THE BIODIVERSITY OF THE VIRUNGA VOLCANOES

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EXECUTIVE SUMMARY

The Virunga Volcanoes is divided by the international borders of Uganda, Rwanda and the Democratic Republic of Congo (DRC). The Virunga Volcanoes is made up of three parks; Mgahinga Gorilla National Park (MGNP) in Uganda, Parc National des Volcans (PNV) in Rwanda and Parc National de Virunga in Democratic Republic of Congo (PNVi).

A biological inventory of birds (chapter 2) and plants (chapter 3) was undertaken in the Virunga Volcanoes from 10th Jan to 2nd Feb 2004 to provide information on the diversity, abundance and distribution of species found in the area. Emphasis was placed on documenting species that are Albertine Rift Endemics and threatened species to provide information that would allow the development of a zoning plan for the Virunga Volcanoes. The survey also served as a training exercise for the staff of ICCN, ORTPN and DFGFI to help them undertake research and monitoring in plants and birds. Methods of point counts, mist netting and opportunistic observations were used to survey birds while plants were surveyed using circular plots and opportunistic observations. In addition faecal counts of the ungulates were made in plots to obtain a measure of the distribution and abundance of four mammal species (chapter 4). These data were combined with large mammal observations from the 2003 mountain gorilla census to assess large mammal species richness around the Virunga Volcanoes. The survey aimed to cover most of the Volcanoes massif and divided the area into nine sectors to ensure fairly even coverage. These allowed maps to be made of the distribution of different species across the massif.

The ornithological team surveyed a total of 123.50 km of reconnaissance trails in the Virunga Volcanoes. They sampled a total of 527 points with 254 points in PNVi, 212 points in PNV and 61 points in MGNP. A total of 176 bird species were recorded during the study with 36 new species added to the previous list of 258 for Virunga Volcanoes compiled by Plumptre *et al* (2003) from existing literature. The current total number of species for Virunga Volcanoes is now 294. 18 endemic species were sighted which represented 90% of endemics so far recorded for the Volcanoes (20 – Plumptre *et al.*, 2003). The highest numbers of endemics were recorded in MGNP (17 species) while the lowest number was recorded in PNV even though the least amount of time was spent in MGNP. Out of the total of 176 species recorded, 39 were species of forest interiors (FF – species), 57 were less specialized species (F – species), 28 were forest visitors (f – species) and the rest were non-forest species that utilise the other habitats that occur in the Virunga Volcanoes. Species richness varied between the different sites surveyed with the highest number of species recorded around the Volcano Sabinyo (91) while the least number of species was recorded south of Karisimbi Volcano (49).

The botanical team surveyed a total of 84.75 km of reconnaissance trails in the Virunga Volcanoes. They evaluated 348 circular botanical plots covering a total surface area of 43.69 hectares. 153 plots (19.21 hectares) were sampled in PNV; 155plots (19.46 hectares) were surveyed in PNVi while 40 (5.02 ha) plots were evaluated in MGNP. On average 5.0 hectares were surveyed in each sector. The botanical study recorded 860 species of plants. 348 species were recorded that were previously unknown to exist in Virunga Volcanoes. 107 plants were new to the Albertine Rift plant checklist produced by Plumptre *et al* 2003. 12 plant species could not be identified to species level and may represent new species. The total number of species for the Virunga Volcanoes now numbers 1265 plants. 92 of the species recorded were Albertine Rift Endemics. 7 plant species recorded were IUCN listed. The highest number of plant species was recorded in PNV (624) and least number was recorded in MGNP (313). Herbs accounted for the greatest number of plants recorded in each park. Species richness varied between the different sites surveyed with the highest number of species recorded around the Volcano Sabinyo with 358

species followed by the region between Sabinyo and Visoke volcanoes (346 species) while the least number of species was recorded in the lower altitude forest between Sabinyo and Visoke in DRC with 161 species. The western part of the massif was rich in both total number of plant species and endemic plant species recorded.

The vegetation types in Virunga Volcanoes were divided into 7 broad types; alpine/sub-alpine, *Hagenia- Hypericum*, mixed forest, bamboo, disturbed woodland, open grassland and swamp. The most abundant vegetation type surveyed within the plots in PNVi was the mixed forest type represented (68.4% of plots). In PNV bamboo (43.2% of plots) was the most abundant vegetation type, followed by *Hagenia- Hypericum* woodland. MGNP was dominated by mixed forest 34% and bamboo 24%. The sector around Sabinyo had all the 7 habitat types represented in it and was also the most species rich. The lowest number of habitat types occurred in the region south of Karisimbi volcano with only three types and this sector also had fewest species.

Analysis of bird distributions in different habitat types showed that the highest number of bird species occurred in mixed forest (95), followed by the bamboo (72) and the lowest number of species (35) was recorded in grassland. Fifteen Albertine Rift Endemics were recorded in the mixed forest followed by bamboo (12 species). Species abundance was highest at the lowest altitudes within the range, between 2,100-2,700 metres altitude above sea level for both plants and birds followed by a decline with increasing elevation above this. This could be due to the moist climate of the Virunga Volcanoes at this altitudinal range that provides a habitat for only a limited number of species adapted to the high altitude conditions.

For both plant and bird species the eastern part of Virunga Volcanoes was richest in total species number and in number of endemic species. The area around Sabinyo Volcano was the richest in total species number for both plants and birds. However, for birds the western part of the massif was also important for both species number and endemic species. Both these areas tend to have low numbers of mountain gorillas and tend to be less intensively managed as a result. Large mammal species richness was greatest around the volcano Sabinyo also. The two endemic mammals, mountain gorilla (*Gorilla beringei beringei*) and Golden monkey (*Cercopithecus kandti*) are more evenly distributed across the massif than other species.

These data were combined to assess the conservation value of each of the nine sectors across the Virunga Volcanoes. Large mammals, birds and plants were ranked for species richness per sector, number of endemic species and numbers of threatened species and the ranks summed to provide an overall ranking. Overall ranked species richness was highest between Sabinyo and Gahinga volcanoes followed by the area west of Mikeno volcano. Ranked numbers of endemic species were highest between Sabinyo and Muhabura volcanoes. Ranked threatened species were highest west of Mikeno volcano and between Visoke and Karisimbi volcanoes (the Karisoke Research Station study area). Apart from the Visoke-Karisimbi site these other sites have few mountain gorillas and therefore have not been a focus of conservation activity. This study highlights the importance of these other sites for conservation and efforts must be taken to ensure that they are as carefully managed as the mountain gorilla range. Even the sites that ranked poorly such as the southern most sector are important for some species. In this sector the golden monkey is most abundant, a species that is classified as endangered by IUCN. The only significant population of the golden monkey occurs in the Virunga Volcanoes now as the population in Gishwati forest has been mostly wiped out with the destruction of that forest after the genocide in Rwanda in 1994. It is therefore a critical species for conservation management and as significant a conservation priority as the mountain gorilla for conservation in the Virunga Volcanoes.

GLOSSARY

ARE	Albertine Rift Endemics
DFGF-I	Dian Fossey Gorilla Fund International
DRC	Democratic Republic of Congo
GIS	Geographic Information Systems
GPS	Global Positioning System
ICCN	Institut Congolais pour la Conservation de la Nature
IGCP	International Gorilla Conservation Program
ITFC	Insitute of Tropical Forest Conservation – Mbarara University of Science and Technology
IUCN	The World Conservation Union
MGNP	Mgahinga Gorilla National Park
NP	National Park
ORTPN	Rwanda Office of Tourism and National Parks
PNV	Parc National des Volcans
PNVi	Parc National de Virunga
UWA	Uganda Wildlife Authority
WCS	Wildlife Conservation Society

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CHAPTER ONE: THE VIRUNGA VOLCANOES

1.0 INTRODUCTION

Resources for conservation are always limited therefore attention should be focused on the highest conservation priorities. The conservation importance of an area is determined by assessing its biodiversity using species as the basic units of biodiversity. At the continental scale, inventory has permitted the definition of large-area administrative and planning units such as ecoregions (Olson et al. 2001; Wikramanayake et al. 2002) and hotspots (Myers *et al.* 2000) within which conservation planning and management can occur. At smaller scales inventory data are being used to develop landscape plans (Margules and Pressey, 2000). The collection of inventory data at the scale of protected areas has usually been to provide species lists. Few studies in Africa have quantified species distributions within protected areas. However, in East Africa there is a process of designating multiple use zones in which local community members can harvest forest products or put their beehives to improve honey quality. These zones have rarely been allocated with respect to the conservation importance of different sites in the forest because the data to assess these have been lacking.

This survey aimed to provide data on the distribution of birds, plants and to some extent, large mammals, across the Virunga Volcanoes massif. Large mammals had been surveyed in an independent survey mainly focused on the mountain gorilla (*Gorilla beringei beringei*) population (Gray *et al.* in press). This survey collected additional data on dung of the more cryptic mammals. The presence and abundance of key species (endemic and threatened species) was one of the criteria used by this study for assessing importance of sites for conservation in the Virunga Volcanoes.

1.1 THE VIRUNGA VOLCANOES

The Virunga Volcanoes are dissected by the international borders of Uganda, Rwanda and the Democratic Republic of Congo (DRC). The Virunga Volcanoes is made up of three parks; Mgahinga Gorilla National Park (MGNP) in Uganda, Parc National des Volcans (PNV) in Rwanda and Parc National des Virunga in Democratic Republic of Congo (PNVi). The parks contain six volcanic mountains Karisimbi (4507 m), Mikeno (4437 m), Bisoke (3711 m), Mgahinga (3474 m), Muhabura (4127 m) and Sabinyo (3634 m) and covers an area of 447 km^2 (figure 1.1). The park lies in the Albertine rift region, which is characterised by a high degree of avian and mammalian endemism due to its proximity to a pleistocene refugium, created during the last ice age (Hamilton 1984). MGNP is situated in the southwestern Uganda in Kisoro District. It covers an area of 33.7 km^2. MGNP is contiguous with PNVi (240 km^2) in the DRC, and PNV (160 km^2) in Rwanda. PNVi is a World Heritage Site and the oldest national park in Africa, created in 1925. PNVi borders with an extensive network of protected areas in neighbouring Uganda and Rwanda and together these contiguous protected areas form the Greater Virunga Landscape.

The research documented here aimed at building on previous work that has been undertaken in Mgahinga Gorilla National Park, Park National des Virunga and Park National des Volcans by collecting data on plants, birds and mammals. Initial surveys were undertaken in the 1930s by Belgian Scientists who made extensive collections in what was then the Albert National Park (which included both PNVi and PNV). These were summarised for mammals by de Witte (1938), birds (Schouteden, 1938) and plants (Robyns 1948-1955). Additional surveys of the birds were made by Verheyen (1947) and Wilson (1982). Additional surveys were made of plants by Troupin (1978-1988) in Rwanda, Burtt (1934) in Uganda and a summary of vegetation types made by Spinage (1972). The data collected during this study were used to not only increase the

list of species for the massif but also to determine species distributions and to map the relative importance of different sites within the three national parks to serve as baseline information for monitoring particularly of the globally threatened and the Albertine Rift Endemics.

1.2 VEGETATION ZONES

A total of 878 plants have been recorded from the massif in past surveys, with 124 endemic to the Albertine Rift and four threatened species (Plumptre *et al.* 2003).

The vegetation types of Virunga Volcanoes are diverse and are broadly classified into three belts and several zones within the belts. The vegetation belts are alpine, subalpine (ericaceous) and montane forest (Schaller, 1963). Some of the different vegetation zones are shown in Photos 1-3.There is considerable overlap between zones and numerous mosaic patterns exist in the different vegetation belts that has led to a total of 878 plants found in Virunga Volcanoes out of which 81 species were trees prior to this survey. 124 species were endemic to the Albertine Rift, and four species were threatened according to the IUCN Red Data book (Plumptre *et al* 2003).

The vegetation types of the three parks found in Virunga Volcanoes also varies with the history of each park. For example the vegetation in MGNP consists of woodland, and only a small area of pure montane forest still remains at the base of Mt Muhabura following encroachment in the 1950s. Above the montane forest belt is the bamboo (*Arundinaria alpina*) zone (shown in Photo 1b) that stretches from the western boundary on Sabyinyo to the lower slopes of Muhabura. The *Hagenia-Hypericum* zone appears above the bamboo zone on Mt. Sabyinyo and below it on Gahinga. The Afro-Alpine Belt, characterised by giant *Senecio* and *Lobelia* species, occurs above the Ericacious Belt and reaches its maximum development on Mt. Muhabura. Human settlements in MGNP used to occupy a large part of the park before its gazettement and because of the various boundary changes. According to Lejju (1999), close to 0.6% of the park's area is covered by introduced black wattle (*Acacia mearnsii*), *Eucalyptus, Cupressus* and *Pinus*. These were planted by the Forest Department when it was a forest reserve. The extent of *Acacia mearnsii* and *Eucalyptus* seems to be increasing. It was also noted that there is low recruitment of indigenous tree species.

In PNVi the Mikeno sector has extensive lower montane forest that changes with elevation into bamboo, Hagenia-Hypericum zone, sub-alpine and alpine similar to MGNP and PNV.

Photo 1 a) *An overview of mixed forest in Virunga Volcanoes and* **b**) *Bamboo zone dominated by Arundinaria alpina*

In PNV the biologically diverse lower montane forest zone, between 1600 and 2600m has been eliminated by human settlement and clearing. A relic band remains only between Mts. Gahinga and Sabyinyo. Generally, PNV contains the upper stages of the afromontane vegetation sequence of bamboo, *Hagenia-Hypericum* zone, sub-alpine and alpine associations (Spinage, 1972, Plumptre, 1991). With increasing elevation, bamboo gives way to *Hagenia-Hypericum* zone between 2700 and 3200 meters that form open canopies with abundant herbaceous undergrowth. Marsh communities also exist within this zone, where physical conditions favour their establishment, especially in the saddles between volcanoes (Weber, 1987).

The sub-alpine vegetation covers the zone between the elevations of 3000 and 3,800 meters and is composed of Giant *Senecio*, Giant *Lobelia* and ericaceous zones. These zones grade into moorland in the alpine zone. The ericaceous zone is characterised by *Philippia johnstonii, Erica arborea* and *Hypericum revolutum,* which are often densely laden with *Usnea* sp. lichens (Kalina, 1991). The ground is characterized by communities of *Rubus, Alchemilla, Helichrysum* and *Volkensia* shrubs, mixed with various grasses and lichens. The major vegetation types of Virunga volcanoes are summarized in Table 1.1.

Photo 2. *a) Sub-alpine zone characterized by abundant Dendrosenecio adnivalis, and b) Philippia johnstonii and Hypericum revolutum.*

Above 3,800m alpine vegetation dominates, shrubs disappear and give way to communities of grasses, mosses and lichens. These alpine formations are not only less diverse, but also more fragile than other zones.

Photo 3. a) An alpine zone above the limit of most herbaceous and woody plants, with low grass and mosses and occasional giant Senecios and b) a high altitude swamp consisting of mainly herbs and grasses.

Table 1. 1. *Summary of major vegetation zoneswith dominant species*

Vegetation Zone	General characteristics	Altitude
Alpine	Grasses, mosses and lichens, *Dendrosenecio*, giant lobelia	Above 3,600 m
Sub-alpine	*Philippia johnstonii, Erica arborea,* Giant *Lobelia*	3200-3,600
Hagenia-Hypericum woodland	*Hypericum revolutum, Hypericum absi, Hagenia abyssinica*	2800-3200
Bamboo	*Arundinaria alpina,*	2500-2800
Mixed forest	Moist semi-deciduous forests with broad leaves	1600-2500m
Disturbed woodland = woodland	Areas of regenerating forest that were cultivated in Mgahinga	2300-2800
Grassland	Areas dominated by grass	Occurs at various altitudes
Swamp	Marshy/boggy areas	Occurs at various altitudes

1.3 FAUNA

According to Plumptre *et al* (2003) Virunga Volcanoes has a total list of 86 species of mammals out of which 34 are large mammals. There are 18 species of mammals that are endemic, 3 that are near endemic, 6 species that are threatened and 16 that are IUCN listed. The larger mammals include the mountain gorilla (*Gorilla beringei beringei*), buffalo (*Syncerus caffer*), bushbuck (*Tragelaphus scriptus*), black-fronted duiker (*Cephalophus nigrifrons*) and elephant (*Loxondata africana*). There is also the endangered golden monkey (*Cercophithecus kandti*) known only to occur in the Virunga Volcanoes and the blue monkey (*Cercopithecus mitis*).

A total of 258 species of birds have been previously recorded in Virunga Volcanoes of which 20 species are endemic to the Albertine Rift, and four species are threatened Plumptre *et al* (2003).

1.4 SURVEY SITES IN THE VIRUNGA VOLCANOES

The Virunga Volcanoes was divided into nine sampling regions or sectors as shown in Figure 1.1. Sectors Akabarozi (B), Rubindi (D), Bukima (E) and Jomba (G) were located in PNVi-south (Mikeno Sector) in DRC while Ngando (A), Karisoke (C) and Kago (F) were in PNV in Rwanda. Sites Kagano & Ntebebeko formed sector H, while Minoga & Muhavura formed sector I and these two sectors H and I were shared between PNV and MGNP. The average GPS points and altitude are given in table 1.2. These nine sites varied greatly in habitat types, topography and altitude (table 1.2). Due to insecurity, it was not possible to cover the whole forest evenly but every attempt was made to cover the range of habitats and altitudes.

Within each sector at least four reconnaissance trails were followed that were selected to cover as much of the sector as possible (including the variation in altitude and habitat). Each reconnaissance trail followed aimed to walk a fixed compass direction but where paths were available these were used rather than cutting through the vegetation. Occasionally the direction was changed to ensure more sampling in rarer habitats.

Sampling points were marked at 250 m intervals along the reconnaissance trails, measured by hipchain and topofil thread. Bird point counts, botanical sampling plots and mammal dung plots were each located at these points.

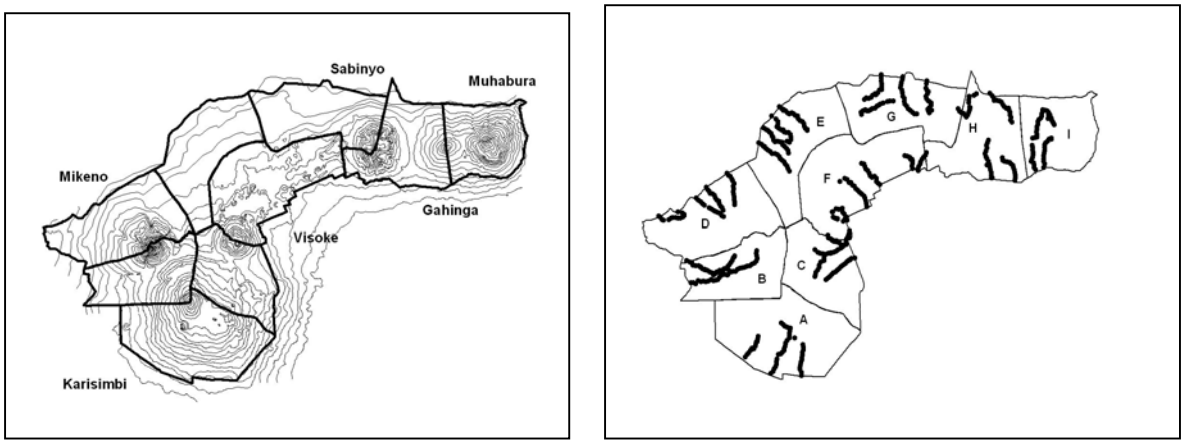


Figure 1. 1. *Map of Virunga Volcanoes showing the nine sectors and the volcano names. Sectors were represented as follows: A = Ngando B = Akabarozi C= Karisoke D = Rubindi E=Bukima F = Kago G = Jomba H = Kagano & Ntebeko I = Minoga & Muhavura. The reconnaissance trails in each sector are shown on the map on the right.*

Table 1. 2 *The average GPS points (UTM Zone 35 south, Datum:WGS 84) and altitude*

Sector	Average GPS UTM EW	Average GPS UTM NS	Average Altitude (m)
A	772710	9829055	3183
B	766801	9835539	2665
C	777623	9836911	3027
D	765911	9841129	2388
E	772718	9846794	2284
F	780665	9842622	2697
G	783152	9850014	2302
H	791537	9847327	2549
I	796176	9846809	2922

CHAPTER TWO: BIRDS

2.1 INTRODUCTION

An ornithological survey was carried in the Virunga Volcanoes from 10th Jan to 2nd Feb 2004 to provide biological information on the diversity, abundance and distribution of bird species found in the area. Emphasis was placed on documenting bird species that are Albertine Rift Endemics and IUCN threatened species to help develop a zoning plan for the Virunga Volcanoes. The survey also served as a training exercise for the staff of ICCN, ORTPN and DFGFI to help them undertake research and monitoring in avifauna in future. Three methods were used to survey birds. Birds were detected by use of sight, calls and mistnetting. The observers used 10 x 40 pairs of binoculars and birds were identified using a standard text for East Africa (Stevenson and Fanshawe, 2002). It was necessary to be accompanied by military for security and hence few campsites were established in the park. Some areas of the forest were not visited as a result.

