**
D2	**D**	1	2	2	1		1		**7**
D3	**D**	1							**1**
D4	**D**	1							**1**
D5	**D**	1		2	2	1			**6**
D6	**D**	1				1		2	**4**
E1	**E**	1	2	1		3	2	6	**15**
E2	**E**	1	1			1			**3**
E3	**E**	2	7	7	4	10	7	1	**38**
E4	**E**	2	2						**4**
E5	**E**	1	1						**2**
	F								**0**
Total									**130**

Table 5. Gorilla groups found in 2004

Sector	Group name	Group No	Adults	Infants	Total
Tshivanga	Mpungwe	G1	7	0	7
Tshivanga	Mufanzala	G9	12	5	17
Mugaba	wild group	G2	10	3	13
Mugaba	wild	G10	5	2	7
Mugaba	wild	G11	13	2	15
Tshivanga	Langa	G3	6	1	7
Tshivanga	Birindwa	G12	6	3	9
Tshivanga	wild group	G4	3	0	3
Tshivanga	Mugaruka	G5	10	1	11
Tshivanga	Chimanuka	G13	17	2	19
Mugaba	wild	SM1	1	0	1
Mugaba	wild	G6	13	3	16
Madhiriri	wild	SM2	1	0	1
Madhiriri	wild	G7	11	0	11
Madhiriri	wild	G8	4	0	4
Madhiriri	wild	G14	7	1	8
Tshibati	Ganywamulume	G15	11	3	14
Total			**137**	**26**	**163**

Human sign

Teams recorded all sightings of human activity in the park when on recce and transect walks. The encounter rates of these signs show that in the lowland sector in particular human activity is prevalent (figure 12). Poaching sign is relatively abundant in the high altitude sector but the presence of agriculture, settlements and mining was absent unlike the lowland sector.

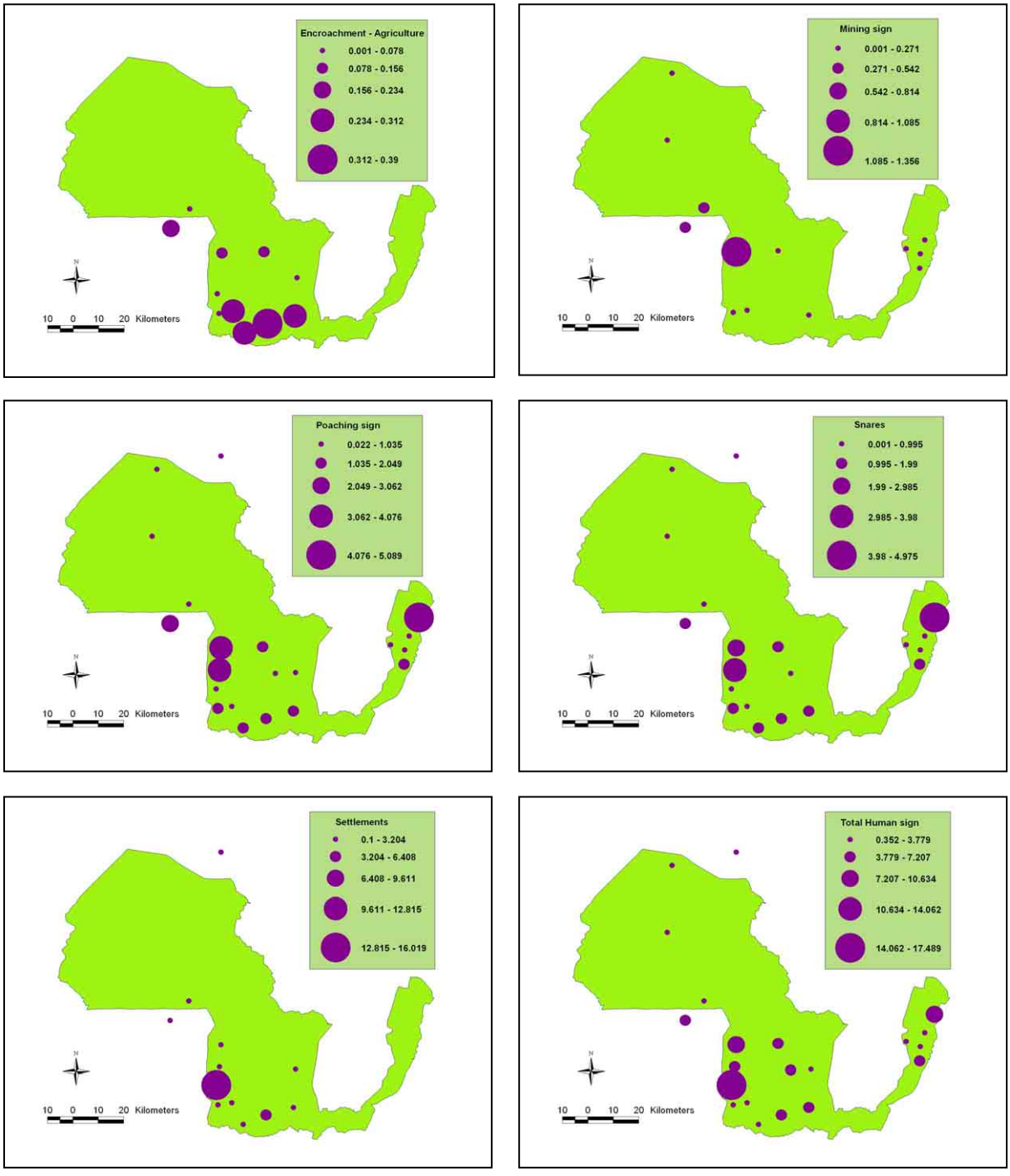

Figure 12. Encounter rates per km walked for various signs of human impact. Encounter rates of snares is a subset of the poaching sign and total human sign sums all observations of human activity. Clockwise from top left: Encroachment, mining, snares, total human sign, settlements, and poaching sign.

The actual encounter rates per km walked are summarized in Table 6.

Table 6. Encounter rates of signs of human impact (no. per km walked).

Site	Encroachment	Mining	Poaching	Snares	Settlements	Camps	Total human sign
High altitude sector (2000) survey							
A	0.000	0.057	1.994	1.909	0.000	0.940	5.526
C	0.000	0.014	0.988	0.960	0.000	0.014	1.962
D	0.000	0.048	0.760	0.713	0.000	0.523	2.542
E	0.000	0.013	0.919	0.906	0.000	0.089	1.749
F	0.000	0.000	5.089	4.975	0.000	0.160	8.672
Average	**0.000**	**0.026**	**1.950**	**1.893**	**0.000**	**0.345**	**4.090**
Lowland Sector							
Buise	0.032	0.000	0.895	0.512	16.019	0.384	17.489
Idunga central	0.000	0.000	0.574	0.574	0.000	0.000	3.928
Idunga east	0.022	0.000	0.022	0.000	0.242	0.000	0.352
Idunga north	0.146	0.073	1.972	1.972	0.000	0.000	5.405
Idunga south	0.254	0.051	1.067	1.067	0.712	0.000	3.964
Kyasa central	0.000	0.145	0.797	0.676	0.048	0.314	1.256
Kyasalala	0.390	0.000	1.822	1.171	3.579	0.586	6.486
Kyasa north	0.000	0.064	0.644	0.644	0.000	0.290	0.998
Kyasa south	0.061	0.345	0.873	0.812	0.122	0.102	1.604
Luamba	0.247	0.000	1.892	1.618	0.713	0.274	3.235
Luyuyu	0.148	1.356	3.289	2.873	2.967	1.544	8.403
Monika	0.000	0.000	3.457	3.093	0.104	0.312	3.977
Nzovu	0.012	0.060	1.230	1.037	1.181	0.217	2.821
Suiza	0.179	0.411	2.339	1.910	1.750	0.339	5.089
Trail	0.303	0.017	0.287	0.084	0.135	0.219	0.944
Itebero_Utu	0.000	0.000	0.089	0.069	0.563	0.020	0.652
Average	**0.112**	**0.158**	**1.328**	**1.132**	**1.758**	**0.287**	**4.163**

High altitude Sector Bird surveys

A total of 120 bird species were observed at all sites within the highland sector of the park out of a known list of 336 for the whole park (Plumptre et al. 2003; 2007). These numbers include opportunistic sightings as well as the point count survey data. Thirteen species were added to the total list for the park: bronze manikin, black-necked heron, eurasian bee-eater, grey-headed sparrow, kestrel, lesser honeyguide, narina's trogon, olive long-tailed cuckoo, red-backed shrike, scaly francolin, white-tailed ant thrush, white-tailed blue flycatcher, and yellow wagtail. This brings the total species list to 349 for Kahuzi-Biega. Mapping the relative abundance of birds shows that the eastern side of the high altitude sector tends to be richer in bird species (Table 7; Figure 13) but endemic bird species are more evenly spread across the central part of the sector.