2.2 STUDY SITES

The nine sectors were sampled as described in Chapter 1 (Figure 1.1). The sampling points every 250 m along each reconnaissance trail were used to record birds seen and heard. Ornithologists with a good knowledge of birdcalls were employed to undertake the data collection. Additional sampling was made in specific habitats with mist netting and opportunistic recording of species was made at all sites visited.

2.3 METHODS

In each Sector four days were spent surveying the birds. Three methods were used as detailed below. In general reconnaissance walks were made through the forest, aiming to traverse the variation in vegetation types and altitude and approximately following a straight-line direction. Where possible footpaths were used to ease access and enable more sites to be visited.

2.3.1 Point counts

Points were established in the nine sectors surveyed. The points were established at an interval of 250m along the reconnaissance trails that were used by the plant and mammal team. A point is a single station from which a count is made and each point in this study was visited once. Habitat types at the points were defined by the following categories: grass, woodland, mixed forest, bamboo, Hagenia-Hypericum, subalpine and swamp. GPS readings and altitude were taken for each point where it was possible to help map the points and distribution of species. At each point observers waited for 2 minutes to allow birds settle down and then recorded all sightings and calls of birds for a period of 5 minutes. The team then moved on to the next point and repeated this same process. The data were used to measure relative encounter rates for the threatened and Albertine Rift Endemic species. No attempt was made to estimate bird density because of the few sightings for majority of the species recorded.

2.3.2 Mist netting

Understorey birds, some of which were not conspicuous and might have been missed by point counts, were sampled using mist nets. Ten 12-meter nets were placed in areas surveyed to maximise the number of species for each site. Nets were opened at dawn and closed at dusk or just before rains. Nets were checked at every half hour interval while they were open and any birds caught placed in bags to keep them calm. Netted birds were handled with great care, processed quickly and carefully. Birds were released near the spot where they were caught but away from the net to avoid being caught again and disruption of their normal movements.

2.3.3 Opportunistic sampling

Opportunistic recording was used to maximise the number of species encountered in each sector. All bird species seen or heard at different times of the day and night at the different camping sites visited was recorded. These data was used to compile the total species list for sites and eventually for each national park.

2.4 ANALYSES

2.4.1 Total species list

Total bird species lists (species richness) were compiled for each of the three protected areas and sectors surveyed from point counts, mist netting and opportunistic observations data. The species lists were used to compare the different sites visited in each park and make comparison with the other national parks in the massif. Birds recorded were assigned the categories below to look at patterns of forest specialists. (Wilson, 1995; Bennun, Dranzoa & Pomeroy 1996).

A	Afrotropical migrant – a species migrating within Africa
P	Palearctic migrant – a species that breeds in Europe or Asia
p	A species with at least some palearctic populations
FF	Forest specialist – species typical of forest interiors
F	Forest generalist – less specialized also occur in small patches of forest
f	Forest visitor
W	Waterbird specialist – normally restricted to wetlands or open waters
w	Waterbird non-specialist – often found near water

2.4.2 Species diversity

Species diversity for each sector visited was calculated using the Shannon-Wiener Index using the point count data. A high value of H' indicates a large number of species with similar abundances, a low value indicates domination by a few species.

2.4.3 Species accumulation curves

Species accumulation curves were plotted for all the nine sectors surveyed using the point count data. Bird species number were plotted against the number of individual bird species encountered to estimate how much of the total bird community had been recorded during the survey. The curve was also used to compare the species richness between the sectors and the protected areas.

2.4.4 Similarity indices

Similarity indices were calculated and dendrograms created using Bray-Curtis linked cluster analysis using the bird point count data. Similarity indices measure the degree to which the species and their relative abundances are shared between different communities. Completely similar communities have an index of 1 (one) while completely dissimilar communities have an index of 0 (zero)

2.4.5 Threatened and Albertine Rift Endemic Species

The threatened and Albertine Rift endemic (ARE) species are key species for conservation hence their presence/absence could be used as an indicator of the importance of a site for conservation. The total number of threatened and ARE species were compiled for each sector and also for the 3 national parks and were used to compare sites.

2.4.6 Encounter rates

Relative estimates of abundance for the threatened and ARE species were computed using the method of encounter rates from point count data. The encounter rate for each species is equal to

the total number of individuals recorded divided by the period of observation to give number of individuals, recorded per hour of survey.

2.4.7 Bird distribution maps

The distribution of Albertine Rift Endemic species, total species richness, and species diversity of birds were plotted on maps of the three protected areas in ARCVIEW 3.2a so that relative differences between sites could be visualised in a spatial context.

2.5 RESULTS

2.5.1 Survey effort

The ornithological team surveyed a total of 123.50 km of reconnaissance trails in nine sectors in the Virunga Volcanoes. They sampled a total of 527 points with 254 points in PNVi, 212 points in PNV and 61 points in MGNP. The results are summarised in Table 2.1.

Table 2. 1 *Distance walked (km) and number of point counts sampled at every 250 m, interval in the 9 sectors.*

Forest	Site	Distance Walked (km)	Number of Plots
PNV	A	11.5	48
	C	11.75	50
	F	14.25	61
	*H_{PNV}	6.5	28
	*I_{PNV}	5.75	25
Total		**49.75**	**212**
PNVi	B	14.5	62
	D	13.5	58
	E	16	68
	G	15.5	66
Total		**59.5**	**254**
MGNP	*H_{MGNP}	8.75	37
	*I_{MGNP}	5.5	24
Total		**14.25**	**61**
Grand Total		**123.5**	**527**

**Sectors H and I straddle the Uganda-Rwanda border and were separated in the table*

2.5.2 Total number of bird species in Virunga Volcanoes

A total of 176 species were recorded during the study with 36 new species added to the previous list of 258 for Virunga Volcanoes compiled by Plumptre *et al* (2003) from existing literature. The current total number of species for Virunga Volcanoes is therefore 294 and this study recorded 54.3% of all species recorded for the Virunga Volcanoes. However, the majority of the species missed by this study were either migrants, non-forest birds or were wetland species. Appendix 2 gives the total number of all bird species so far recorded in Virunga Volcanoes including other surveys. The list of each species recorded during the study is given in Appendix 3. The number of species recorded in each park is summarised in Table 2.2. PNV had 119 species recorded followed by PNVi with 109 and MGNP had 88 species recorded despite its small size. Out of the 176 species recorded, 39 were species of forest interior (FF – species), 57 were less specialized species (F – species), 28 were forest visitors (f – species) and the rest were non-forest species that utilise the other habitats that occur in the Virunga Volcanoes. The largest number of FF species

occurred in the adjacent sectors B and D in PNVi and all the sectors in PNV had low numbers of FF species (see table 2.2 and table 2.3).

Table 2. 2 *Total number, IUCN listed species and Albertine Rift Endemic species seen/heard.*

	MGNP	PNVi	PNV	MASSIF
Total No. of spp	88	109	119	176
No. of IUCN spp	2	2	2	2
No. of ARE spp	17	16	15	18
No. of FF spp	20	31	24	39
No. of F spp	27	37	43	57
No. of f spp	16	21	20	28

Table 2. 3 *Total number of FF, F, f species, seen/heard for each sector surveyed.*

	A	B	C	D	E	F	G	H	I
No. of FF spp	10	24	14	23	21	15	18	19	15
No. of F spp	19	29	24	30	28	25	30	28	22
No. of f spp	10	13	8	11	13	12	14	18	10

2.5.2 Species accumulation curves

Rarefaction graphs were plotted for a) bird species richness for the three protected areas b) species richness in the nine sectors c) species richness in the major habitat types and d) species richness at different altitudes as given in Figure 2.2. PNVi had the highest species richness per unit effort followed by MGNP and lastly PNV, which was the least species rich but tending towards same line as PNVi. Sector H was the most species rich followed by sector B, although sector F was rapidly approaching B and would probably exceed it in species number with more effort. Sector A was the least species rich. Species accumulation curves for habitat types and altitudes further showed that the most species rich habitat types in Virunga Volcanoes were mixed forest, disturbed woodland, bamboo and *Hagenia-Hypericum* woodland.

Species richness in Virunga Volcanoes probably depended on habitat types, which were in turn determined by altitude. Sectors that had a diversity of habitat types were species rich compared to those that had little variation.

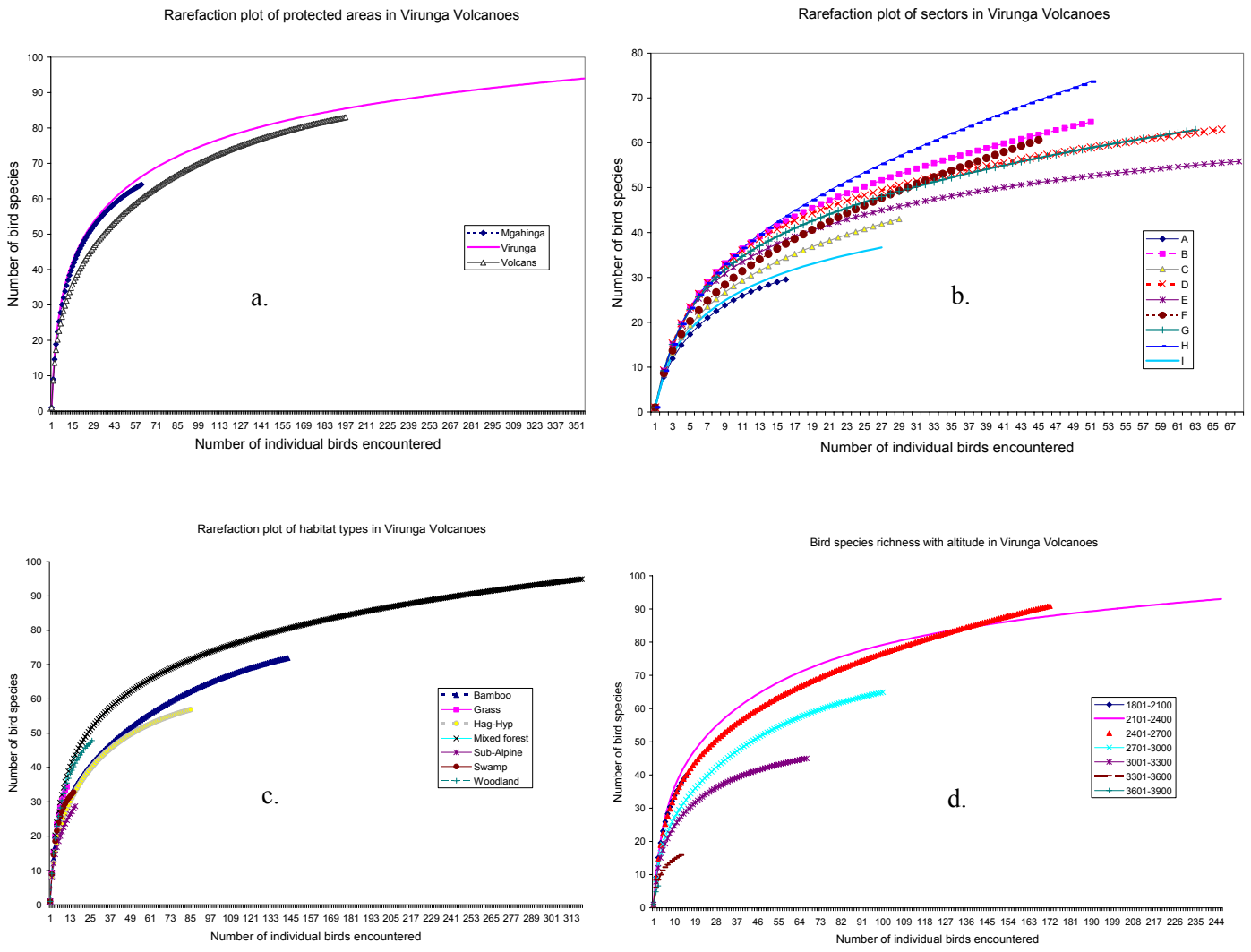


Figure 2. 2. *a) Species accumulation curves for the 3 protected areas* b*) bird species richness in sectors* c*) species richness in major habitat types and* d*) species richness at different altitudes.*

2.5.3 Total number of bird species in sectors

Species richness varied between the different sites surveyed with the highest number of species recorded in sector H (Kagano and Ntebeko) while the least number of species was recorded in A (Ngando - table 2.4). Meanwhile a comparison of total number of species with total number of endemics showed that the eastern and western parts of the massif were rich in endemics compared to the other sites (Fig 2.3)

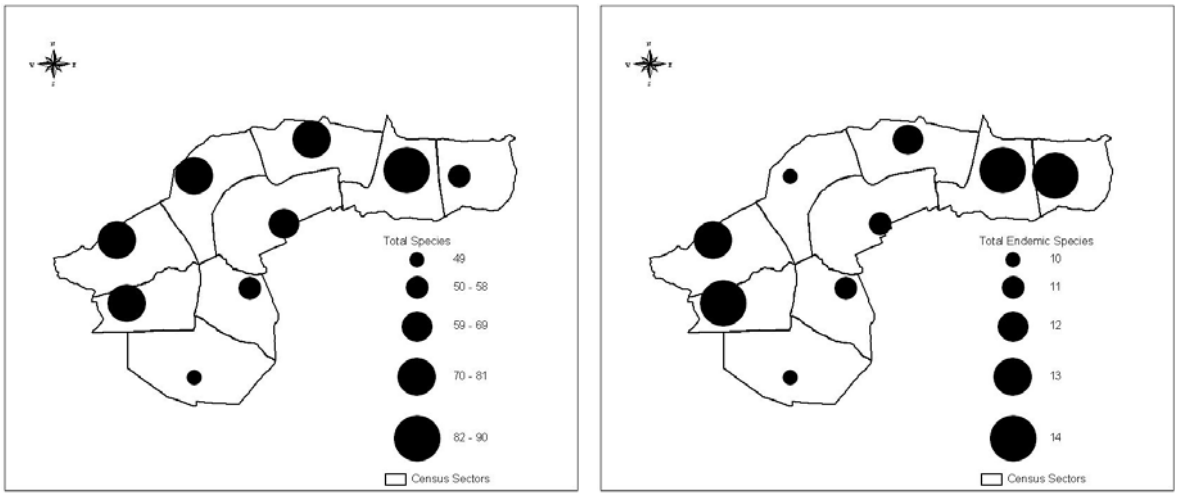


Figure 2. 3. *A comparison of total bird species (left) and number of endemic species (right.*

Table 2. 4 *Total number IUCN listed species and number of Albertine Rift Endemic in each sector*

	A	B	C	D	E	F	G	H	I
No. of ARE spp	11	15	12	14	11	12	13	15	15
Total No. of spp	49	77	57	77	76	70	82	91	59
Total No. of points	50	62	51	58	68	61	66	65	50

2.5.4 Diversity indices in the sectors

A Shannon-Wiener Index of diversity and evenness was calculated for each of the nine sectors surveyed based on the point count data (Table 2.5). As found for species richness and FF species, sectors in PNVi and MGNP were more diverse compared to sectors in PNV.

Table 2. 5 *Shannon-Wiener Diversity values for each of the nine sectors.*

Index	A	B	C	D	E	F	G	H	I
Shannon H'	1.191	1.511	1.269	1.537	1.497	1.392	1.506	1.542	1.299
Shannon Hmax	1.477	1.813	1.633	1.799	1.748	1.785	1.799	1.869	1.568
Shannon J'	0.806	0.834	0.777	0.854	0.856	0.78	0.837	0.825	0.829

2.5.5 Similarity between bird communities in sectors

The similarity between bird communities for the 9 sectors was calculated based on point count data. Sectors E and G in PNVi were the most similar (73.9% similar) followed by H and F in PVN (70.2%). These sectors lie adjacent to each other, are contiguous and are at low elevation with similar vegetation types. Sectors A & E were the most dissimilar Figure 2.4 and Table 2.6.

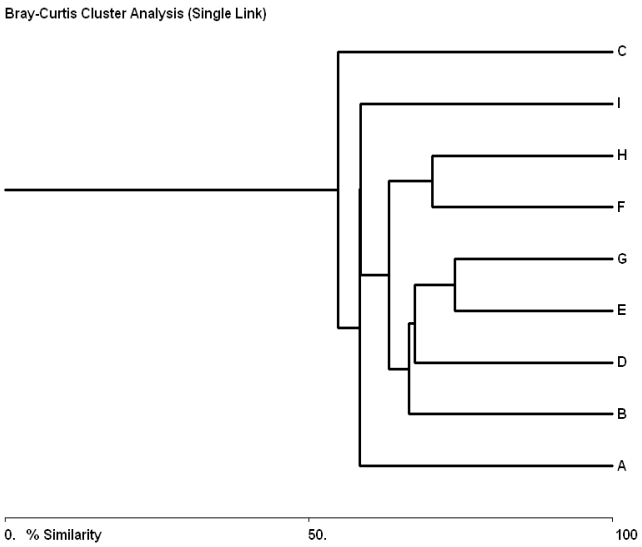


Figure 2. 4. *Cluster analysis for the nine sectors surveyed using point count data grouped into three main groups.*

Table 2. 6. *Values for percentage similarity for the nine sectors.*

	A	B	C	D	E	F	G	H	I
A	*	39.9	54.9	29.1	27.1	40.4	28.6	40.9	58.3
B	*	*	49.2	66.4	57.1	63.1	61.2	60.1	55.1
C	*	*	*	41.6	31.4	51.2	34.1	48.7	53.8
D	*	*	*	*	67.4	57.9	67.5	59.3	43.8
E	*	*	*	*	*	52.6	73.9	56.8	38.6
F	*	*	*	*	*	*	53.4	70.2	56.9
G	*	*	*	*	*	*	*	58.7	40.9
H	*	*	*	*	*	*	*	*	58.4

2.5.6 Albertine Rift Endemic Species

Table 2.7 gives the threatened and Albertine Rift Endemic species seen/heard for each of the three protected areas surveyed. Eighteen endemic species were recorded which represented 90% of these species so far recorded for the massif. Plumptre *et al.* (2003) gave the number of endemics in the area as being 20. The highest number of endemics occurred in MGNP (17 species) while the least number was recorded in PNV even though less time was spent in MGNP.

Relative estimates of abundance for the threatened and Albertine Rift Endemic species for MGNP, PNVi and PNV were calculated as encounter rates (Table 2.7). In MGNP a total of 61 points were visited for a total period of 5 survey hours of observation. In PNVi a total of 254 points were visited for a period of 21 survey hours while PNV had a total of 212 points visited for a total period of 17 survey hours. Handsome Francolin, Red-throated Alethe, Kivu Ground Thrush and Dusky Crimson-wing were rarely recorded using the Point Count method. On the other hand, Archer's Ground Robin, Collared Apalis, Red-faced Woodland Warbler and Mountain Masked Apalis were relatively common wherever they occurred. Grauer's Rush

Warbler, Rwenzori Nightjar and Shelley's Crimson-wing were not detected by the Point Count method, but were detected by the opportunistic method of observations.

Table 2. 7 *Encounter rates (no/hour) for threatened and Albertine Rift Endemic species in the three protected areas.*

Species	Category	MGNP	PNVi	PNV
Handsome Francolin	FF	0.4		
Rwenzori Turaco	FF	6.4	1.4	2.5
Rwenzori Double-collared Sunbird	F	8.6	1.8	11.4
Rwenzori Nightjar	F	P		
Archer's Ground Robin	F	6.4	5.5	8.9
Red-throated Alethe	FF	0.2	0.3	
Kivu Ground Thrush	FF	0.4	0.1	0.1
Collared Apalis	F	2.8	7.0	3.0
Mountain Masked Apalis	FF	2.0	3.7	0.8
Red-faced Woodland Warbler	FF	3.2	5.0	4.1
Grauer's Rush Warbler	EN	P		
Rwenzori Batis	F	1.0	2.3	2.1
Stripe-breasted Tit	FF	0.4	0.3	1.2
Blue-headed Sunbird	FF	0.2	0.9	0.1
Regal Sunbird	F	1.4	4.5	1.1
Strange Weaver	F	0.6	3.3	0.4
Dusky Crimson-wing	F		0.2	
Shelley's Crimson-wing	F/VU		P	P
Total number of species		**17**	**16**	**15**

0.1-0.4 Rare; 0.5 - 1.0 Uncommon; 1.1 – 2.0 Frequent; 2.1-5.0 Common; 5.1 – 10+ Abundant
P= Present

2.5.7 Bird species and habitat types

The highest number of bird species (95) was recorded in the mixed forest and was followed by the bamboo zone (72) species (Table 2.8), although examination of the rarefaction curves (Figure 2.2) shows that grassland and woodland may have higher numbers of species for the same number of individuals sampled (i.e. when effort is controlled). The lowest number of species (35) was recorded in grassland but this is a rare habitat type and hence was not sampled greatly. Fifteen Albertine Rift Endemics were recorded in the mixed forest followed by bamboo (12 species). Generally species number and the abundance of many of the species increased up to the *Hagenia-Hypericum* woodland and then declined in the sub-alpine zone. The Blue-headed Sunbird, Red-throated Alethe and Dusky Crimson-wing were only recorded in the mixed forest while Archer's Ground Robin, Collared Apalis, Rwenzori Double-collared Sunbird and Rwenzori Turaco were recorded in all the major habitat types. The Regal Sunbird, Mountain Masked Apalis and Strange Weaver were most encountered in the mixed forest while the Rwenzori Double-collared Sunbird and stripe breasted Tit were common in the *Hagenia-Hypericum* woodland. Only three species Archer's Ground Robin, Rwenzori Double-collared Sunbird and Rwenzori Turaco were common in the sub-alpine zone.