Table 7. Number of bird species and Albertine Rift endemic bird species for each site surveyed in the high altitude sector.

Site	Bird species	Endemic birds
A	62	14
B	53	14
C	52	8
D	74	16
E	70	16
F	68	11

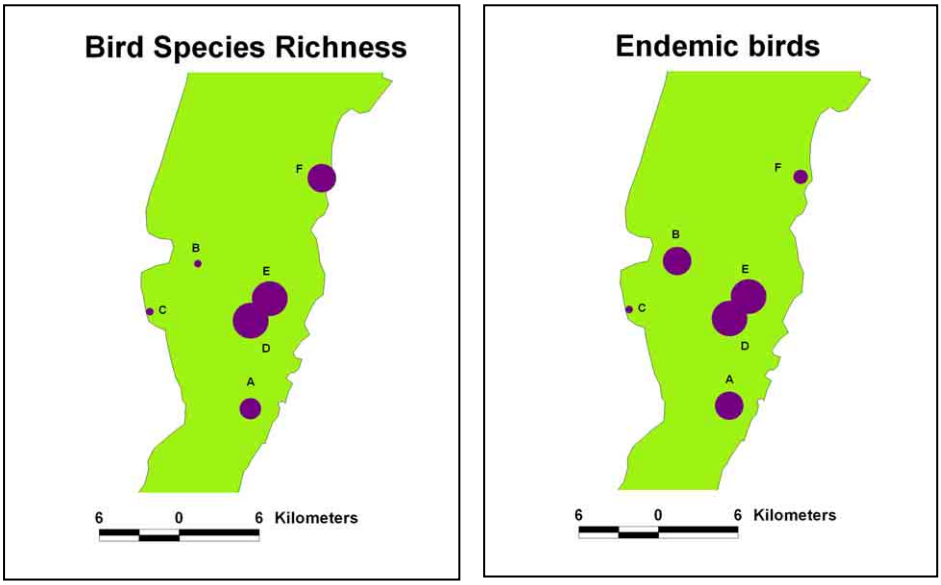

Figure 13. Relative abundance of total number of bird species and number of endemic species in the high altitude sector of the park.

Species accumulation curves from the point data show that some of the sites with a low count for total species actually rank high amongst the sites. Site B in particular ranked low in the total species list but ranked high in the rarefaction curve data. This may be because the teams spent less time at this location because of security reasons so that the number of birds seen was fewer (figure 14). Only site C was consistently lower than all other sites in terms of species richness.

Bray Curtis Similarity analyses showed that sites D, E and F were most similar in terms of bird species composition (figure 15). Shannon Wiener and Alpha diversity indices were calculated for each site also and show that sites B and F were most diverse (table 8).

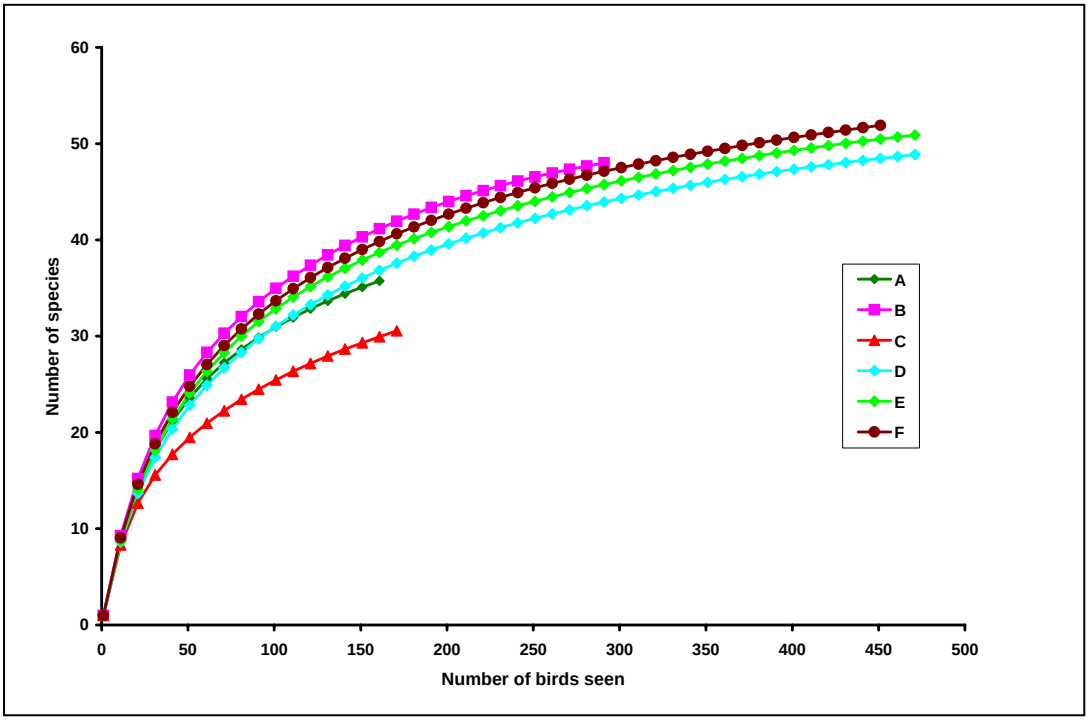

Figure 14. Rarefaction curves for each site surveyed using point count data.

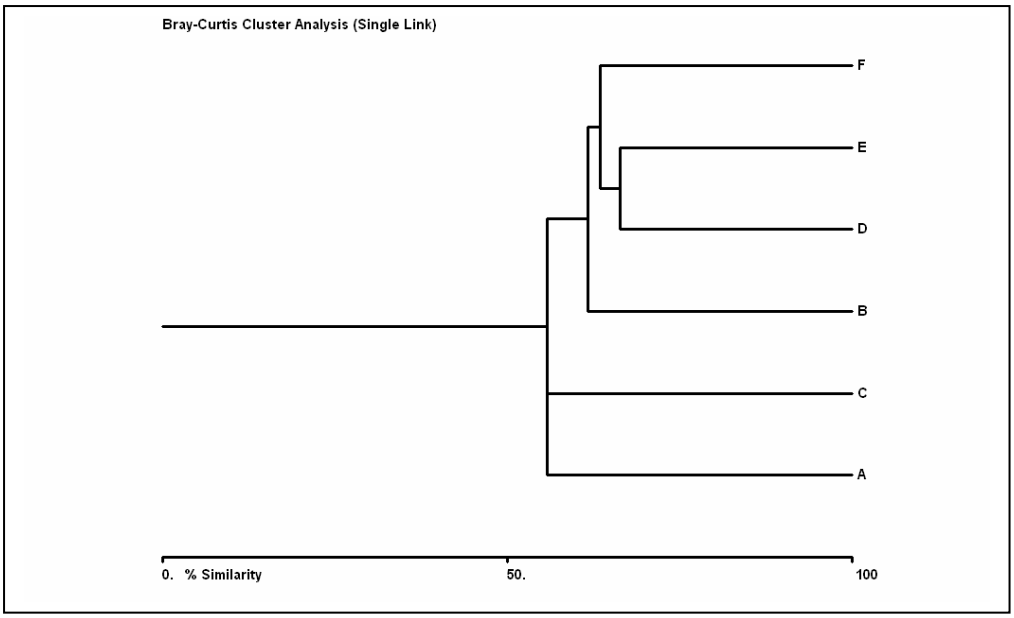

Figure 15. Similarity of the different sites in terms of the bird species composition. Analysis from point count data.

Table 8. Diversity of each site calculated using point count data.

Index	A	B	C	D	E	F
Shannon H' Log Base 10.	1.40	1.51	1.29	1.42	1.45	1.49
Shannon J'	0.90	0.90	0.86	0.84	0.85	0.87
Alpha	14.20	16.36	10.82	13.69	14.47	15.14

The total of 349 bird species is still relatively low for this park and as a result this park ranks 12th of the sites surveyed in the Albertine Rift region (Plumptre et al. 2003). The additional 13 species listed for the park from this survey does not change the ranking of the forest but we believe that many more species could be found for the park, particularly if the lowland sector is surveyed for its bird fauna.

High altitude Sector Plant Surveys

A total of 1,178 plant species were recorded from the high altitude sector alone. The total number of plants listed for the park prior to this survey was 1,171 species (Plumptre et al. 2003; 2007) and this survey found more than the total for the park in just the high altitude sector. There are therefore likely to be many more species that could be found for the whole park, particularly in the lowland sector.

The number of species fund in each site and the diversity indices calculated for each site show that site D had most species collected but this was partly because more time was spent here because security was better and more opportunistic collecting could take place (table 9, figure 16). Diversity indices calculated for the sites from plot data showed that site B was the most diverse.

Table 9. Diversity of each site calculated using point count data.