Table 2. 8 *The total number and encounter rates of Albertine Rift Endemics recorded in the major habitat types*

	Grass	Disturbed woodland	Mixed forest	Bamboo	*Hagenia-Hypericum*	Sub-Alpine/ Alpine	Swamp
Archer's Ground Robin	2.40	6.35	5.87	7.90	7.78	6.78	5.33
Blue-headed Sunbird			0.98				
Collared Apalis	6.00	3.13	6.90	4.18	1.14	0.52	5.33
Dusky Crimson-wing			0.21				
Handsome Francolin			0.05	0.08			
Kivu Ground Thrush			0.05	0.15	0.16		
Mountain Masked Apalis		1.04	3.66	1.47	0.97		9.33
Red-faced Woodland Warbler		1.57	5.05	6.12	1.62	1.04	
Red-throated Alethe			0.26				
Regal Sunbird		2.61	3.66	2.71	0.49	0.52	5.33
Rwenzori Batis	1.20		2.11	2.55	2.11		
Rwenzori Double-collared Sunbird	4.80	6.26	1.91	2.63	27.57	8.35	1.33
Rwenzori Turaco	2.40	4.70	1.65	2.63	2.92	3.13	2.67
Strange Weaver	1.20		3.30	0.77	0.32		2.67
Stripe-breasted Tit			0.21	0.23	3.08	1.57	
Total No. ARE	**6**	**7**	**15**	**12**	**11**	**7**	**7**
Total No. Species	**35**	**48**	**95**	**72**	**57**	**29**	**33**
Total No. Points	**10**	**23**	**233**	**155**	**74**	**23**	**9**

2.5.8 Bird species richness with altitude

Bird species richness and abundance was highest between 2,100-2,700 m then decreased with increasing altitude. There were no Albertine Rift endemics recorded above 3600 m although 9 species (non endemic) were recorded here (Table 2.9). There were only 5 Albertine Rift Endemics recorded between the altitudinal ranges of 3300-3600 m. Species richness in Virunga Volcanoes appears to be dependent on vegetation types which in turn depend on altitudinal range or climate.

Table 2.10 summarises the number of Albertine Rift Endemics detected in each sector. Sectors B, H and I had 15 Albertine rift endemics each while sectors A and E had only 10 endemics detected. Almost half of the endemics were detected in each of the sectors and were wide spread and the remaining 9 species were not all that wide spread as seen from the distribution maps (Appendix 1). There was a general pattern of some of the species preferring montane mixed forest while the others preferred the higher altitude habitats.

Table 2. 9 *The total number and encounter rates of Albertine Rift Endemics species at different altitudinal range in Virunga Volcanoes*

	1801-2100	2101-2400	2401-2700	2701-3000	3001-3300	3301-3600	3601-3900
Archer's Ground Robin	6.00	4.83	5.54	4.14	3.76	5.40	
Blue-headed Sunbird	0.86	0.75		0.11	0.18		
Collared Apalis	5.14	5.89	5.21	2.44	0.72		
Dusky Crimson-wing		0.23					
Handsome Francolin			0.08	0.11			
Kivu Ground Thrush		0.08	0.17	0.11			
Mountain Masked Apalis		1.66	1.90	1.59			
Red-faced Woodland Warbler	0.86	2.79	2.90	3.93	0.90		
Red-throated Alethe		0.30	0.08				
Regal Sunbird		3.02	1.66	1.27	0.72	0.60	
Rwenzori Batis	1.71	1.89	1.08	1.59	0.54		
Rwenzori Double-collared Sunbird		0.83	2.32	3.50	9.49	9.00	
Rwenzori Turaco		0.23	1.90	3.93	3.04	3.00	
Strange Weaver	0.86	2.94	1.24	0.42			
Stripe-breasted Tit		0.15	0.08	0.32	0.90	0.60	
Total No. of ARE Spp	**6**	**14**	**13**	**13**	**9**	**5**	
Total No. of Species	**40**	**93**	**91**	**65**	**45**	**16**	**8**
Total No. of Points	**14**	**159**	**145**	**113**	**67**	**20**	**9**

Table 2. 10 *Presence/absence of Albertine Rift Endemic species detected in each sector.*

	A	B	C	D	E	F	G	H	I
Handsome Francolin		1				1	1	1	1
Rwenzori Turaco	1	1	1	1		1		1	1
Rwenzori Nightjar							1		1
Archer's Ground Robin	1	1	1	1	1	1	1	1	1
Red-throated Alethe				1	1		1	1	
Kivu Ground Thrush	1	1				1		1	
Grauer's Rush Warbler									1
Collared Apalis	1	1	1	1	1	1	1	1	1
Mountain Masked Apalis		1	1	1	1	1	1	1	1
Red-faced Woodland Warbler	1	1	1	1	1	1	1	1	1
Rwenzori Batis	1	1	1	1	1	1	1	1	1
Stripe-breasted Tit	1	1	1	1		1		1	1
Blue-headed Sunbird		1		1	1		1	1	1
Regal Sunbird	1	1	1	1	1	1	1	1	1
Rwenzori Double-collared Sunbird	1	1	1	1	1	1	1	1	1
Strange Weaver	1	1	1	1	1	1	1	1	1
Dusky Crimson-wing	1	1	1	1	1		1	1	1
Shelley's Crimson-wing		1	1	1					
Totals	**11**	**14**	**12**	**14**	**11**	**11**	**12**	**14**	**14**

2.6 DISCUSSION

The total species list of a site describes the diversity of a site and the presence and absence of threatened, endemic and rare species is used as an indicator of the importance of the site for conservation. The results show that the Virunga Volcanoes is important for bird conservation with 294 species recorded. There are 20 endemic species recorded with 4 IUCN Red Data book species. Species richness varied between the different sites possibly being influenced by altitude and types of vegetation. Generally, parts of Virunga Volcanoes at lower altitude with mixed forest, bamboo and Hagenia-Hypericum were more species rich. Therefore sectors in Virunga Volcanoes that represent these habitat types are important for conservation of birds.

Species richness increased gradually with elevation up to 3000 m above sea level then declined with increasing elevation. Many of the species recorded in Virunga Volcanoes occurred at a range of 2100-3000 m above sea level. This could be due to the moist climate of the Virunga Volcanoes at this altitudinal range that provided several habitats. At higher altitude fewer species are adapted to the cold climatic conditions while at lower altitudes (primarily in PNVi) the variety of habitat types was lower. The number of data points does not allow a separation of altitude by habitat type to assess whether this might be the explanation.

The cluster analysis showed that sites in PNVi (G, E, D &B) were similar in species composition (similar altitudinal range with mixed forest as the dominant vegetation type) compared to those sites in PNV and MGNP (C, I, H & F) at higher altitude that had bamboo, *Hagenia-Hypericum* woodland and sub-alpine vegetation types.

Three sectors B, H and I had 15 ARE bird species recorded in each. The distribution patterns of majority of Albertine Rift Endemic species for both plants and birds in Virunga Volcanoes are patchy such that proper assessment of their abundance would require more detailed studies. Such studies could then help managers to identify a few species for future monitoring. For example, Virunga Volcanoes could be one of the best areas in the Albertine Rift for watching and studying the Rwenzori Turaco, Rwenzori Double-collared Sunbird, Archer's Ground Robin and Red-faced Woodland Warbler if alternative trails could be developed in PNV and PNVi. At the moment only MGNP has well developed trail systems that could be used for bird watching. These four species, the Rwenzori Turaco, Rwenzori Double-collared Sunbird, Archer's Ground Robin and Red-faced Woodland Warbler were abundant in all the three protected areas while the Red-throated Alethe, Shelley's Crimson-wing and Rwenzori Nightjar were rarely recorded and more work needs to be done to assess their distributions. This could either be a result of the methods used (as these birds are cryptic and don't call very often) or because these species naturally occur at low densities. A combination of methods especially those that encourage deliberate searching for these species would be recommended for their study. Meanwhile conservation efforts should be focused on the sectors where the majority of the threatened and ARE are distributed as priority sectors.

CHAPTER THREE: PLANTS

3.1 INTRODUCTION

A botanical survey was carried in the Virunga Volcanoes from 10th Jan to 2nd Feb 2004 to provide biological information on the diversity, abundance and distribution of plant species found in the area. Emphasis was placed on documenting plant species that are Albertine Rift Endemics and threatened species to help develop zoning strategy in Virunga Volcanoes. The survey also served as a training exercise for the staff of ICCN, ORTPN and DFGFI to help them undertake research and monitoring in botany in future. This study built upon previous survey work early in the 20th Century and upon a small herbarium at the Karisoke Research Centre.

3.2 STUDY SITES

The nine sampling sectors were surveyed as for the bird survey except not as many points could be visited because of time constraints (Figure 1.1). The sampling points every 250 m along each reconnaissance trail were used to record plants in plots. Botanists with a good knowledge of different species and experience with other surveys in the region were employed to undertake the data collection. Opportunistic recording of species was made at all sites visited.

3.3 METHODS

3.3.1 Circular Plots

Data on herbaceous plants, lianas, shrubs and trees were collected along reconnaissance trails that were also used by the bird team. However, due to the time required to collect and identify plants, the botanical team was generally unable to survey the entire length of the reconnaissance route on a given day. Circular plots of 20 meters in radius measured by a help of calibrated string were established at every 250 meters interval along the reconnaissance trails. Where paths were followed for the reconnaissance trail the plot was centred by more than 20 metres off the path at alternating sides of the path. GPS position, altitude and vegetation type were recorded at each point to help map the plots surveyed. The topographic category of the point location was noted and designated as follows: flat, valley, valley bottom, slope, ridge and ridge top. Trees and shrubs over 2.5 cm diameter at breast height (Dbh) were identified to species level if possible and all species found to be present in the plot were recorded on data sheets. All species of woody plants ≥ 10cm Dbh were counted to quantify the frequency and relative density of each species. All young plants identified as tree species were recorded as saplings if their diameter was less than 2.5 cm at breast height (Dbh). All woody plants above 2.5 cm were recorded in one of the following diameter classes of 2.5 – 9.9 cm, 10 cm – 19.9 cm 20 cm – 39.9 cm, and over 40 cm. Heights and crown cover were estimated for each size class within the plot. Herbs were recorded by their presence in a radius of 2 metres and lianas of over 1 cm diameter just above the ground were recorded within a radius of 10 meters of the plot from the centre. The habitat type of a plot was designated using the following categories: grass, woodland, mixed forest, bamboo, *Hagenia-Hypericum*, subalpine-alpine and swamp. The data were used to show the relative abundance, distribution and diversity of species within sectors. Canopy cover estimation above the plot was classified as <25% (open canopy above the plot), 26-50% (moderately dense canopy cover), 51-75% (very dense canopy cover) and 76-100% (closed canopy cover). Daily opportunistic records were made to include species that were missed during plot sampling and these records were combined with the plot data to produce total species numbers for each sector.

3.3.2 Voucher Specimens

Voucher specimens of the majority of plants of interest in this study were collected from the areas visited. These were collected in triplicate to allow for further identification of those plants that

could not be positively identified and to confirm the identification of those that were identified in the field. Duplicate specimens were deposited in Herbaria in the three countries for preservation and for future studies.

3.4 ANALYSES

3.4.1 Total species

The plant species lists (species richness) were compiled from the plot data and the opportunistic observations. This information was used to compare the three protected areas and the nine sectors.

3.4.2 Species diversity

Species diversity for each of the sectors in the Virunga Volcanoes was calculated using Shannon-wiener index using the plot data. A high value of H' indicates a large number of species with similar abundance, a low value indicates domination by a few species.

3.4.3 Species accumulative curves

Species accumulation curves were plotted for the three protected areas and for the nine sectors. These curves were used to show the trend of species encountered for the same sampling effort as measured by number of individuals measured.

3.4.4 Similarity index

Similarity indices for the forests were presented as dendrograms created using Bay-Curtis linked cluster analysis on the plant plot data. Similarity indices show the percentage similarity between the comparative abundance of species in each site. Those communities that are comparable have an index of 1 while those that are completely dissimilar (i.e. share no species) have an index of zero.

3.4.5 Plant distribution maps

The distribution of the plants within the massif and between sectors was plotted on the map of Virunga Volcanoes to show the sectors that have high species richness and a high number of endemic species.

3.5 RESULTS

3.5.1 Survey routes

The botanical team surveyed a total of 84.75 km of reconnaissance trails in nine sectors in the Virunga Volcanoes. They evaluated 348 circular botanical plots covering a total surface area of 43.69 hectares. 153 plots (19.21 hectares) were sampled in PNV, 155 plots (19.46 hectares) were surveyed in PNVi while 40 (5.02) plots were evaluated in MGNP. Table 3.1 gives the distance walked (km), number of circular plots sampled at every 250 m, and total surface area (ha) of the circular plots evaluated during the botanical inventory in the 9 sectors.

3.5.2 Species Numbers

According to Plumptre *et al* (2003) the number of plant species known for the Virunga volcanoes was 878, of which 81 were trees, 124 plants were Albertine Rift Endemics, 5 plants were IUCN Red data book species. This study recorded 860 species of plants and the list of those plants positively identified is given in Appendix 3. Twenty six plants were identified to genus level only while 822 were identified to species level. 348 species were recorded that were previously unknown to exist in Virunga Volcanoes. 107 plants were new to the Albertine Rift plant checklist

produced by Plumptre *et al* 2003. 12 plant species could not be identified and may represent new species, and are still being reviewed by plant taxonomists. This brings the current list of Virunga Volcanoes plants to 1265. 92 of the species recorded were Albertine Rift Endemics. 7 plant species recorded were IUCN listed. The highest number of plant species was recorded in PNV (624) and least number was recorded in MGNP (313). Herbs accounted for the greatest number of plants recorded in each park as given in Table 3.2. Generally there were very few tree species that were recorded in Virunga Volcanoes with the highest number of trees recorded in PNVi and least number in MGNP.

Table 3. 1 *Distance walked (km), number of circular plots sampled at every 250 m, and total surface area (ha) of the circular plots*

Forest	Site	Distance Walked (km)	Number of Plots	Surface area Of plots (ha)
PNV	A	8.0	36	4.52
	C	8.25	37	4.64
	F	9.5	40	5.02
	H_V	5.0	20	2.51
	I_V	4.5	20	2.51
Total	**5**	**35.25**	**153**	**19.21**
PNVi	B	10.0	40	5.02
	D	11.0	39	4.89
	E	9.75	38	4.77
	G	9.25	38	4.77
Total	**4**	**40**	**155**	**19.46**
MGNP	H_M	5.0	20	2.5
	I_M	4.5	20	2.5
Total	**2**	**9.5**	**40**	**5.02**

Table 3. 2 *Different plant life forms and total number recorded in plots in the 3 protected areas*

	MGNP	PNVi	PNV
Herbs	231	394	478
Lianas	40	87	84
Trees	42	84	62
Totals	**313**	**504**	**624**

Table 3. 3 *Different plant life forms and total recorded in each plots in each sector*

Sectors	A	B	C	D	E	F	G	H	I	Total
Herbs	195	145	203	163	81	253	189	268	208	627
Lianas	28	48	22	54	44	60	50	43	39	126
Trees	28	40	22	43	36	33	44	47	36	107
No. ARE spp	32	24	28	28	17	28	35	48	35	92
No. IUCN spp	2	3	2	2	1	2	2	2	2	7
Total	251	233	247	260	161	346	283	358	281	860

Species richness varied between the different sites surveyed with the highest number of species recorded in sector H with 358 species followed by sector F (346 species) while the least number of species was recorded in E with 161 species (Table 3.3). The western part of the massif was

richer in total number of species and endemics (Figure 3.1). The distribution of some of the endemic species is given in Appendix 4 and the list of plants per sector in Appendix 5.

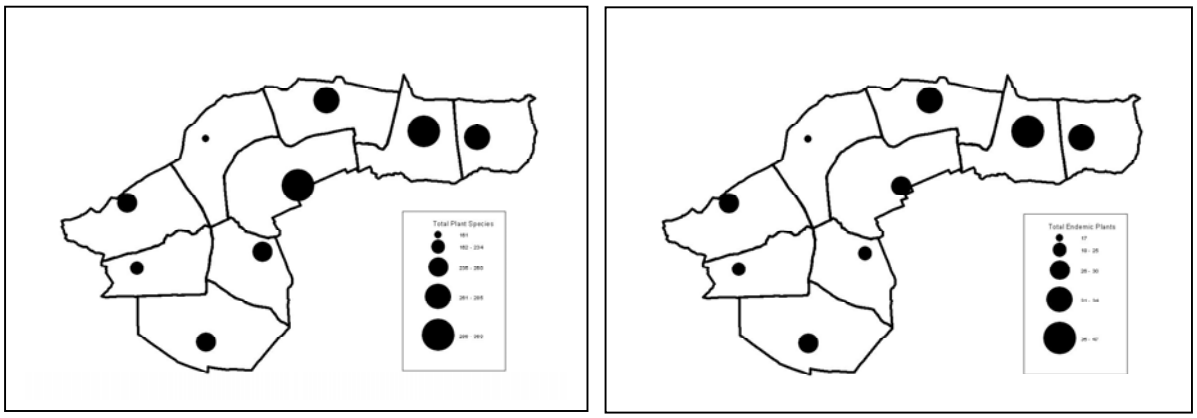


Figure 3. 1 *A comparison of total plant species(left) and number of endemic species (right)*

3.5.3 The Vegetation types

The vegetation types in Virunga Volcanoes were divided into 7 broad types (Table 3.4). On average 5 ha of vegetation was surveyed in each sector. The largest vegetation type found in PNVi was the mixed forest type represented by 16.34 ha (68.4%). In PNV bamboo 8.04 ha (43.2%) was the largest vegetation type represented which was followed by *Hagenia-Hypericum* woodland. MGNP had the mixed forest 34% and bamboo 24% as the dominant vegetation types. Sector H had all the 7 habitat types represented in it and was also the most species rich. The least number of habitat types occurred in sector A with only three representatives and was least in species number.

Table 3. 4 *Surface area surveyed (ha) of each of the dominant vegetation types in each sector.*

	A	B	C	D	E	F	G	H	I
Sub-Alpine/Alpine		0.25	0.38					0.26	0.38
Hypericum-Hagenia	1.26	0.88	2.89	0.25		0.38		0.88	0.63
Mixed closed forest	0.75	3.14	1.26	4.65	4.53	0.63	4.02	2.15	2.77
Bamboo zone	2.51	0.88			0.50	3.89		1.01	1.64
Open grassland								0.50	
Swamp forest			0.13	0.13			0.75	0.38	0.38
TOTAL	**4.52**	**5.15**	**4.66**	**5.03**	**5.03**	**4.9**	**4.77**	**5.18**	**5.8**

3.5.3 Diversity indices

A Shannon-Wiener Index of diversity and evenness was calculated for each of the nine sectors surveyed based on the plot data and (Table 3.5). Sectors H and I were the most diverse.

Table 3. 5 *Shannon-Wiener Diversity values for each of the nine sectors.*

Index	A	B	C	D	E	F	G	H	I
Shannon H'	1.882	1.958	1.96	1.868	1.91	2.151	2.052	2.27	**2.125**
Shannon Hmax	2.086	2.188	2.204	2.137	2.161	2.365	2.27	2.42	**2.322**
Shannon J'	**0.902**	**0.895**	**0.889**	**0.874**	**0.884**	**0.909**	**0.904**	**0.938**	**0.915**

3.5.4 Species accumulation curves

The rarefaction curves for the parks indicate that MGNP and PNV were similar in species richness but that PNVi had fewer species per unit effort (Figure 3.2).

The rarefaction graphs for the plant species richness for the 9 sectors surveyed in the Virunga Volcanoes showed that sector H that lies partly in PNV and partly in MGNP had the highest species richness followed by sector B in PNVi. Sector A in PNV was the poorest in species richness of all the sectors surveyed and also in number of plants encountered per point. A similar trend was observed in the bird results. Species richness found in these sectors could be attributed to the varied habitat types at different altitudes. All the graphs had not levelled off showing that new species could still be added with more effort. This indicated that species list derived from this short sampling period was likely to be far from complete (Figure 3.3).