Index	A	B	C	D	E	F
Number of species	421	419	286	561	316	397
Shannon H' Log Base 10.	1.40	1.51	1.29	1.42	1.45	1.49
Shannon J'	0.90	0.90	0.86	0.84	0.85	0.87
Alpha	14.20	16.36	10.82	13.69	14.47	15.14

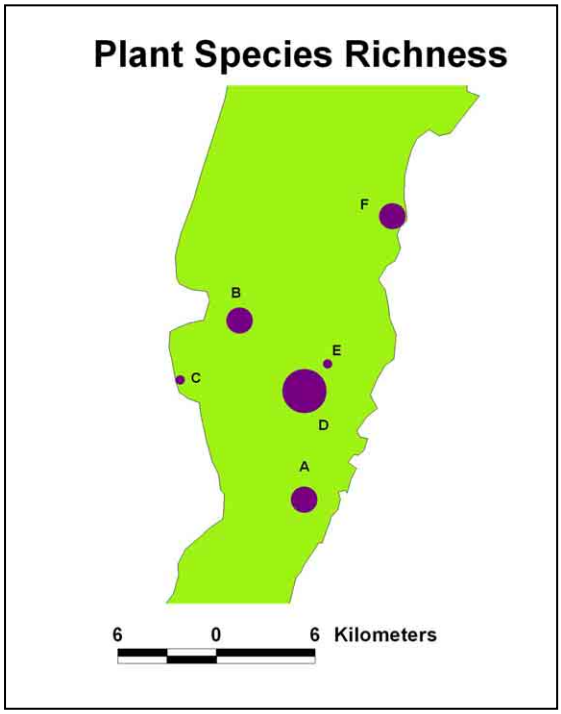

Figure 16. Relative plant species richness as calculated from plots and opportunistic collections between plots and along paths.

Rarefaction curves also show that site B was the richest in terms of plant species, followed by site A and site D (figure 17). At all sites curves were still increasing fairly steeply indicating that species richness is likely to be much higher than measured (although species

numbers from plots were much lower than the total species lists which also included *ad. lib.* sampling).

Sites B, E and D were most similar in terms of plant species composition from the plot data (figure 18), while site C was most dissimilar.

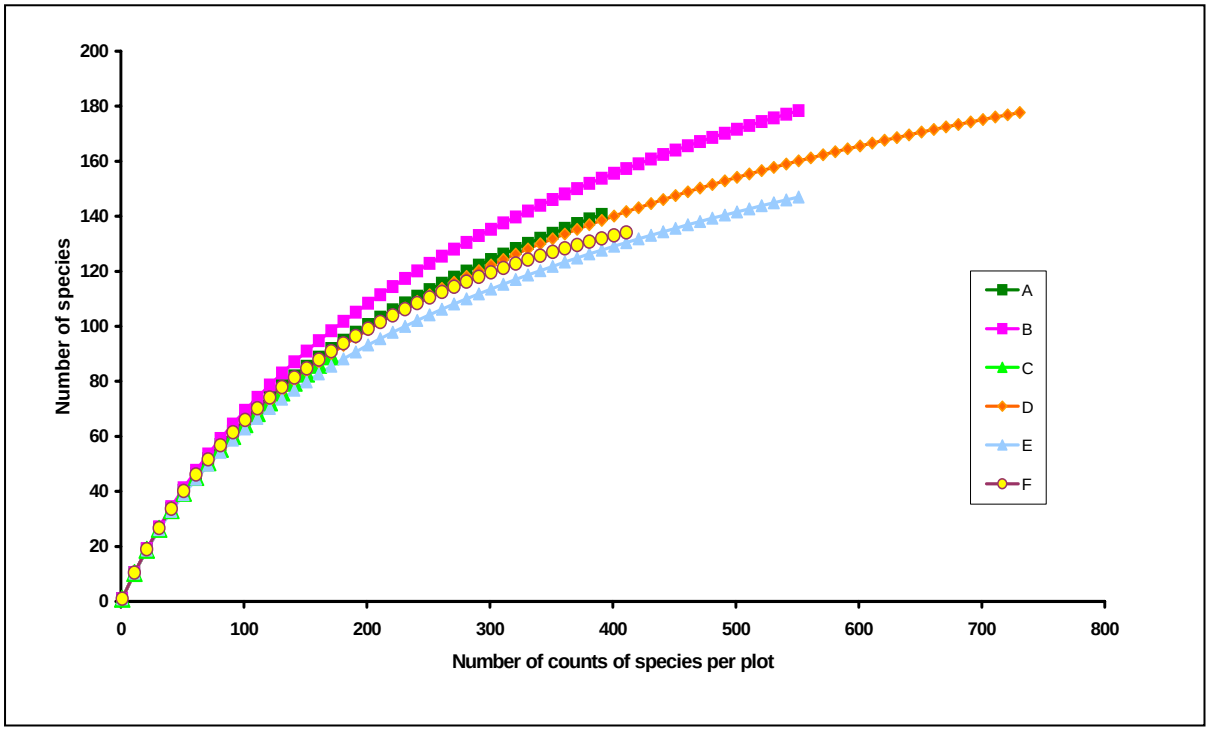

Figure 17. Species accumulation curves for plant species found in plots along transects for each site.

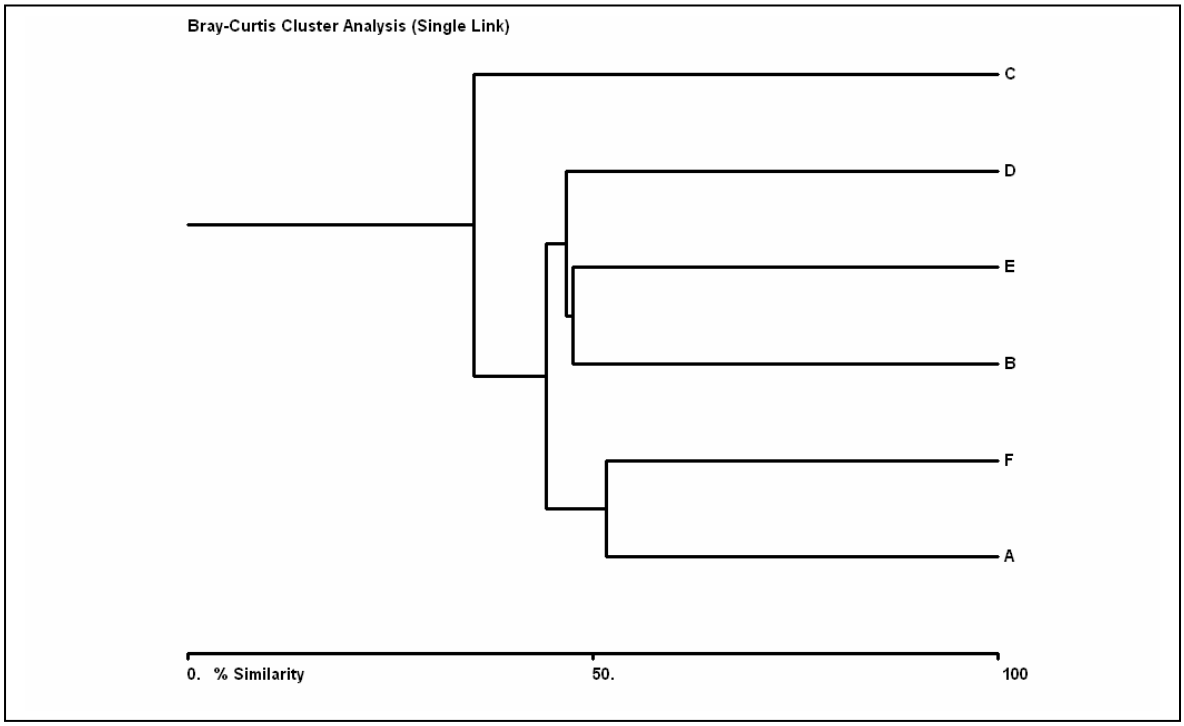

Figure 18. Similarity dendrogram of plant species composition between sites.

The plant species richness in Kahuzi Biega National Park measured in this study moves this forest from 4th highest ranked site in the Albertine Rift region to the third after Virunga National Park and Bwindi Impenetrable National Park (Plumptre et al. 2003). It is very probable that many more species will be found in this park, particularly with more surveys in the lowland sector. We only covered a small area of the park and still found over 1,100 plant species.

Discussion

Despite the major impacts of the civil war in DRC it is clear that there remains a lot of fauna and flora that should be conserved in the park. These surveys continue to show that the park is globally important for plant and bird diversity even though only the high altitude sector could be surveyed for these taxa. The Albertine Rift region is one of the most biodiverse regions of Africa and Kahuzi Biega is one of the richest sites within the Albertine Rift.