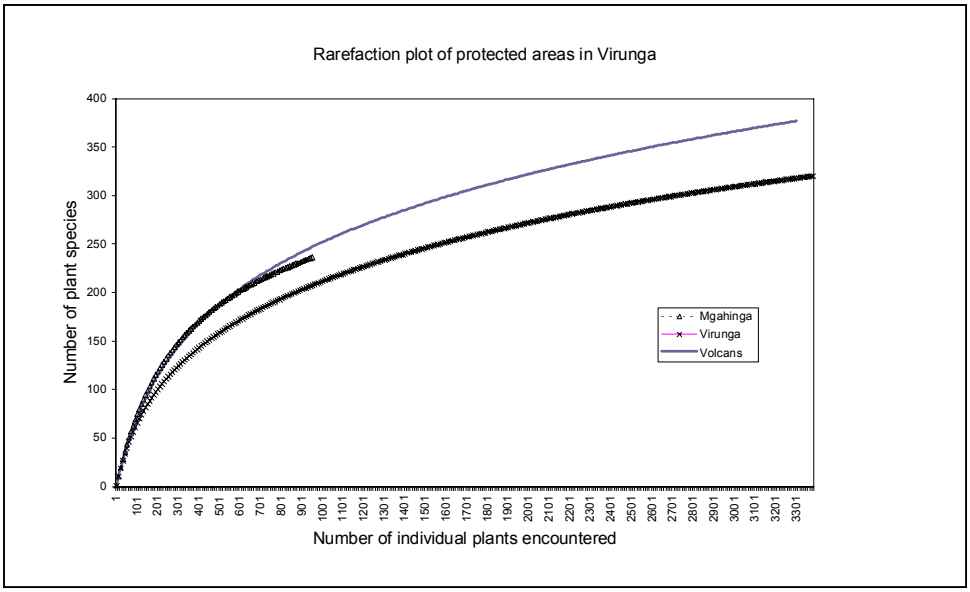


Figure 3. 2 *Plant species richness in Virunga Volcanoes. PNV was the most species rich followed by MGNP and PNVi was the least.*

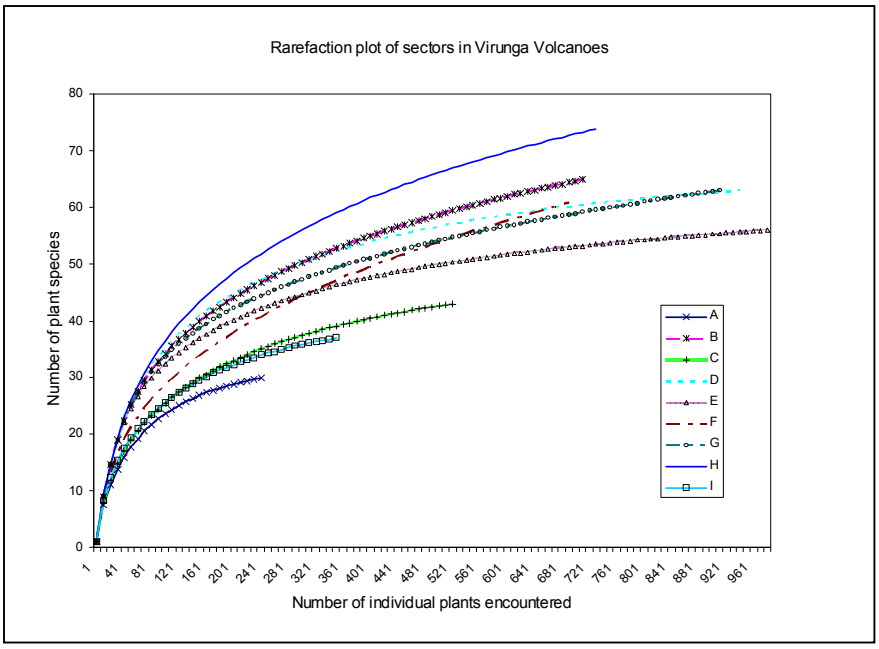


Figure 3. 3 *Plant species richness in sectors.*

3.5.5 Similarity between plant communities

The similarity between plant communities for the 9 sectors was calculated based on plot data. Sectors D, E and G in PNVi were the most similar (E & G by 61.71% and D and E by 53.28%). Sectors A, C & E were the most dissimilar (A & E similar by 18.98 and C & E similar by 17.98) (Figure 3.4 and Table 3.6).

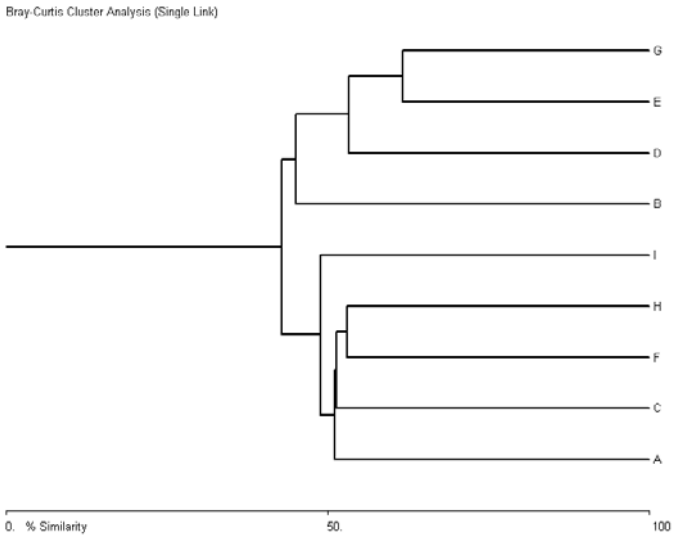


Figure 3. 4 *Cluster analysis for the nine sectors surveyed using plot data*

Table 3. 6. *Values for percentage similarity between the nine sectors.*

	Im	B	D	E	G	A	C	F	Hv	Iv
Hm	28.15	29.08	29.55	23.94	28.48	29.51	32.91	42.48	39.97	42.90
Im	*	32.98	22.16	20.26	26.80	27.22	26.02	28.03	28.91	32.17
B	*	*	45.02	37.73	40.29	38.48	40.48	41.26	29.49	34.63
D	*	*	*	53.28	47.25	27.15	28.48	38.81	27.72	27.12
E	*	*	*	*	61.71	18.98	17.94	27.14	21.22	20.22
G	*	*	*	*	*	22.78	20.23	30.20	25.71	23.65
A	*	*	*	*	*	*	51.10	42.55	26.07	42.81
C	*	*	*	*	*	*	*	51.34	27.18	39.09
F	*	*	*	*	*	*	*	*	42.45	43.51
Hv	*	*	*	*	*	*	*	*	*	40.44

3.5.6. Plant species richness with altitude

Generally, plant species richness was highest at the lower altitudes (2100-2700 m) and decreased with altitude above 2700 m. Numbers of endemic plant species were highest between 2700-3000 m but there were at least seven endemic plants above 3300 m. (table 3.7, figure 3.5). The differences between the rarefaction curves at different altitudes is not as great as for birds (figures 2.2 and 3.5) indicating that birds are affected more by altitude changes than plants.

Table 3. 7 *Total species richness and number of endemic plant species recorded at different altitudes using the plot data.*

Altitude	**2101-2400**	**2401-2700**	**2701-3000**	**3001-3300**	**3301-3600**	**3601-3900**
Number of plots	107	100	82	46	10	3
Plant species	311	374	282	200	70	28
Endemics	19	19	24	13	7	1

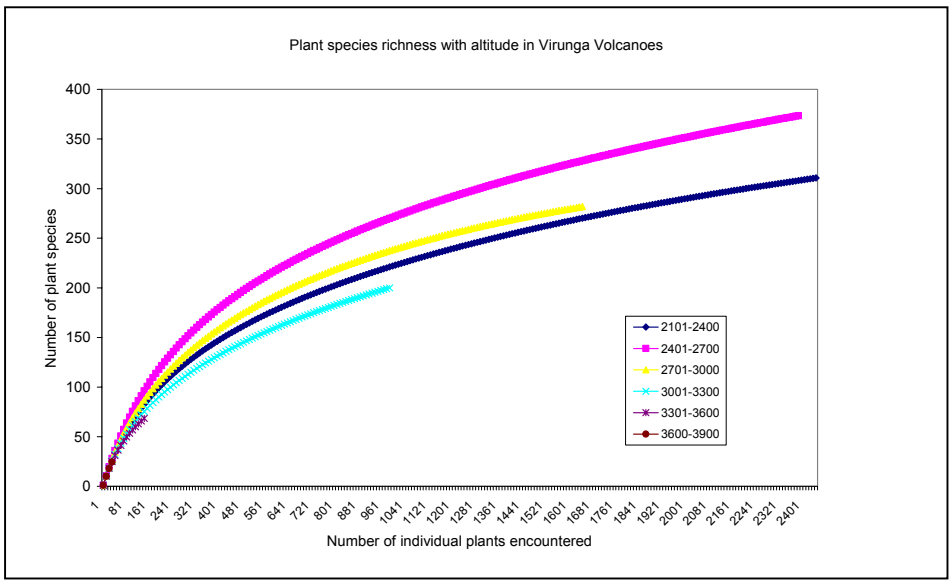


Figure 3. 5 *Species rarefaction curves for plants collected in plots at different altitude ranges.*

3.6 DISCUSSION

The total species list of a site describes the diversity of a site and the presence and absence of threatened, endemic and rare species is used as an indicator of the importance of the site for conservation. The results show that the Virunga Volcanoes is important for plant conservation with 1265 species now recorded. There were 92 endemic species recorded with 7 IUCN listed plant species. The addition of 348 species to the previous list of Virunga Volcanoes within a period of 1 month's survey showed how rich the massif was. 107 plant species were new to the Albertine Rift plant checklist produced by Plumptre *et al* (2003). Species richness varied between the different sites, possibly being influenced by altitude and habitat types.

The cluster analysis showed that sites in PNVi (G, E, D &B) were similar in species composition (similar altitudinal range with mixed forest as the dominant vegetation type) compared to those sites in PNV and MGNP (C, I, H & F). This was very similar to the data found in the bird survey (chapter 2) indicating that both birds and plants reflect similar patterns.

The different vegetation types in Virunga Volcanoes seemed to determine species diversity. For example sector H had all the 7 habitat types represented in it and was also the most species rich for both plants and birds. The least number of habitat types occurred in sector A with only three representatives and this also had the fewest species numbers.

The eastern part of the massif had the highest numbers of endemic plant species, particularly around Sabinyo volcano. This region should therefore be a focus for plant conservation in the Virunga Volcanoes.

Given the short time of the survey and the limited access to certain areas of the massif we would recommend that further botanical survey work be undertaken, particularly at the higher altitudes, to improve on the species lists we have compiled to date.

CHAPTER 4: MAMMALS

4.1 INTRODUCTION

A survey of Mountain Gorillas (*Gorilla beringei beringei)* was undertaken in September 2003 for the first time since 1989. During this survey additional data were collected about the sightings of other large mammals and data were also collected on the sightings of faeces of elephants, buffalos and pigs. It was decided at the time that it would be logistically impractical to include a census of the faeces of other species because they are often cryptic, particularly when semi-decayed, and can be covered with leaves that fall from the trees. They therefore require more intensive searching, which would have slowed teams down. Sightings of some of the mammals such as the duikers, bushbucks, buffalos and elephants were few during the gorilla survey and as a result it was decided that it would be useful to complement this information with a survey of the dung of these species.

Faecal counts provide an index of animal abundance but need to be corrected for the amount of dung produced each day by an individual and also by the rate of decay of the dung if population abundance is required. There are many factors that affect the decay of faeces and hence its relative abundance, which can make comparing sites problematic. Generally two methods of faecal counting have been used: the standing crop count and the marked pellet group count (Staines and Ratcliffe, 1987). The 'standing crop count' provides a count of what dung is present at a site and requires to be corrected by dung decay and dung production rate. The 'marked pellet group count' entails revisiting plots regularly and recording any dung that has appeared since the last visit, destroying or marking any dung found. This technique avoids the need to calculate dung decay rates but is more labour intensive (Plumptre et al. 1997).

4.2 STUDY SITES

The same sampling sites at 250 m along the reconnaissance trails were used to count piles of faeces. In most sectors plots were surveyed along every reconnaissance trail, however in sector B insecurity and the time required meant that two reconnaissance trails were not sampled.

4.3 METHODS

Circular plots of 10 m radius were searched intensively at every sampling point. This included clearing loose vegetation to check for faeces that may have been hidden recently. Faeces of elephant (*Loxodonta africana*), buffalo (*Syncerus caffer*), bushbuck (*Tragelaphus scriptus*), black-fronted duikers (*Cephalophus nigrifrons*) and hyrax (*Dendrohyrax arboreus*) were recorded. Of these species it is possible to mis-identify duiker and bushbuck faeces and training was given to the teams involved in how to identify the differences. They can be distinguished on pellet shape, size as well as smell and training was provided by Dr Andrew Plumptre who had studied these species for his Ph.D. (Plumptre 1991). Hyrax defaecate on the ground in certain areas or latrines within their territory where they come to feed on the ground, but they also defaecate in trees and no attempt was made to count tree latrines.

Faeces of these species decay at different rates in different seasons, at different altitudes and in different habitats. It was impossible to measure decay rates at different sites because the security situation prevented repeated visits to these sites. It is therefore difficult to calculate densities of animals in each of the sectors sampled. However, data do exist from an intensive study carried out in the late 1980s, which monitored decay of black-fronted duiker, bushbuck, buffalo and elephant faeces over the course of a year at different altitudes and in different habitats (Plumptre,

1991; Plumptre and Harris, 1995). Analyses were made about the variability of the decay of these faeces at different altitudes in order to obtain a correction factor to be able to compare dung density at different altitudes within the Virunga Volcanoes. Maps were also produced of the relative distribution of faeces of these species in ARCVIEW 3.2a and these were compared with the sighting data from the mountain gorilla survey.

4.4 RESULTS

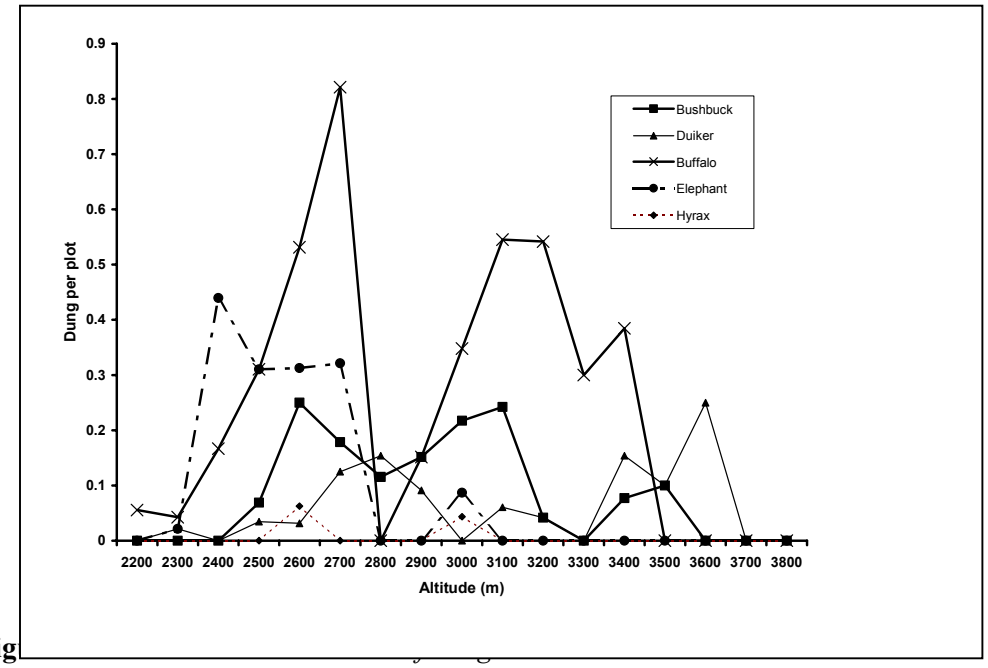
4.4.1. Dung density and altitude

Reasonable data were obtained for four of the species but Hyrax dung sightings were few (only 3 from 445 plots). In general this is partly because they also defaecate in trees but also because they have been hunted fairly intensively at the lower altitudes in DR Congo and probably do not descend to the ground often. Data for the other species are summarised in table 1 and show that buffalo and elephant dung was the most abundant.

Table 4. 1 *Number of dung piles observed in 445 plots and the density of dung (number per hectare) across the massif.*

Species	Number of dung piles	Dung Density (no/ha)
Black-fronted duiker	24	1.72
Bushbuck	44	3.15
Buffalo	141	10.09
Elephant	69	4.94

Observations varied with altitude with most plots occurring between 2,300 and 3,200 metres altitude. The abundance of dung per plot also varied with altitude differently for the different species (figure 4.1).



Fig

4.4.2 Distribution of dung in Virunga Volcanoes

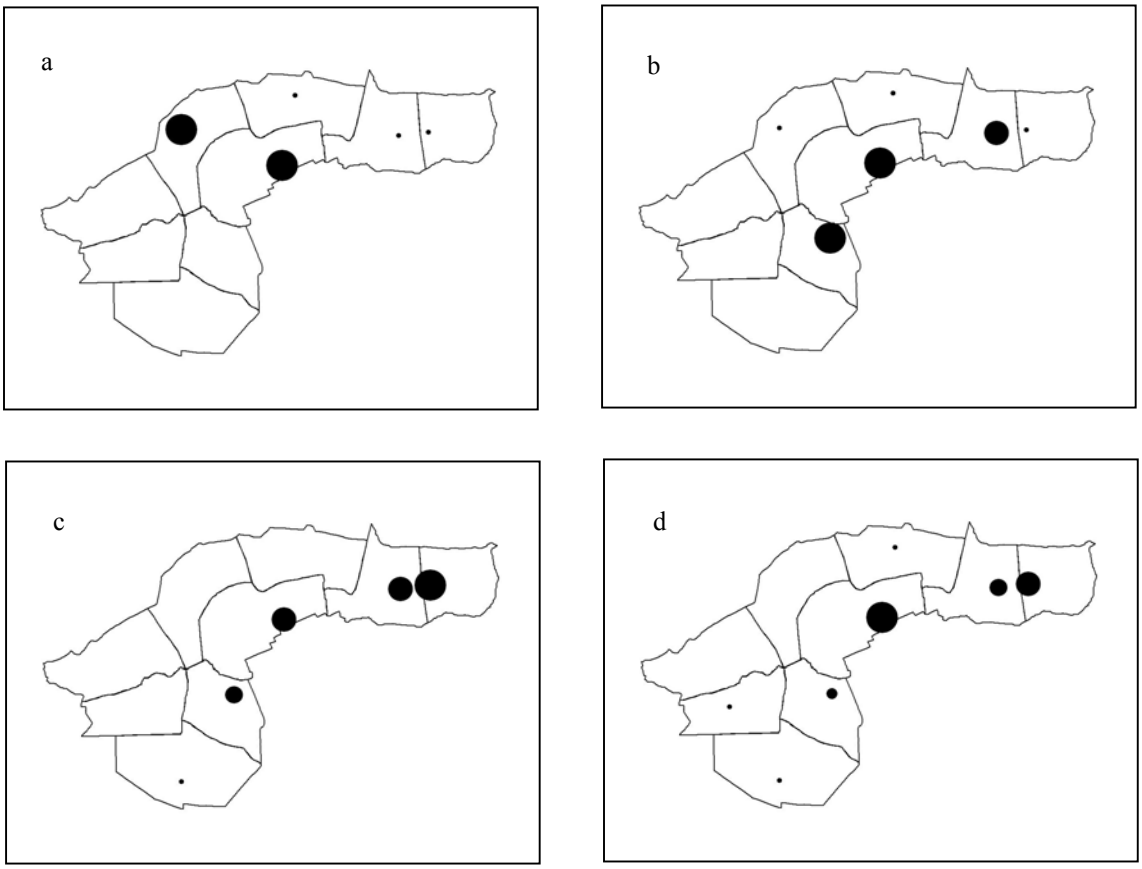


Figure 4. 2 *Relative abundance of faeces in each sector surveyed. a) elephant; b) buffalo; c) bushbuck; d) black-fronted duiker*

The relative distribution of dung across the massif was fairly similar for buffalo, bushbuck and black-fronted duiker (bovids) but was different for elephant (figure 4.2). The bovid dung was more abundant in Rwanda and Uganda when compared with DR Congo while elephant dung was more abundant in the montane mixed forest at the lower altitudes and in the saddle between Visoke and Sabinyo volcanoes.

However, it is possible these patterns are affected by differences in altitude and habitat type and that they do not reflect true animal abundance. In order to assess how habitat and altitude affect dung decay in the Virunga Volcanoes a more detailed analysis was made of data collected in 1988-1990 which monitored the decay of bushbuck, black-fronted duiker, elephant and buffalo dung (Plumptre, 1991).

4.4.3. Variation in dung decay rates

Dung was placed out in various habitats as follows: Bushbuck dung (20 piles) was placed in eight habitat types (alpine, giant *Lobelia*, *Hypericum* woodland, *Hagenia-Hypericum* woodland, meadow, bamboo, herbaceous and high altitude meadows) every month of the year; duiker dung (20 piles) was monitored in *Hagenia-Hypericum* woodland each month of the year only because it was hard to locate enough pellet groups; buffalo dung (at least 20 pats) was monitored in six habitats (Bamboo, herbaceous, meadow, high altitude meadow, alpine and *Hagenia-Hypericum*

woodland) in each quarter of the year and elephant dung was monitored in dry (June-August) and wet seasons (September-October) in three habitats (bamboo, herbaceous and *Hagenia*-Hypericum woodland) when the elephants were in Rwanda. The sample sizes for this study were therefore high: bushbuck (2098 pellet groups), duiker (295 pellet groups); buffalo (652 pats) and elephant (75).