Changes since the civil war in animal numbers

Grauers gorillas

Comparisons with data from previous surveys indicate that gorilla numbers have declined dramatically in the high altitude sector from a high of 258 in the early 1990s to a low of 130 in 2000. The increase between 2000 and 2004 from 130 to 168 is unlikely to have been due to births alone however and it is probable that groups were missed in 2000. This also may be the case in 2004 because in both surveys not all of the high altitude sector could be visited because of insecurity (figure 4). However, both surveys covered areas that contained most of the gorillas in earlier surveys (Inogwabini et al. 2000) so it is unlikely many more exist outside the areas visited. As soon as is feasibly possible a census should try to cover the whole of the high altitude sector of the park.

In the lowland sector the encounter rate of Grauers Gorilla nest groups was estimated at 0.093 km^{-1} in Itebero region and 0.082 km^{-1} in Nzovu region (see figure 1 and figure 3) when corrected for differences between recces and transects (Hart et al. 2007). These surveys produced an average of 0.041 km^{-1} for the whole lowland sector but numbers ranged between 0.000 and 0.288 km^{-1} for different parts of the lowland sector. If we take an average of Buise, Monika, Luyuyu, Nzovu and Trail which approximate the area surveyed in 1994 for Nzovu region the estimate is 0.070 km^{-1}, not too different to the 0.082 found in 1994. The Itebero region was only surveyed from a major trail linking Itebero to Suiza so it is not surprising to find that no gorilla groups were found in this region from these surveys. We hope to return to this region in the near future to survey both to the east and west of this trail.

Chimpanzees

In the high altitude sector Inogwabini et al. (2000) estimated 0.4 nest groups km^{-1} for the 1996 surveys which compares with 0.771 km^{-1} for these surveys. The area in the furthest north of the high altitude sector, Lemera, had an encounter rate similar to these surveys of 0.7 km^{-1} in 1996 but this region was not visited in the 2000 or 2004 surveys because it was insecure. It would appear though that chimpanzees have fared relatively well during the war in the high altitude sector and if anything may be more abundant than previously.

In the lowland sector encounter rates in 1994 were 0.688 km^{-1} in Itebero and 1.010 km^{-1} in Nzovu from transects. If the same correction factor as used for gorilla nests is used to convert transect encounter rates to recce encounter rates is valid then this would give values of 0.194 and 0.271 km^{-1} for Itebero and Nzovu respectively. The average encounter rate from these surveys was 0.106 km^{-1} for all the lowland sector surveyed and 0.012 for Itebero regions in the park and 0.104 km^{-1} for Nzovu. Again the surveys in the Itebero region were along a major trail and so probably are not comparable. In the Nzovu region encounter rates are 38% of the corrected 1994 number indicating a major decline has probably taken place here.

Elephants
Elephant numbers were estimated at 3,720 for the lowland sector (Hall et al. 1997) and 771 for the high altitude sector (Inogwabini et al. 2000) in 1994 and 1996 respectively. No signs of elephants were found in the lowland sector during these surveys and only an encounter rate of 0.007 km^{-1} in the high altitude sector compared to 5.523 in the 1996 survey. This species is probably the one that has been most impacted by the civil war in this park.

Other primates
Hall et al. (2003) found reasonable encounter rates of blue, redtail, Dent's, Owl-faced, L'Hoests, guenons, Grey cheeked Mangabey, red colobus, and olive baboon in the lowland sector of Kahuzi Biega in 1994. These varied between 0.02 and 0.51 per km walked in the Itebero sector. The surveys reported here for 2000-2008 found all these species except the baboon and red colobus but at relatively low densities. Interestingly no blue monkeys were found in the lowland sector this time when they were most abundant in 1994. They were only found in the high altitude sector. Whether this is because they are easily hunted because of the '*piouw*' calls the male gives and this has caused a reduction we are uncertain. Grey cheeked mangabeys were found at five sites in the lowland sector but encounter rates were 0.009 km^{-1}. Dent's monkey was also found at fives sites in the lowland sector with a low encounter rate of 0.076 km^{-1}. L'Hoest monkeys were only found at one site in the high altitude sector. However the numbers given by Hall et al. (2003) were along transects rather than recces and to compare with the 1994 numbers we really need more transect surveys.

Changes in human use of the park
Changes in the presence of people in the park has been exacerbated because of the war. However, even prior to the war there were camps that were mining illegally in the park and some settlements along the old roads. A comparison with the 1994 data shows though that human signs have increased for snares, mines, camps and total human sign in the Nzovu area and snares and camps have increased in the Itebero area but total human sign is less than it was in 1994 in Itebero (table 10).

Table 10. Encounter rates (no. per km walked) for some signs of human presence recorded in 1994 that could be compared with the same data in 2005-8 for the lowland sector.

	Itebero 1994	**Itebero 2005-6**	**Nzovu 1994**	**Nzovu 2005-8**
Trail	0.88	0.00	0.91	0.26
Snare	0.51	0.98	0.94	1.52
Mining	0.17	0.14	0.01	0.29
Camps	0.05	0.45	0.03	0.54
Total human sign	2.31	1.63	3.14	6.73

These results show that there has probably been an influx of people to the park and settlements are likely to be expanding where they occur. Settlements are particularly abundant between the Nzovu region and the high altitude sector (figure 19). Some of the villages were quite large according to field team members with over 100 people living in them, surrounded by cultivated land. Average village size was about 23 people. While average mining camp size was 9 people.

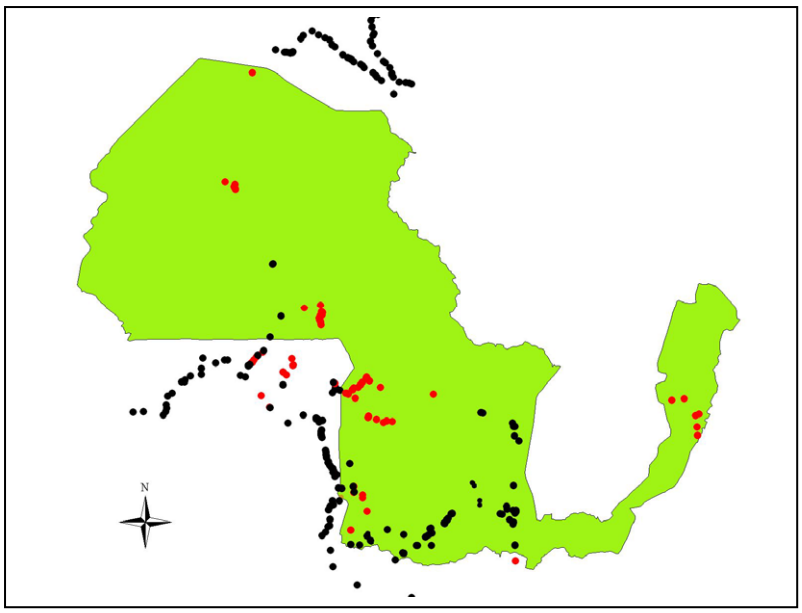

Figure 19. Locations of settlements along the recce trails walked during these surveys. Settlements included villages (black) and active mining camps (red).

Conservation implications

The impacts of the civil war in DRC have been extensive in Kahuzi-Biega National Park. Elephants have been almost exterminated in the park and even those that were remaining in the high altitude sector in 2000 may not exist today. There is a need to survey west of the Kyasa trail to see if any remain in this most remote part of the park (furthest west). Gorillas and chimpanzees have fared better but still declined in most areas except for chimpanzees in the high altitude sector. It appears other primates have also declined but ideally transect data are needed for these animals rather than recces from transects to allow a comparison with previous transect data. There as been an increase in human impacts on the park particularly in the south-central region around Nzovu and Idunga regions. Settlements have probably grown here with three villages of at least 100 people now within the park.

These surveys show that it is possible to operate in the park even in the lowland sector which is controlled by various rebel groups and the FDLR. It may be possible to negotiate some agreements on mining to control the poaching levels that surround mining camps. At present it is unlikely that mining can be stopped all together and it may be better in the long run to allow some form of controlled mining such that the reserves of minerals become exhausted and people would then be more willing to leave the park. Conflict resolution approaches would be needed to start to implement some form of controlled exploitation. However, there is unlikely to be any control over the park until the issue of the FDLR and Rwanda can be resolved. Until then ICCN and its partners will be forced to operate by building partnerships where they can until the armed groups can voluntarily leave the park through a national/international level peace process.

Using surveys as a non-confrontational approach to getting staff on the ground is proving to be feasible and is slowly becoming more acceptable to the armed groups in the park. It is possible these could be developed into ranger monitoring patrols which collect information regularly and monitor changes that are happening in the park. WCS is helping establish MIST (Management Information System) in Kahuzi-Biega after its successful implementation in Virunga Park. This system facilitates easy entry of ranger collected data and then some simple analyses that can map the data and assess changes in encounter rates. If ranger monitoring patrols can be used to develop better rapport with the armed groups then this could potentially progress to development of some form of controlled mining access in the park that would minimize the negative impacts.

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