4.4.4 Variation with altitude

Dung at high altitude (over 3,400 metres) tended to decay more slowly than dung at lower altitudes, however there was little variation between altitudes below 3,400 metres (figure 4.2). An ANOVA of the data for each species with Tukey's test for where differences lie indicated that there are significant differences between mean decay rates: bushbuck ($F=20.96$, $df=6,2091$, $p=0.000$; Tukeys: 3200, 3100 < 3400 and 3600 > all other altitudes); buffalo ($F=31.42$, $df=6,646$, $p=0.000$; Tukeys: 3,400 > 2900,3100,3200,3300 and 3600> all other altitudes); elephant ($F=1.41$, $df=2,73$, $p=0.25$). Effectively dung at 3,400 and above tend to be slower to decay and mean decay time increases with increasing altitude. This may have something to do with temperature slowing down the speed at which organisms can break down the dung.

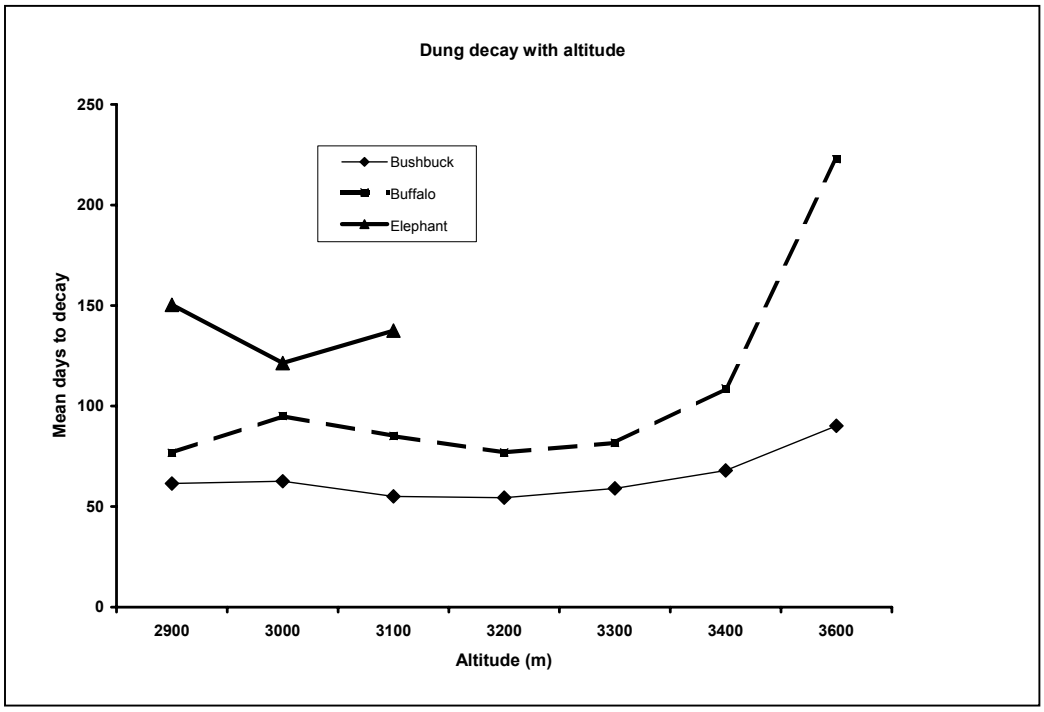


Figure 4. 3 *Mean time to fully decay of bushbuck, buffalo and elephant dung at different altitudes.*

4.4.5 Variation with habitat

Many of the habitats are present at a certain altitude (Spinage, 1972) and as a result it would be expected that decay rate would vary similarly with habitat as it does with altitude. On the whole this is true: bushbuck ($F=18.93$, $df=7,2090$, $p=0.000$; Tukeys: Meadow<Giant *Lobelia*, high altitude meadows, alpine, and alpine>high altitude meadows>all other habitats); buffalo ($F=37.28$, $df=5,647$, $p=0.000$; Tukeys: Alpine > all other habitats), elephant ($F=1.20$, $df=2,73$,

p=0.307). The high altitude habitats (alpine, giant *Lobelia* and high altitude meadows) that differ significantly all occur at or above 3,400 metres.

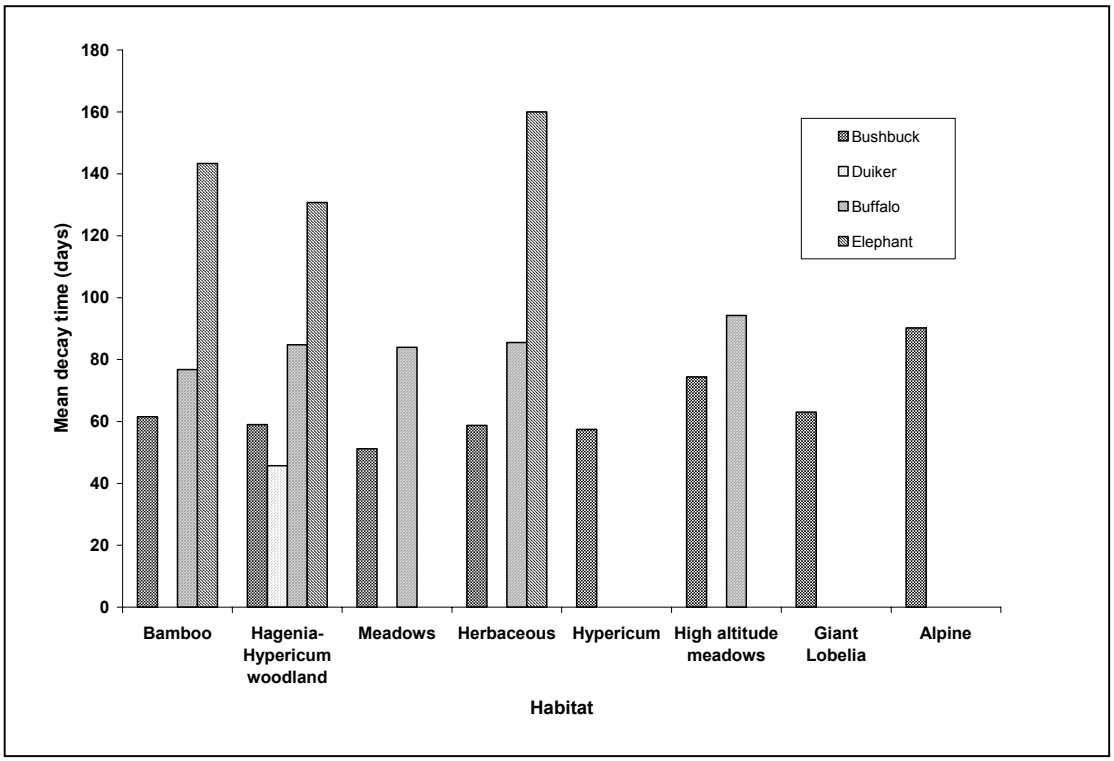


Figure 4. 4 *The mean time to decay for dung monitored in various habitats for the four species.*

4.4.6 Variation with season

Finally there is a seasonal component to the variation in dung decay. There are two wet seasons in the Virunga Volcanoes (March-May and September –November) and two dry seasons. Dung deposited in wet months tended to disappear faster than that deposited in dry months, although if a pellet group/pat survived to the next dry season then it could survive through that season up to the next wet season.

ANOVA comparing mean decay time between seasons shows there are significant differences: bushbuck ($F=184.79$, $df=3,2094$, $p=0.000$; Tukeys: Mar-May< Sep-Nov <Dec-Feb<Jun-Aug); duiker ($F=61.45$, $df=3,191$, $p=0.000$; Tukeys: Mar-May<Sep-Nov; Jun-Aug>other quarters); buffalo ($F=8.55$, $df=3,649$, $p=0.000$; Tukeys: Dec-Feb<other quarters); elephant ($F=4.05$, $df=2,73$, $p=0.021$; Tukey: Sep-Nov <Jun-Aug). The differences between seasons are plotted in figure 4.4 and show that the antelope dung fluctuates similarly whereas the buffalo dung is more stable between seasons. This is probably because it lasts longer and therefore is subject to the climate in subsequent season as well as the season when it is deposited. Interestingly the elephant dung fluctuates more although the sample size in Sep-Nov was only 15 dung piles.

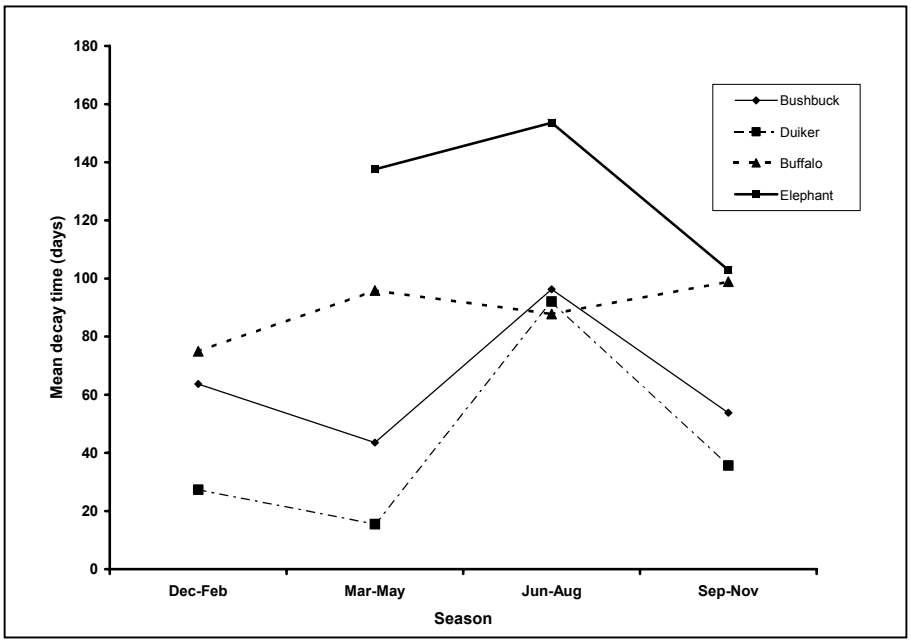


Figure 4. 5 *Variation in mean decay time (days) with season. Mar-May and Sep-Nov are wet seasons.*

4.4.7 General linear models of the variation in dung decay

Which of these factors is responsible for explaining the majority of the variation in decay rates; altitude, habitat type or season. One way this can be explored is the use of general linear models. General linear models area a combination of ANOVA and Multiple Regression analysis and can be used to identify variables that best explain variations in a dependent variable; in this case the mean decay time for dung.

Bushbuck: The bushbuck data was extensive and all three factors were entered. The general linear model identified 'season' and a combined factor of 'season x habitat x altitude' as being the two significant variables that best explained the variation in dung decay. Habitat and altitude on their own were not good predictors once season had been entered.

Black-fronted duiker: The only variable that could be entered was season because dung was only monitored in one habitat and this was at a similar altitude. The results obtained are therefore the same as the ANOVA above.

Buffalo: With all three factors entered the overall general model was highly significant but no single factor was significant on its own or as combined factors. If habitat was omitted then a combined factor of 'season x altitude' was significant. If altitude was omitted then habitat, season and 'habitat x season' were all significant factors. If season was omitted then altitude was just significant as a factor. Consequently season and habitat both seem to be important in determining dung decay in buffalo because habitat is linked closely to altitude and is strongly correlated.

Elephant: Altitude varied little for the elephant dung monitored and hence was omitted. Season was just significant as a factor but habitat was not.

These results indicate that for all species 'season' is probably the key factor in affecting dung decay but that altitude which is closely linked with habitat can also play some role in determining

decay rate. Modelling the variation in decay rates by month and season was necessary when calculating populations from dung counts carried out in 1988-89 (Plumptre & Harris, 1995). It is probable that rainfall is the main cause of variation between seasons and this has been shown to be a good predictor of decay by several studies for elephant dung (Nchanji & Plumptre, 2003).

The fact that seasonality is one of the more important factors in determining decay rates means that the population of dung piles is probably never in a steady state equilibrium. This is one of the assumptions of the Standing Crop Count method (Staines and Ratcliffe, 1987) and therefore this technique is not valid for the Virunga Volcanoes. The Marked Dung Count method is preferable (Plumptre et al. 2003). It also makes it impossible to calculate a density of animals from the existing dung count data from the survey in 2003 by simply using the mean decay rate of dung.

4.4.8 Correcting dung counts

We can, however, use the decay rate data from 1988-89 and estimate the percentage of dung in January that would have been deposited that month and what percentage comes from other months using the model of Plumptre and Harris (1995). If we assume the population remains constant over a period of a year (this may not be completely true as young are born but there was not much seasonality in births so the fluctuations will not be great (Plumptre, 1991)) in the volcanoes then we can estimate how many animals would be needed to create the dung density we found (table 4.2).

Table 4. 2 *Crude population estimates correcting for production rates and assuming the population remains fairly constant. An estimate for the park based on density of animals is calculated using an area of 425 km^2.*

Species	Dung production rate (Plumptre 1991)	Percentage of dung in January deposited in January	Dung density (no/ha)	Estimated Population density (no/km^2)	Estimate of population in park
Bushbuck	19.0	61.3	3.15	0.34	135.2
Duiker	4.4	53.3	1.72	1.38	552.0
Buffalo	5.1	36.4	10.09	2.40	959.2
Elephant	17.0	32.4	4.94	0.21	89.8

These are very much a crude estimates of the population for the Virunga Volcanoes and great care should be used when quoting these figures. It would be preferable to undertake a marked dung count using randomly placed plots than rely on these estimates. It should be remembered that this survey tended to concentrate at the edge of the protected areas because of security concerns and that it was not possible to sample over the whole massif (figure 1.1). Therefore higher altitude areas have probably been under sampled. The bushbuck numbers are particularly low given that they were very high around the Karisoke Research Centre in 1988-1989 (Plumptre & Harris, 1995). Poaching is known to have taken place during the wars in Rwanda and DR Congo but it is unlikely the population is truly this low. It is possible that dung was not searched for carefully enough on the plots (particularly under leaf litter) or that decay rates are ignificantly higher in DR Congo at lower altitudes than the lowest altitude at which dung decay was monitored (2800-2900 metres).

Elephant numbers are probably on the high side as it has always been estimated that about 20-50 animals occur in the massif. Given that less sampling was carried out at high altitude and that elephants rarely move to the high altitudes it is possible that they have been overestimated when

multiplying the density of animals by 425km^2 for the whole massif. Possible a smaller area should be used for all the animals.

4.4.9. Comparisons with sightings

How do the patterns in the distribution of dung (Figure 4.2) reflect the pattern in the distribution of sightings of animals from the gorilla census in September 2003? Figure 4.5 gives the results for the more intensive survey of the Virunga Volcanoes for the encounter rates (number per km walked) of sightings of bushbuck, duikers, and buffalos and of elephant dung. For the most part the patterns are similar to the patterns of dung distribution we obtained indicating that dung distribution does correlate reasonably well with sightings. Sighting methods also have their problems because visibility of animals varies with the density of the vegetation and this was not corrected for in these results.

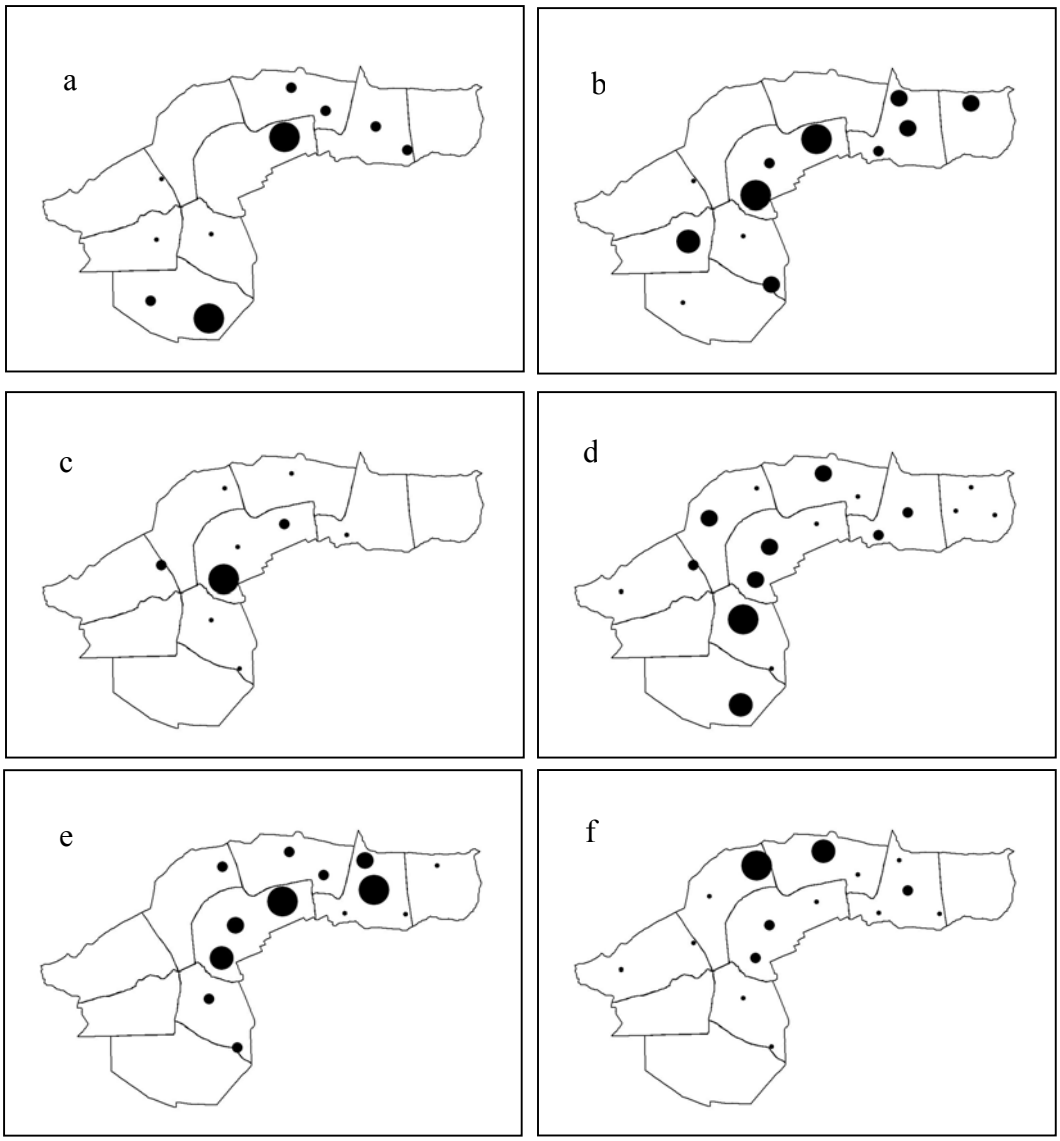


Figure 4. 6 R*elative encounter rates of sightings of a) bushbuck, b) duikers, c) buffalo, and d) gorillas and of sightings of e) buffalo dung and f) elephant dung from the 2003 mountain gorilla survey. Note that more sectors were defined in this survey so several points occur in one sector.*

4.5. CONCLUSIONS

While this survey of large mammals in the Virunga Volcanoes does suffer from using a standing crop count as opposed to a marked dung count method the results are still of some value. In particular the patterns of sightings and faeces of ungulates show a marked drop for these species in the DR Congo part of the massif in comparison with the Rwandan and Ugandan sectors. This may be as a result of higher poaching levels in this region and the lack of security around the Mikeno volcano that prevents rangers patrolling this area regularly. Only elephants consistently use the DR Congo area but concentrate around the ranger stations of Djomba and Bukima.

The 2003 mountain gorilla census also surveyed other large mammal species (figure 4.6) that were encountered along reconnaissance trails while searching for fresh gorilla trail.

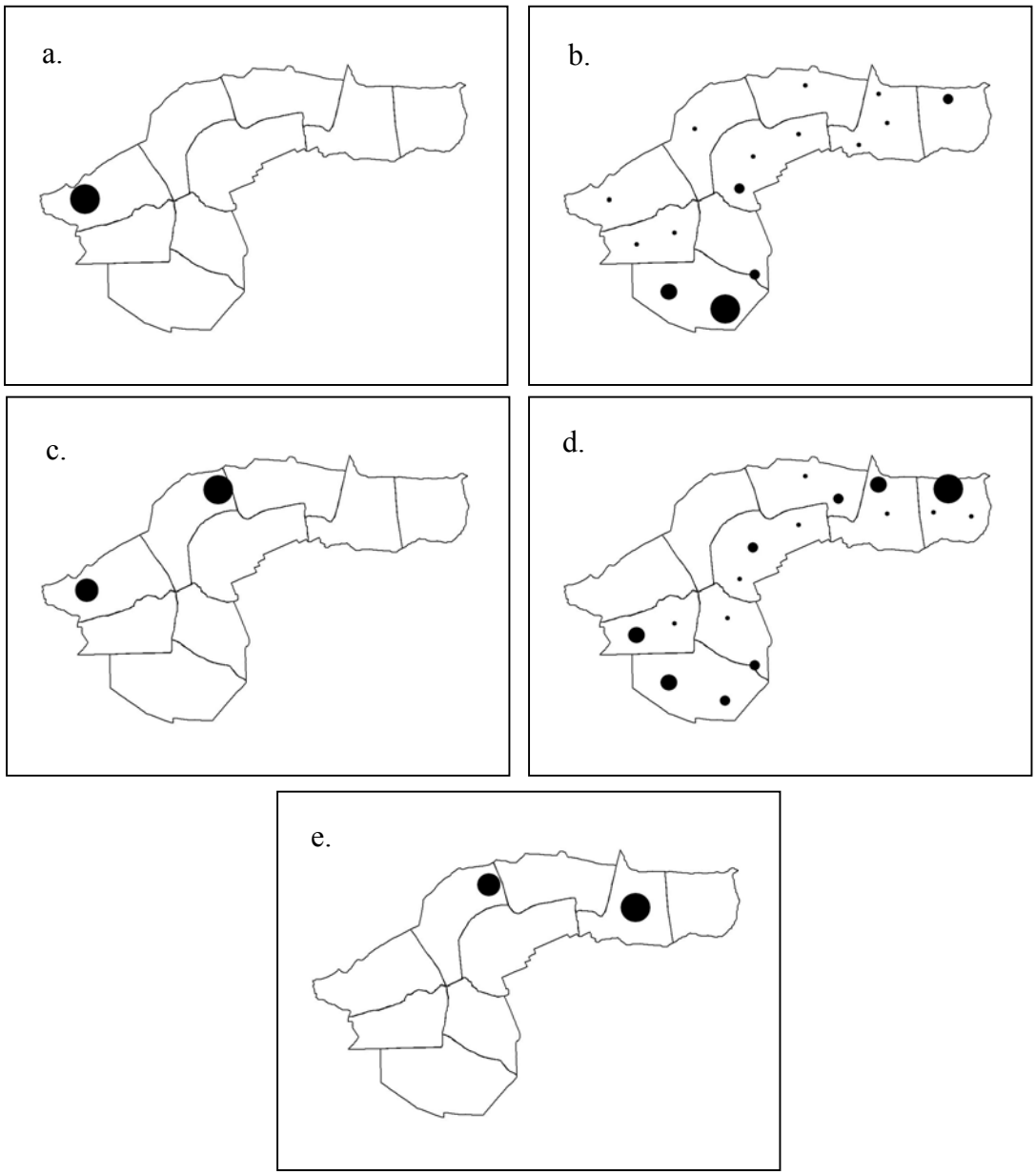


Figure 4. 7 Distributions of other large mammals from the 2003 gorilla census. a) Blue monkey, b) Golden monkey, c) L'Hoest's monkey, d) Carnivore dung, e) Giant Forest Hog dung.

Of the primates, the Golden Monkey (*Cercopithecus kandti)* is of particular concern because the Virunga Volcanoes is the only sure location where this species is found. There has been some debate about whether this animal is a species (Grubb 2001) or subspecies of the blue monkey (*Cercopithecus mitis*) but the most recent classification puts it as a sub-species (Groves et al. 2003). This animal is particularly abundant in the southern part of the Virunga Volcanoes, an area that is not very rich in species of birds or plants and tends to have a lower abundance of other large mammals. However, it is as endangered as the mountain gorilla and should be a focus of more conservation efforts. The other monkey species, Blue and L'Hoest's (*Cercopithecus lhoesti*) are only found at the lower altitudes in the montane forest. Giant forest hog dung was only found at two sites in the forest and is very rare.

Pulling together this information on large mammal species distributions we can create a map that shows the distribution of species richness across the Virunga Volcanoes and the distribution of the endemic sub-species, the mountain gorilla and the golden monkey (figure 4.7).

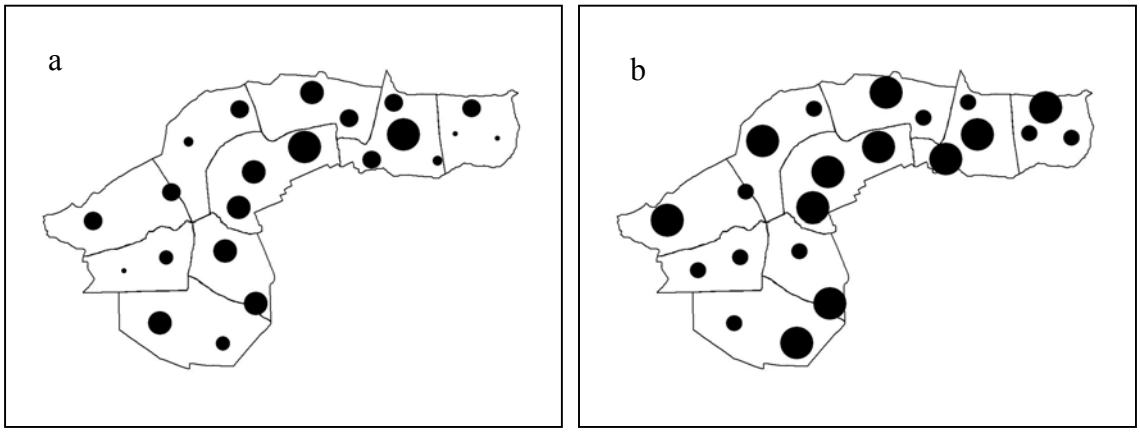


Figure 4. 8 *The distribution of a) large mammal species richness (2-8 species) and b) endemic mammal species (1 –2).*

The two endemic sub-species between them occur over almost the whole massif and do not give any weighting to any particular sectors as a result. Species richness appears to be higher in Rwanda and Uganda but this may be partly because animals are more abundant here and so more readily detected. Little is known about the distribution of smaller mammals in the Virunga Volcanoes massif but we know that a total of 86 mammals have been recorded from here (Plumptre et al. 2003) of which we have only presented data on 10. This should be the subject of a research project to further identify important areas for mammal conservation within the Virunga Volcanoes.

CHAPTER 5: BIODIVERSITY OF VIRUNGA VOLCANOES: CONCULSIONS AND RECOMMENDATIONS

5.1. CONSERVATION IMPORTANCE OF THE VIRUNGA VOLCANOES

The Virunga Volcanoes form part of a larger landscape of contiguous protected areas known as the Greater Virunga Landscape (GVL). This landscape is one of the most species rich in Africa and contains more vertebrate species than any other group of inter-connected protected areas on the whole continent and possibly the world. The GVL is part of the Albertine Rift, a region highlighted by several global priority setting exercises: one of the Global 200 ecoregions, an endemic bird area and part of the eastern montane hotspot (Plumptre et al. 2003). It is particularly important for the number of endemic species it contains (more than any other region in mainland Africa). The Virunga Volcanoes on their own contain a large diversity of species, many of which are endemic. Although the Virunga Volcanoes are only 425 km^2 in area, they contain 45-57% of the endemic vertebrate species found in the Albertine Rift (table 5.1). They also contain 56% of the threatened amphibian species found in the Albertine Rift, making them an important site for amphibian conservation.

Table 5. 1 *The species richness, number of Albertine Rift endemic and IUCN threatened species for five taxa surveyed in the Virunga Volcanoes. Values in parentheses are the percentage of the total for the Albertine Rift.*

	Species Richness	Endemic Species	Threatened species
Mammals	86 (21.3%)	18 (52.9%)	6 (16.7%)
Birds	258 (24.3%)	20 (57.1%)	4 (16.0%)
Reptiles	43 (24.6%)	7 (43.8%)	0 (0%)
Amphibians	47 (39.4%)	16 (47.1%)	9 (56.3%)
Plants	878 (15.2%)	124 (21.5%)	4 (10.0%)
Total	**1,312**	**185**	**23**

This survey added several new species to the list of species for the massif. Thirty six birds were added increasing the species listed for the Virunga Volcanoes to 294. The botanical teams added 366 new species of plant to the existing lists for the massif and the current total list of plant species now numbers 1,244. It is probable that surveys of other taxa could similarly add species for the massif.

5.2. MAPPING SPECIES RICHNESS, ENDEMIC AND THREATENED SPECIES

In order to look at which are the richer sectors of the Virunga Volcanoes and which areas have more endemic species we need to combine the data for the large mammals, birds and plants. The total number of species could be summed for total species richness, number of endemic and number of IUCN threatened species, however, this would give great weighting to the most numerous taxon; plants. A method that gives equal weighting to each taxon is to rank the sectors in terms of the number of species and then sum the sector rankings across the three taxa for species richness, endemic and threatened species separately (table 5.2.). When plotted these give a good overall picture of the conservation importance of the various sectors in the Virunga Volcanoes (figure 5.1).

Table 5. 2 *Species richness (spp), number of endemic(End) and threatened (IUCN) species for the three taxa and the summed rankings across all taxa.*

Sector	Mammals			Birds			Plants			Ranked		
	Spp	End.	IUCN	Spp	End	IUCN	Spp	End	IUCN	Spp	End	IUCN
A	6	2	2	49	11	0	254	30	2	8	9	8
B	4	1	1	77	15	1	234	24	2	9	10	12
C	7	2	2	57	12	1	248	25	2	11	8	13
D	8	2	2	77	14	1	260	27	2	19	12	13
E	6	2	2	76	11	0	161	17	1	9	4	4
F	7	2	2	70	12	0	347	27	1	18	9	4
G	6	2	2	82	13	0	285	34	2	18	14	8
H	8	2	2	91	15	0	360	47	1	26	18	4
I	5	2	2	59	15	1	282	34	1	11	16	9

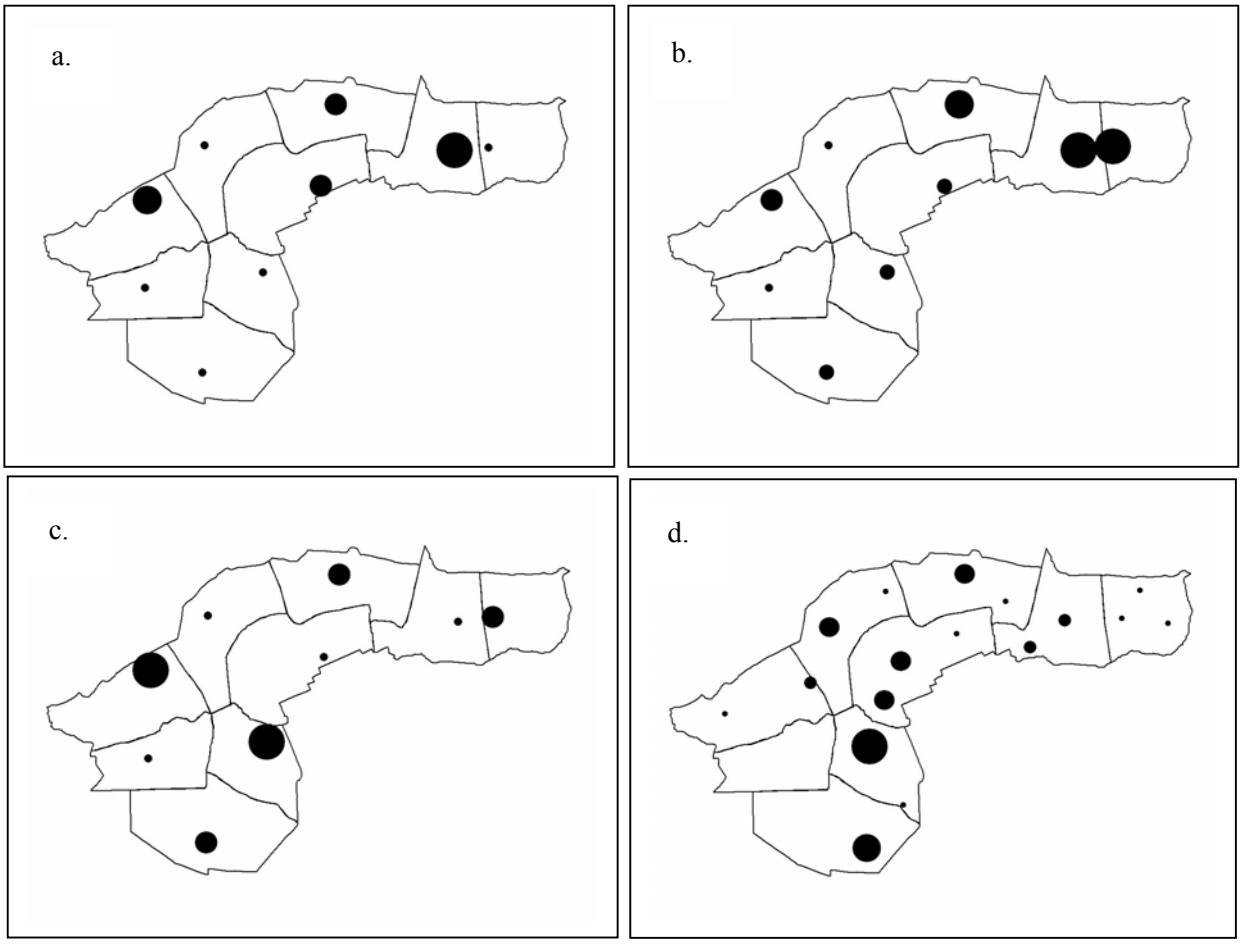


Figure 5. 1 *Combined rankings of a) species richness, b) endemic species, c) threatened species for the three taxa; large mammal, birds and plant and d)gorilla distribution.*

These results show that different parts of the Virunga Volcanoes are important for different conservation targets. If our goal is to conserve biodiversity or total species richness then we will focus on the region between Sabinyo and Mikeno volcanoes (figure 5.1a). However if we want to conserve the restricted range species or endemic species to the Albertine Rift we would focus on the region between Muhabura and Sabinyo volcanoes (figure 5.1b). If we want to conserve threatened species (critically endangered, endangered and vulnerable) then we would focus on the Mikeno-Visoke-Karisimbi region and around Muhabura-Gahinga volcanoes (figure 5.1c). Many of these areas are outside the core concentration of mountain gorilla abundance (figure 5.1d). In reality we want to balance each of these four conservation goals so that we maximise what we can achieve. These results show that the whole massif is important for conservation of these three goals and that any zoning plans should reflect this.

5.3. HUMAN INFLUENCES ON THE VIRUNGA VOLCANOES

This study did not specifically quantify human impacts on the forest as a result of both legal and illegal access because the 2003 mountain gorilla census measured this (Gray *et al.* in press). The census found frequent signs of illegal human disturbance, with antelope snares, paths and tracks of people, and bamboo and wood cutting the most commonly encountered signs. Overall, signs of human activities were most concentrated in the sectors to the south of Karisimbi and Mikeno, and in the far eastern part of the range around Mount Muhavura (Figure 5.2). The distribution of gorillas and at least some other large mammals tended to be negatively correlated with signs of human disturbance, suggesting that either this disturbance has a negative impact on them or that patrol effort tends to focus on areas where gorillas occur and people avoid these areas. Rangers who patrol the Virunga Volcanoes regularly collect a large number of snares from the forest, primarily aimed at killing bushbuck and duikers (Plumptre *et al.* 1997; Plumptre and Williamson, 2001). These have an impact on the large mammal fauna and require constant patrolling to minimise the threat which they pose.

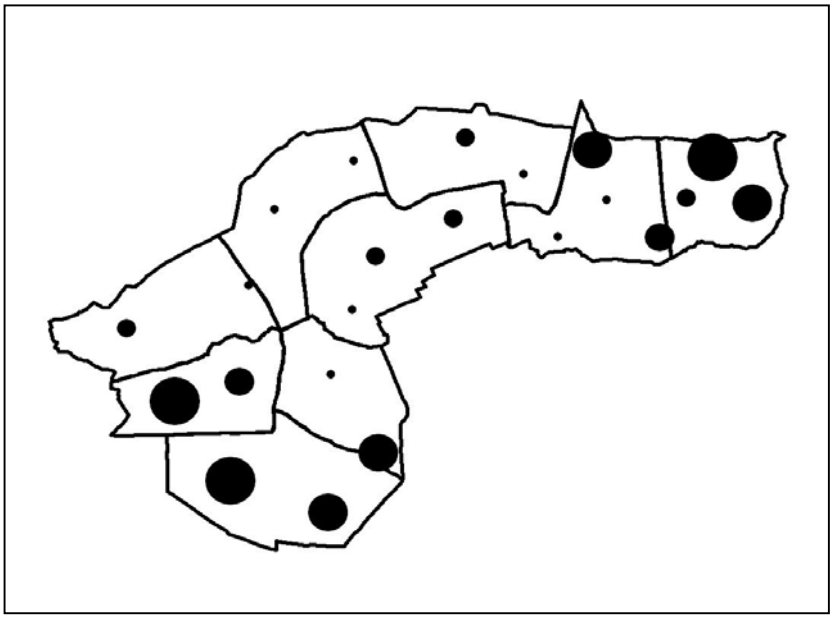


Figure 5.2 *The frequency of encounter of signs of human disturbance found during the 2003 gorilla census in the Virunga Volcanoes – adapted from Gray et al., in press.*

As described above, the whole of the Virunga Volcanoes can be considered a high priority area when species richness, endemism and rarity are all considered as important conservation values, including those areas where levels of human disturbance are highest. The eastern part is important for richness and endemism, while the Karisimbi-Mikeno area is particular important for rare and threatened species.

This study also concluded that the more species rich areas are those at lower altitudes. Much of the lower altitude forest has been cleared for farming and it is really only on the DR Congo side that large areas of this type of montane forest are still found. In the Ugandan portion, most of the forest at this altitude was cleared for agricultural land in the 1950s, but some of this area has since be reclaimed, incorporated into the park, and is now regenerating.

5.4 RECOMMENDATIONS

Implications for zoning

The findings of this study have important implications of any conservation planning involving zoning of the Virunga Volcanoes for different forms of management and use. Although the current management and zoning plans in the Rwanda and DR Congo do not plan for multiple use zones, there has been some pressure to allow human access to parts of the massif. This does occur already in Bwindi Impenetrable National Park in Uganda where there are multiple use zones close to the edge of the park adjacent to certain parishes. Within these multiple use zones, registered beekeeping groups are permitted to keep their beehives, or forest resource users are permitted to harvest limit quantities of non-timber forest products (medicinal plants and weaving materials). Similarly, in the Virungas people are allowed access to the forest in the dry seasons to collect water.

However, given that the whole area can be considered as a high priority for conservation, and that the most species rich areas tend to be the lowest altitude areas near the boundaries of the park, the results of this study caution against the creation of multiple use zones, since if people are allowed access to the parks, particularly in the areas immediately adjacent to the boundaries, they will be accessing some of the most biodiverse areas. Given the small area of the massif and the fact that much of its original extent has been lost in the last 30-40 years, and given the high biodiversity value of what is left we would caution strongly about allowing much human use of the forest at all. If access is allowed, careful monitoring programs should be developed to measuure the impacts on the plant and animal community, particularly those species of conservation concern.

While community conservation strategies aimed at providing local communities with benefits derived directly from protected areas (such as multiple use programmes) can help improve attitudes towards conservation (McShane and Wells, 2004; Namara et al., in prep), there is limited evidence that illegal activities are reduced in MU zones. Indeed in Bwindi high levels of human disturbance are often found in these zones (Namara et al, in prep; Olupot, 2004). Given that illegal activities are already frequent in the Virunga Volcanoes, it would more prudent to concentrate on other ways of generating benefits for local communities and improving attitudes (for example though tourism revenue sharing, trust funds, enterprise development, etc.). Development organisations aiming to provide water to communities should investigate techniques that would harvest rainfall and store it for the dry season months rather than encouraging increased use of the forest. This would not only benefit the forest but also reduce the time people require to obtain water.

In Mgahinga, management plans do allow for the possibility of creating multiple use zones. However, UWA policy indicates that these should be at the edge of the national park, and in Mgahinga this is the area which was cleared for agriculture and is now regenerating. Since resource harvest might interfere with the regeneration process, and since this area in its current state is unlikely to support many of the forest plant resources which local communities would like to access, the programme has not yet been implemented in Mgahinga. Given the potential importance of the low altitude forest, which it is hoped will regenerate in this area, it would be prudent not to implement the programme in the foreseeable future. Community participation could help to clear exotic species (Eucalyptus and black wattle), which are common in this area, and people could benefit from the use of these trees for firewood and building poles, but this should be regarded as a short term removal program rather than a longer term sustainable management strategy.

Need for wider monitoring and conservation efforts beyond gorillas.

Much of the focus of conservation and research activities in the Virunga volcanoes has been on the mountain gorilla, and for good reason. The Karisoke Research Station has one of the longest running studies anywhere on earth on a single species (Robbins, Sicotte & Stewart, 2001) and the history of individuals in three research groups is very well known. However, there are many other species in the massif, which have an equal or greater need for research and conservation management and have received far less attention than the gorillas. The Golden Monkey, for example, is a sub species (possibly a species; Grubb, 2003) confined to the Virunga Volcanoes and classified as Endangered by IUCN. As such it could be considered to be at least as significant a conservation priority. The same is true for several amphibian, bird and plant species. There is an urgent need to broaden the scope of conservation and research to include these other species in the Virunga massif.

There is also an urgent need to establish a long term monitoring programme in the Virunga Volcanoes to monitor changes in species abundances and distribution. The small area of the massif and its elongated nature means that it will be influenced by edge effects, which because of the distribution of altitudes will mean that the lower altitude and most species rich habitats will be affected. Monitoring to date has primarily focused on the mountain gorillas (Gray *et al.*in press; Robbins, Sicotte and Stewart, 2001) with some monitoring of the ungulates (Plumptre *et al.*1997). The Karisoke Research Station in Rwanda would be best placed to be involved in this with collaboration with the Institute for Tropical Forest Conservation in Uganda, which has developed an ecological monitoring system for Bwindi and Mgahinga, which includes monitoring of vegetation changes and the impacts and sustainability of resource harvesting.

Strengthen law enforcement

Strengthened law enforcement is needed in those areas of the Virungas where illegal activities are high. Although these areas may not be used much by the gorillas at present, this study has demonstrated that they are important for other aspects of biodiversity conservation, and they may have the potential to provide additional gorilla habitat in the future. Most of the people who carry out poaching and other illegal activities are the poorest people living around the forests (Plumptre *et al.* 1997) and are involved in this in order to survive and care for their families. There is a need to develop better community programs that target more specifically the sectors of the

communities from which these threats arise, and reduces the desire and need for these people to illegally extract forest resources.

Biodiversity surveys of other taxa

It is clear that this survey of plants, birds and large mammals has shown the importance of areas of the massif outside where the mountain gorilla is found. It is necessary that other taxa of animals are assessed to determine which areas are important for their conservation. As mentioned above the massif protects 56% of the threatened amphibia found in the Albertine Rift yet there been little research into their distribution in the massif. This is probably a taxon that needs attention if all the species are to be effectively monitored and conserved. Other taxa that coule be readily assessed might include butterflies, moths, dragonflies and reptiles for which there are reasonable taxonomic keys from which species can be identified. Other taxa are more complicated because of the difficulties in identifying species, requiring expertise that is often difficult to find.

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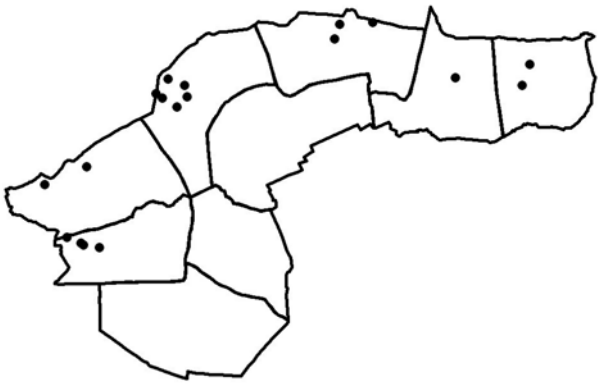
Appendix 1. *The sightings of Albertine Rift Endemic Species in the Virunga Volcanoes using point counts, mist netting and opportunistic observations. Some of the Albertine Rift endemics were sighted quite often while others were rarely seen.*

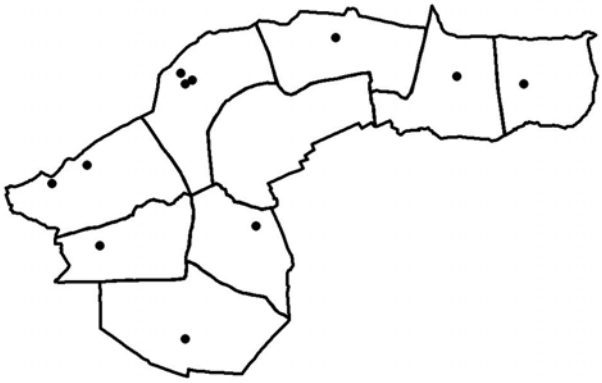
Archer's Ground Robin

Blue-headed Sunbird

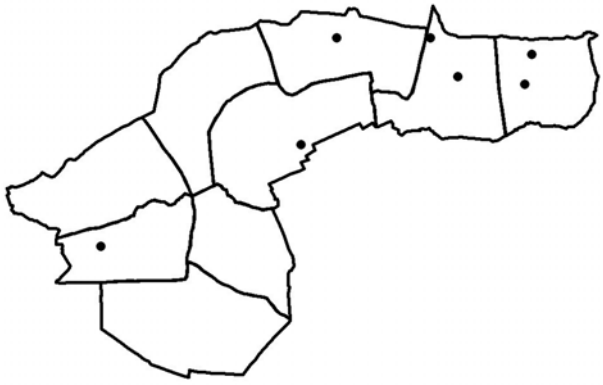


Collared Apalis

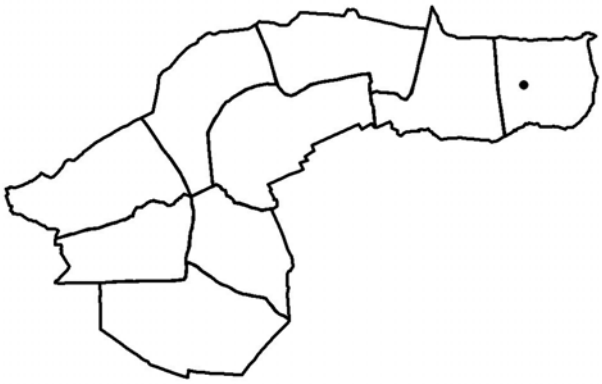
Dusky Crimson-wing



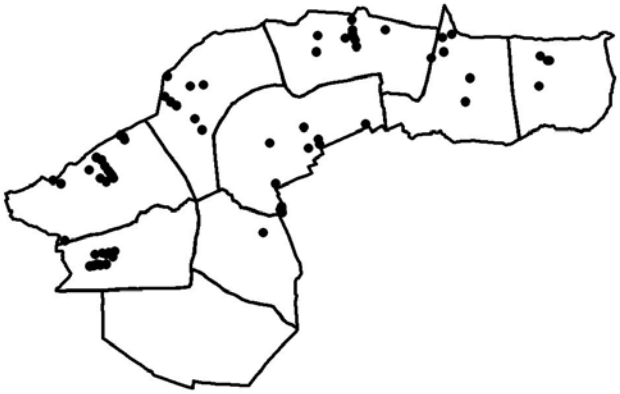
Handsome Francolin



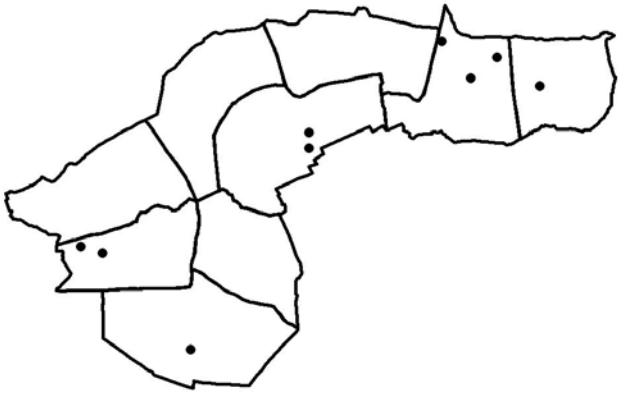
Grauer's Rush Warbler



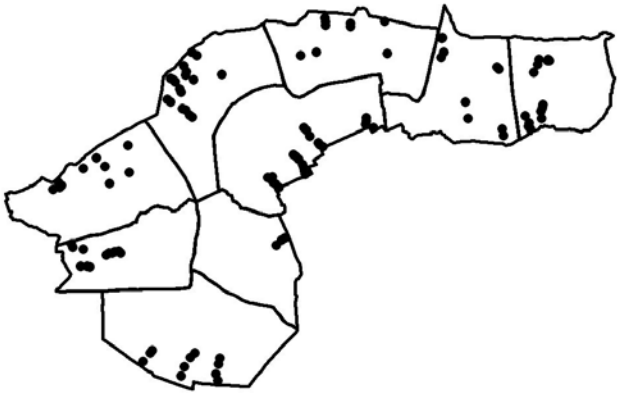
Mountain Masked Apalis



Kivu Ground Thrush

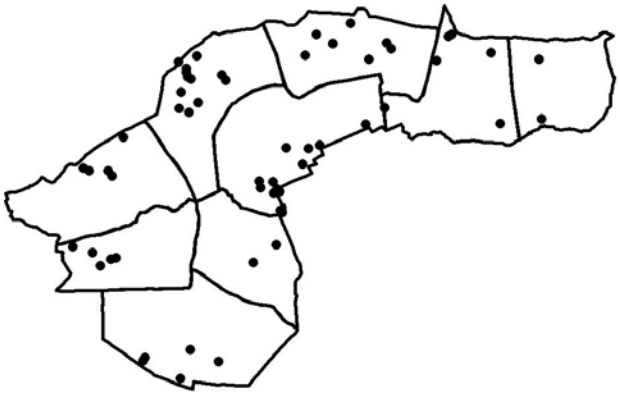


Red-faced Mountain Warbler



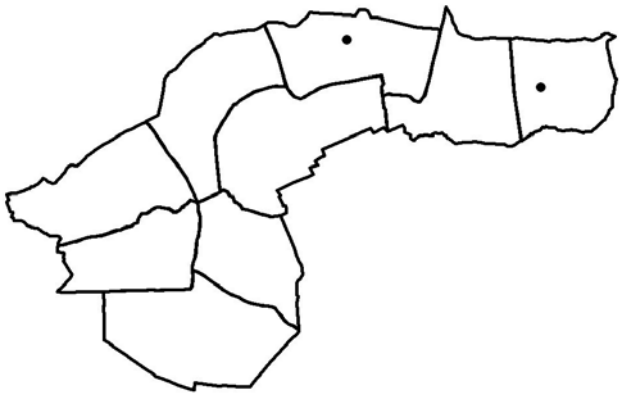
Regal Sunbird

Rwenzori Batis



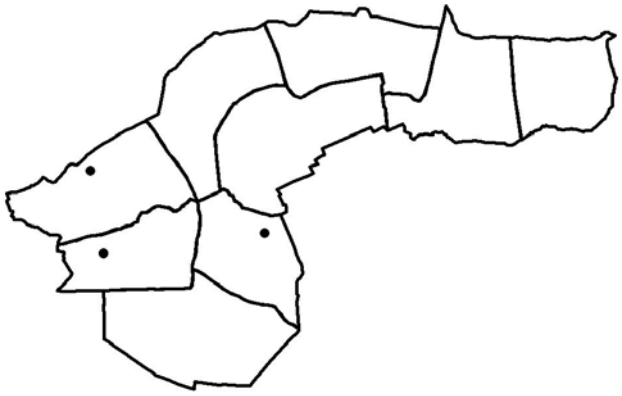
Rwenzori Double-collared Sunbird

Rwenzori Nightjar

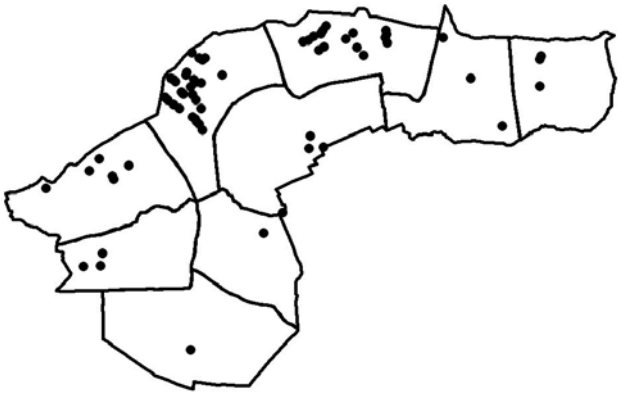


Rwenzori Turaco

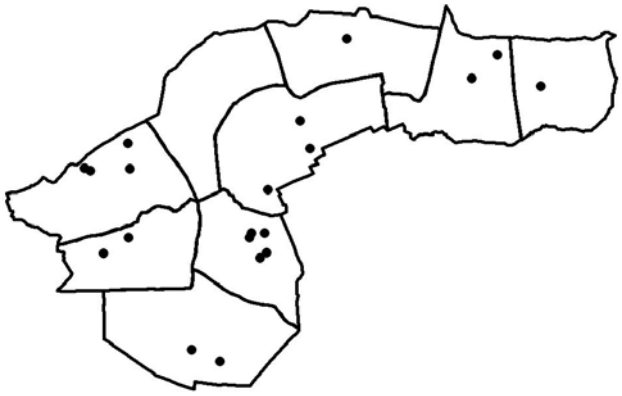
Shelley's Crimson-wing



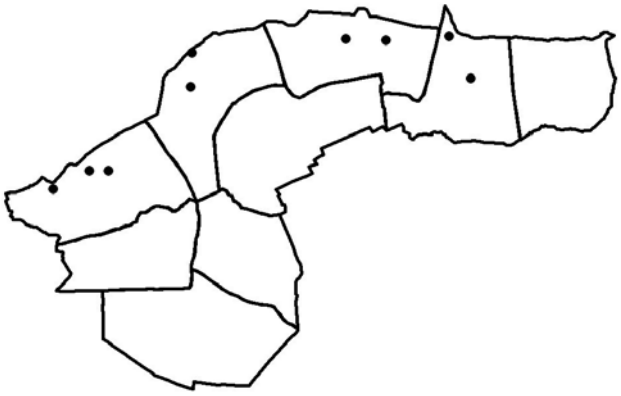
Strange Weaver



Stripe-breasted Tit



Red-throated Alethe



Appendix 2. *The checklist of birds of Mgahinga National Park, Parc National de Virunga and Parc National des Volcans.*

This checklist is complied from the bird survey by the Wildlife Conservation Society (WCS) Ornithological team in Mgahinga National Park, Parc National de Virunga and Parc National des Volcans from 10 Jan - 02 Feb 2004 coupled with species identified in previous surveys (Schouteden, 1938; Verheyen, 1947 and Wilson, 1982).

Records of some transient birds are included, as well as residents. Some of the species listed are not true forest birds, but will be found in the other habitats that occur in the three national parks.

Taxonomy and nomenclature follow the standard 1996 East African list produced by the Ornithological Sub-committee of the East African Natural History Society. The common names of some of the birds listed may differ in the main field guides.

Where appropriate, dependence on forest is indicated by the codes of Bennun, Dranzoa & Pomeroy. (*The forest birds of Kenya and Uganda* – Journal of East African Natural History 1997).

Names of bird species added by this study are marked with plus sign (+) and those that were not encountered by this study are marked with asterisk (*).

BIRD FAMILY AND SPECIES	**Category**	**Mgahinga**	**Virunga**	**Volcans**
PODICIPEDIDAE: grebes				
*Little Grebe *Tachybaptus ruficolis*	W			
ARDEIDAE: herons, egrets and bitterns				
Black-headed Heron *Ardea melanocephala*	w		1	
*Cattle Egret *Bubulcus ibis*				
SCOPIDAE: hamerkop				
*Hamerkop *Scopus umbretta*	w			
CICONIIDAE: storks				
*Abdim's Stork *Ciconia abdimii*	A			
*White Stork *Ciconia ciconia*	P			
THRESKIORNITHIDAE: ibises, spoonbills				
Hadada *Bostrychia hagedash*	w	1	1	1
ANATIDAE: ducks, geese				
*White-backed Duck *Thalassornis leuconotus*	W			
*Egyptian Goose *Alopochen aegyptiacus*	W			
Yellow-billed Duck *Anas undulate*	W			1
*Spur-winged Goose *Plectopterus gambensis*	W			
*African Black Duck *Anas sparsa*	W			
*Pintail *Anas acuta*	PW			
*Red-billed Teal *Anas erythrorhyncha*	W			
*Hottentot Teal *Anas hottentota*	W			
*Southern Pochard *Netta erythrophthalma*	AW			
*Maccoa Duck *Oxyura maccoa*	W			
ACCIPITRIDAE: vultures, eagles, hawks, kites etc.				
*Osprey *Pandion haliaetus*	PW			
*Honey Buzzard *Pernis apivorus*	PF			
Bat Hawk *Machaerhamphus alcinus*	F			1

BIRD FAMILY AND SPECIES	**Category**	**Mgahinga**	**Virunga**	**Volcans**
Black Kite *Milvus migrans*	pA	1		1
*Hooded Vulture *Necrosyrtes monachus*	f			
*White-headed Vulture *Aegypius occipitalis*				
Harrier Hawk *Polyboroides typus*	f		1	
*Bateleur *Terathopius ecaudatus*				
+African Marsh Harrier *Circus ranivorus*	W	1		
Eurasian Marsh Harrier *Circus aeruginosus*	Pw			1
African Goshawk *Accipiter tachiro*	F		1	1
+Little Sparrowhawk *Accipiter minullus*	F			1
Rufous Sparrowhawk *Accipiter rufiventris*	F			1
Great Sparrowhawk *Accipiter melanoleucus*	F			1
*Peregrine Falcon *Falco peregrinus*				
Common Buzzard *Buteo Buteo*	P	1	1	1
Mountain Buzzard *Buteo oreophilus*	FF	1	1	1
Augur Buzzard *Buteo rufofuscus*		1		1
*Tawny Eagle Aquila rapax				
Wahlberg's Eagle *Aquila warlbergi*	Af		1	
Long-crested Eagle *Lophaetus occipitalis*	F	1		
Crowned Eagle *Stephanoaetus coronatus*	FF	1		
Martial Eagle *Polemaetus bellicosus*				1
FALCONIDAE: falcons and pygmy falcons				
*Kestrel *Falco tinnunculus*	P			
+Grey Kestrel *Falco ardosiaceus*				1
+Amur Falcon *Falco amurensis*	P	1		
*Eurasian Hobby *Falco subbuteo*	P			
African Hobby *Falco cuvieri*	F		1	1
Lanner Falcon *Falco biarmicus*				1
PHASIANIDAE: guineafowl, quail, francolins				
*Quail *Coturnix coturnix*	P			
*Red-winged Francolin *Francolinus levaillantii*				
Handsome Francolin *Francolinus nobilis*	FF/ARE	1	1	1
+Scaly Francolin *Francolinus squamatus*	F			1
*Red-necked Spurfowl *Francolinus afer*				
GRUIDAE: cranes				
Grey-crowned Crane *Balearica regulorum*	W		1	
CHARADRIIDAE: plovers				
*Caspian Plover *Charadrius asiaticus*	P			
*Wattled Plover *Vanellus senegallus*	W			
SCOLOPACIDAE: sandpipers, snipe				
*Common Snipe *Gallinago gallinago*	PW			
*African Snipe *Gallinago nigripennis*	W			
*Curlew *Numenius arquata*	PW			
+Marsh Sandpiper *Tringa stagnatalis*	PW	1		
*Greenshank *Tringa nebularia*	PW			
Green Sandpiper *Tringa ochropus*	PW		1	
Wood Sandpiper *Tringa glareola*	PW			1
*Common Sandpiper *Actitis hypoleucos*	PW			
RALIDAE: rails, crakes, gallinules, moorhens, coots				
*Buff-spotted Pygmy Crake *Sarothrura elegans*	FF			
*Black Crake *Amaurornis flavirostris*	W			

BIRD FAMILY AND SPECIES	Category	Mgahinga	Virunga	Volcans
*Red-knobbed Coot *Fulica cristata*	W			
COLUMBIDAE: pigeons, doves				
Green Pigeon *Treron calva*	F			
Tambourine Dove *Turtur tympanistria*	F		1	
Blue-spotted Wood Dove *Turtur afer*	f		1	
*Lemon Dove *Columba larvata*	FF			
Olive Pigeon *Columba arquatrix*	FF	1	1	1
+Afep Pigeon *Columba unicincta*	FF			1
*Speckled Pigeon *Columba guinea*				
Red-eyed Dove *Streptopelia semitorquata*	f	1	1	1
Dusky Turtle Dove *Streptopelia lugens*	f	1		1
PSITTACIDAE: parrots				
+Grey Parrot *Psittacus erithacus*	FF			1
Brown-necked Parrot *Poicephalus robustus*	f	1	1	1
MUSOPHAGIDAE: turacos, plantain-eaters, etc				
Black-billed Turaco *Tuaraco schuetti*	FF		1	
Rwenzori Turaco *Musophaga johnstoni*	FF/ARE	1	1	1
*Ross's Turaco *Musophaga rossae*	F			
CUCULIDAE: cuckoos, coucals, yellowbill				
*Levaillant's Cuckoo *Oxlophus levaillantii*	Af			
*Madagascar Lesser Cuckoo *Cuculus rochii*	Af			
Red-chested Cuckoo *Cuculus solitarius*	AF	1	1	1
Black Cuckoo *Cuculus clamosus*	Af/FF			1
*Eurasian Cuckoo *Cuculus canorus*	P			
+Olive Long-tailed Cuckoo *Cercococcyx olivinus*	FF	1	1	
+Barred Long-tailed Cuckoo *Cercococcyx montanus*	AFF		1	
+Emerald Cuckoo *Chrysococcyx cupreus*	F		1	
Klaas' Cuckoo *Chrysococcyx klaas*	f	1	1	1
+Didric Cuckoo *Chrysococcyx caprius*			1	
*Yellowbill *Ceuthmochares aereus*	F			
White-browed Coucal *Centropus superciliosus*		1		
Blue-headed Coucal *Centropus monachus*	w	1	1	1
STRIGIDAE: true owls				
African Wood Owl *Strix woodfordii*	F	1		1
*Spotted Eagle Owl *Bubo africanus*				
*Long-eared Owl *Asio otus*				
CAPRIMULGIDAE: nightjars				
Montane Nightjar *Caprimulgus poliocephalus*	F			1
Rwenzori Nightjar *Caprimulgus ruwenzorii*	F/ARE	1		
*Pennant-winged Nightjar *Macrodipteryx vexillaria*	A			
APODIDAE: swifts, spinetails				
Scarce Swift *Schoutedenapus myioptilus*	F			1
*Palm Swift *Cypsiurus parvus*				
Black Swift *Apus barbatus*	P			1
*Eurasian Swift *Apus Apus*				
*White-rumped Swift *Apus caffer*				
*Little Swift *Apus affinis*				
*Mottled Swift *Tachymarptis melba*				
Alpine Swift *Tachymarptis melba*	p		1	1

BIRD FAMILY AND SPECIES	Category	Mgahinga	Virunga	Volcans
COLIIDAE: mousebirds				
Speckled Mousebird *Colius striatus*		1	1	1
TROGONIDAE: trogons				
[+]Narina's Trogon *Apaloderma narina*	F	1	1	1
MEROPIDAE: bee-eate				
[+]Little Bee-eater *Merops pusillus*		1		
Cinnamon-chested Bee-eater *Merops oreobates*	F	1	1	
*Eurasian Bee-eater *Merops apiaster*	Pf			
CORACIIDAE: rollers				
*Lilac-breasted Roller *Coracias caudata*				
*Broad-billed Roller *Eurystomus glaucurus*	Afw			
PHOENICULIDAE: wood hoopes				
White-headed Wood Hoopoe *Phoeniculus bollei*	FF		1	
BUCEROTIDAE: hornbills				
*Crowned Hornbill *Tockus alboterminatus*	f			
Black and White Casqued Hornbill *Bycanistes subcylindricus*	F		1	
*White-thighed Hornbill *Ceratogymna cylindricus*	FF			
INDICATORIDAE: honeyguides, honeybirds				
*Thick-billed Honeyguide *Indicator conirostris*	FF			
*Dwarf Honeyguide *Indicator pumilio*	NT/ARE			
CAPITONIDAE: barbets and tinkerbirds				
Grey-throated Barbet *Gymnobucco bonapartei*	F		1	
Speckled Tinkerbird *Pogoniulus scolopaceus*	F			1
Western Green Tinkerbird *Pogoniulus coryphaeus*	FF	1	1	1
Yellow-rumped Tinkerbird *Pogoniulus bilineatus*	F	1	1	1
*Hairy-breasted Barbet *Tricholaema hirsuta*	F			
[+]Yellow-billed Barbet *Trachyphonus purpuratus*	FF		1	
PICIDAE: wrynecks, woodpeckers and piculets.				
[+]Golden-tailed Woodpecker *Campethera abingoni*	F			1
*Little Spotted Woodpecker *Campethera cailliautii*	f			
*Fine-banded Woodpecker *Campethera tullbergi*	FF			
Cardinal Woodpecker *Dendropicos fuscescens*			1	
Olive Woodpecker *Dendropicos griseocephalus*	FF		1	1
ALAUDIDAE: larks				
*Rufous-naped Lark *Mirafra africana*				
HIRUNDINIDAE: swallows, martins and roughwings				
Black Rough-wing *Psalidoprocne pristoptera*	f		1	1
African Sand Martin *Riparia paludicola*	w			1
Sand Martin *Riparia riparia*	PW			
Striped Swallow *Hirundo abyssinica*				1
*Red-rumped Swallow *Hirundo daurica*				
*African Rock Martin *Hirundo fuligula*				
Angola Swallow *Hirundo angolensis*	w	1	1	1
*Eurasian Swallow *Hirundo rustica*				
*House Martin *Delichon urbica*	P			
MOTACILLIDAE: wagtails, pipits and longclaws				
*Yellow Wagtail *Motacilla flava*				
African Pied Wagtail *Motacilla aguimp*	w			
*Richard's Pipit *Anthus novaeseelandiae*				

BIRD FAMILY AND SPECIES	Category	Mgahinga	Virunga	Volcans
Cape Wagtail *Motacilla capensis*	w			1
Tree Pipit *Anthus trivialis*	f			1
Grassland Pipit *Anthus cinnamomeus*			1	
+Yellow-throated Longclaw *Macronyx croceus*		1		
CAMPEPHAGIDAE: cuckoo shrikes				
Grey Cuckoo Shrike *Coracina caesia*				
PYCNONOTIDAE: bulbuls				
*Shelley's Greenbul *Andropadus masukuensis*	FF			
Mountain Greenbul *Andropadus tephrolaemus*	FF	1	1	1
*Little Greenbul *Andropadus virens*	F			
Yellow-whiskered Greenbul *Andropadus latirostris*	F	1	1	1
*Honeyguide Greenbul *Baeopogon indicator*	FF			
Common Bulbul *Pycnonotus barbatus*	f	1	1	1
TURDIDAE: thrushes, robins etc				
Red-capped Robin Chat *Cossypha natalensis*	F			
Snowy-headed Robin Chat *Cossypha niveicapilla*	Fw			
White-starred Forest Robin *Pogonocichla stellata*	F	1	1	1
Archer's Ground Robin *Cossypha archeri*	F	1	1	1
Robin Chat *Cossypha caffra*	f	1		1
+White-browed Robin Chat *Cossypha heuglini*	f	1	1	
Red-throated Alethe *Alethe poliophrys*	FF/ARE	1	1	
Red-tailed Chat *Cercomela familiaris*				
+Rufous Thrush *Neocossyphus fraseri*	FF		1	
Stonechat *Saxicola torquata*		1	1	
*Sooty Chat *Myrmecocichla nigra*				
+Abyssinian Ground Thrush *Zoothera piaggiae*	FF			1
Kivu Ground Thrush *Zoothera tanganjicae*	FF/ARE	1	1	1
Olive Thrush *Turdus olivaceus*	F		1	1
*Northern Olive Thrush *Turdus olivaceus*	F			
African Thrush *Turdus pelios*	f		1	
SYLVIIDAE: Old World warblers				
Grauer's Rush Warbler *Bradypterus graueri*	ARE	1		
+Evergreen Forest Warbler *Bradypterus lopezi*	FF			1
Cinnamon Bracken Warbler *Bradypterus cinnamomeus*	F	1	1	1
+Black-faced Rufous Warbler *Bathmocercus rufus*	FF		1	
+Dark-capped Yellow Warbler *Chloropeta natalensis*		1		1
Mountain Yellow Warbler *Chloropeta similis*	F	1	1	1
*Singing Cisticola *Cisticola cantans*				
Chubb's Cisticola *Cisticola chubby*	F	1	1	1
*Stout Cisticola *Cisticola robustus*				
*Wing-snapping Cisticola *Cisticola ayresii*				
*Tawny-flanked Prinia *Prinia subflava*	fw			
White-chinned Prinia *Prinia leucopogon*	F			1
Banded Prinia *Prinia bairdii*	F		1	1
Collared Apalis *Apalis ruwenzori*	F/ARE	1	1	1
Mountain Masked Apalis *Apalis personata*	FF/ARE	1	1	1
Chestnut-throated Apalis *Apalis porphyrolaema*	F	1	1	1
Buff-throated *Apalis Apalis rufogularis*	FF			1
Grey-backed Camaroptera *Camaroptera brachyura*	f		1	
+White-browed Crombec *Sylvietta leucophrys*	FF	1	1	1

BIRD FAMILY AND SPECIES	Category	Mgahinga	Virunga	Volcans
*Willow Warbler *Phylloscopus trochilus*				
Brown Woodland Warbler *Phylloscopus umbrovirens*	F	1	1	1
Red-faced Woodland Warbler *Phylloscopus laetus*	FF/ARE	1	1	1
Garden Warbler *Sylvia borin*	Pf			
Blackcap *Sylvia atricapilla*	PF			
MUSCICAPIDAE: flycatchers				
White-eyed Slaty Flycatcher *Melaenornis fischeri*	F	1	1	1
Yellow-eyed Black Flycatcher *Melaenornis ardesiacus*				
*Spotted Flycatcher *Muscicapa striata*	P			
Dusky Flycatcher *Muscicapa adusta*	F		1	1
*Collared Flycatcher *Ficedula albicollis*				
MONARCHIDAE: paradise flycatchers, monarchs				
White-tailed Blue Flycatcher *Elminia albicauda*	F	1	1	
White-tailed Crested Flycatcher *Elminia albonotata*	FF	1	1	1
+Blue-mantled Crested Flycatcher *Trochocercus cyanomelas*	FF			1
Paradise Flycatcher *Terpsiphone viridis*	f	1	1	1
PLATYSTEIRIDAE: shrike-flycatchers, wattle-eyes, etc				
Black and White Flycatcher *Bias musicus*				
Wattle-eye *Platysteira cyanea*	f			1
+Black-throated Wattle-eye *Platysteira peltata*	F		1	
Rwenzori Batis *Batis diops*	F/ARE	1	1	1
Chin-spot Batis *Batis molitor*	f	1	1	1
TIMALIIDAE: babblers				
Mountain Illadopsis *Illadopsis pyrrhoptera*	FF		1	1
Grey-chested Illadopsis *Kakamega poliothorax*	FF	1	1	
African Hill Babbler *Pseudoalcippe abyssinica*	FF	1	1	1
+Arrow-marked Babbler *Turdoides jardineii*		1		
PARIDAE: tits				
Stripe-breasted Tit *Parus fasciiventer*	FF/ARE	1	1	1
*Black Tit *Parus leucomelas*	f			
NECTARINIIDAE: sunbirds				
*Green-headed Sunbird *Cyanomitra verticalis*	FF			
Blue-headed Sunbird *Cyanomitra alinae*	FF/ARE	1	1	1
[+]Olive Sunbird *Nectarinia olivacea*	FF		1	
[+]Scarlet-chested Sunbird *Chalcomitra senegalensis*	f			1
*Green-throated Sunbird *Chalcomitra rubescens*	F			
Bronze Sunbird *Nectarinia kilimensis*	f	1	1	
Malachite Sunbird *Nectarinia famosa*	F		1	
Scarlet-tufted Malachite Sunbird *Nectarinia johnstoni*				1
Collared Sunbird *Hedydipna collaris*	F		1	1
[+]Tiny Sunbird *Cinnyris minulla*	F			1
Rwenzori Double-Collared Sunbird *Cinnyris stuhlmanni*	F/ARE	1	1	1
Olive-bellied Sunbird *Cinnyris chloropygia*	F	1		1
Regal Sunbird *Cinnyris regia*	F/ARE	1	1	1
*Rockefeller's Sunbird *Cinnyris rockefelleri*	FF/ARE			
Variable Sunbird *Cinnyris venusta*	f	1	1	1
ZOSTEROPIDAE: white-eyes				
Yellow White-eye *Zosterops senegalensis*	f	1	1	1
LANIIDAE: shrikes				

BIRD FAMILY AND SPECIES	Category	Mgahinga	Virunga	Volcans
Fiscal *Lanius collaris*		1		1
Mackinnon's Shrike *Lanius mackinnoni*			1	
*Red-backed Shrike *Lanius collurio*	P			
MALACONOTIDAE: bush shrikes				
*Lagden's Bush Shrike *Malaconotus lagdeni*	NT			
Doherty's Bush Shrike *Telophorus dohertyi*	FF	1	1	1
Brown-headed Tchagra *Tchagra australis*		1		1
Northern Puffback *Dryoscopus gambensis*		1	1	1
+Black-backed Puffback *Dryscopus cubla*	F			1
Montane Sooty Boubou *Laniarius poensis*	F	1	1	1
Lühder's Bush Shrike *Laniarius luehderi*	F		1	
Tropical Boubou *Laniarius ferrugineus*	f	1	1	1
PRIONOPIDAE: helmet shrikes				
Yellow-crested Helmet Shrike *Prionops alberti*				
ORIOLIDAE: orioles				
Montane Oriole *Oriolus percivali*	FF		1	
*African Golden Oriole *Oriolus auratus*	Af			
*Golden Oriole *Oriolus oriolus*	Pf			
CORVIDAE: crows				
Pied Crow *Corvus albus*				1
White-necked Raven *Corvus albicollis*		1	1	1
STURNIDAE: starlings, oxpeckers				
Narrow-tailed Starling *Poeoptera lugubris*	FF		1	
*Stuhlmann's Starling *Poeoptera stuhlmanni*				
*Slender-billed Chestnut-winged Starling *Onychognathus tenuirostris*	FW			
*Waller's Chestnut-winged Starling *Onychognathus walleri*	FF			
+Sharpe's Starling *Pholia sharpie*	FF		1	
*Violet-backed Starling *Cinnyricinclus leucogaster*	Af			
*Yellow-billed Oxypecker *Buphagus africanus*				
PASSERIDAE sparrows, petronias				
*Grey-headed Sparrow *Passer griseus*				
PLOCEIDAE: weavers etc				
Baglafecht Weaver *Ploceus baglafecht*	f	1	1	1
*Black-necked Weaver *Ploceus nigricollis*				
Strange Weaver *Ploceus alienus*	F/ARE	1	1	1
Vieillot's Black Weaver *Ploceus nigerrimus*	f			1
*Slender-billed Weaver *Ploceus pelzelni*	fW			
*Black-headed Weaver *Ploceus cucullatus*				
*Dark-backed Weaver *Ploceus bicolor*				
Brown-capped Weaver *Ploceus insignis*	F	1		
+Red-billed Quelea *Quelea quelea*	A			1
Yellow Bishop *Euplectes capensis*				1
+Black Bishop *Euplectes gierowii*	w		1	
*Fan-tailed Widowbird *Euplectes axillaris*	w			
*Grosbeak Weaver *Amblyospiza albifrons*	fw			
ESTRILDIDAE: waxbills etc				
Red-billed Firefinch Indigobird *Hypochera Chalybeata*				
Grey-headed Negrofinch *Nigrita canicapilla*	F		1	
*White-collared Olive-back *Nesocharis ansorgei*	fw			

BIRD FAMILY AND SPECIES	**Category**	**Mgahinga**	**Virunga**	**Volcans**
Red-faced Crimson-wing *Cryptospiza reichenowii*	F			1
Dusky Crimson-wing *Cryptospiza jacksoni*	F/ARE	1	1	1
Shelley's Crimson-wing *Cryptospiza shelleyi*	F/ARE		1	1
Red-headed Blue-bill *Spermophaga ruficapilla*	F			1
*Red-billed Firefinch *Lagonosticta larvata*				
*African Firefinch *Lagonosticta rubricata*				
*Yellow-bellied Waxbill *Estrilda melanotis*	f			
+Fawn-breasted Waxbill *Estrilda paludicola*		1		1
Common Waxbill *Estrilda astrild*		1	1	
Black-crowned Waxbill *Estrilda nonnula*	f			1
Black-headed Waxbill *Estrilda atricapilla*	F	1	1	1
Bronze Mannikin *Lonchura cucullata*		1	1	1
+Black and White Mannikin *Lonchura bicolor*	f		1	
VIDUIDAE whydahs				
Pin-tailed Wydah *Vidua macroura*			1	
FRINGILLIDAE: finches				
Yellow-crowned Canary *Serinus canicollis*				
African Citril *Serinus citrinelloides*	f	1	1	1
Yellow-fronted Canary *Serinus mozambicus*		1		1
Brimstone Canary *Serinus sulphuratus*				1
Streaky Seed-eater *Serinus striolatus*	f	1	1	1
Thick-billed Seed-eater *Serinus burtoni*	FF	1	1	
EMBERIZIDAE: old world buntings				
Golden-breasted Bunting *Emberiza flaviventris*				1

A Afrotropical migrant – a species migrating within Africa
P Palearctic migrant – species which breed in Europe or Asia
p Species with at least some palearctic populations
FF Forest specialist – species typical of forest interiors
F Forest generalist – less specialized and could be found in small forest patches
f Forest visitor
W Waterbird specialist – normally restricted to wetlands or open waters
w Waterbird non-specialist – often found near water

Appendix 3. *The bird species recorded in each sector of the Virunga Volcanoes by this study*

Bird Family and Species	Category	A	B	C	D	E	F	G	H	I
ARDEIDAE: herons, egrets and bitterns										
Black-headed Heron *Ardea melanocephala*	w					1				
THRESKIORNITHIDAE: ibises, spoonbills										
Hadada *Bostrychia hagedash*	w		1			1	1	1	1	
ANATIDAE: ducks, geese										
Yellow-billed Duck *Anas undulate*	W						1			
ACCIPITRIDAE: vultures, eagles, hawks, kites etc.										
Bat Hawk *Machaerhamphus alcinus*	F						1			
Black Kite *Milvus migrans*	pA			1	1			1	1	
Harrier Hawk *Polyboroides typus*	f					1				
African Marsh Harrier *Circus ranivorus*	W								1	
Eurasian Marsh Harrier *Circus aeruginosus*	Pw						1			
African Goshawk *Accipiter tachiro*	F				1				1	
Little Sparrowhawk *Accipiter minullus*	F	1		1	1		1		1	
Rufous Sparrowhawk *Accipiter rufiventris*	F						1			
Common Buzzard *Buteo Buteo*	P	1	1		1				1	1
Mountain Buzzard *Buteo oreophilus*	FF	1	1	1	1	1	1	1	1	1
Augur Buzzard *Buteo rufofuscus*		1		1	1		1		1	1
Wahlberg's Eagle *Aquila warlbergi*	Af				1					
Long-crested Eagle *Lophaetus occipitalis*	F		1							
Crowned Eagle *Stephanoaetus coronatus*	FF							1	1	
Martial Eagle *Polemaetus bellicosus*						1	1			
FALCONIDAE: falcons and pygmy falcons										
Amur Falcon Falco amurensis	P								1	
African Hobby Falco cuvieri	F					1	1			
Lanner Falcon *Falco biarmicus*										1
PHASIANIDAE: guineafowl, quail, francolins										
Handsome Francolin *Francolinus nobilis*	FF/ARE		1				1	1	1	1
GRUIDAE: cranes										
Grey-crowned Crane *Balearica regulorum*	W							1		
SCOLOPACIDAE: sandpipers, snipe										
Marsh Sandpiper *Tringa stagnatalis*	PW									1
Green Sandpiper *Tringa ochropus*	PW					1				
Wood Sandpiper *Tringa glareola*	PW		1							
COLUMBIDAE: pigeons, doves										
Green Pigeon *Treron calva*	F				1			1		
Tambourine Dove *Turtur tympanistria*	F		1		1			1		
Blue-spotted Wood Dove *Turtur afer*	f				1					
Olive Pigeon *Columba arquatrix*	FF	1	1	1	1	1	1		1	1
Red-eyed Dove *Streptopelia semitorquata*	f	1	1		1	1	1	1	1	1
Dusky Turtle Dove *Streptopelia lugens*	f								1	1
PSITTACIDAE: parrots										
Grey Parrot *Psittacus erithacus*	FF			1						
Brown-necked Parrot *Poicephalus robustus*	f		1	1			1	1	1	
MUSOPHAGIDAE: turacos, plantain-eaters, go-away birds										
Black-billed Turaco *Tuaraco schuetti*	FF		1		1	1		1		
Rwenzori Turaco *Musophaga johnstoni*	FF/ARE	1	1	1	1		1		1	1
CUCULIDAE: cuckoos, coucals, yellowbill										

Bird Family and Species	**Category**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Red-chested Cuckoo *Cuculus solitarius*	AF		1		1	1	1	1	1	1
Black Cuckoo *Cuculus clamosus*	Af/FF			1		1				
Olive Long-tailed Cuckoo *Cercococcyx olivinus*	FF		1							
Barred Long-tailed Cuckoo *Cercococcyx montanus*	AFF				1	1		1		
Emerald Cuckoo *Chrysococcyx cupreus*	F		1							
Klaas' Cuckoo *Chrysococcyx klaas*	f		1	1	1	1		1	1	
Didric Cuckoo *Chrysococcyx caprius*								1		
White-browed Coucal *Centropus superciliosus*									1	
Blue-headed Coucal *Centropus monachus*	w		1		1	1	1	1	1	
STRIGIDAE: true owls										
African Wood Owl *Strix woodfordii*	F		1	1						1
CAPRIMULGIDAE: nightjars										
Montane Nightjar *Caprimulgus poliocephalus*	F									
Rwenzori Nightjar *Caprimulgus ruwenzorii*	F/ARE							1		1
APODIDAE: swifts, spinetails										
Scarce Swift *Schoutedenapus myioptilus*	F						1			
Black Swift *Apus barbatus*							1			
Alpine Swift *Tachymarptis melba*	p	1				1	1	1		
COLIIDAE: mousebirds										
Speckled Mousebird *Colius striatus*			1	1			1	1	1	1
TROGONIDAE: trogons										
Narina's Trogon *Apaloderma narina*	F		1			1		1	1	
MEROPIDAE: bee-eaters										
Little Bee-eater *Merops pusillus*									1	
Cinnamon-chested Bee-eater *Merops oreobates*	F				1	1		1	1	
PHOENICULIDAE: wood hoopes										
White-headed Wood Hoopoe *Phoeniculus bollei*	FF				1					
BUCEROTIDAE: hornbills										
Black and White Casqued Hornbill *Bycanistes subcylindricus*	F					1				
CAPITONIDAE: barbets and tinkerbirds										
Grey-throated Barbet *Gymnobucco bonapartei*	F					1				
Speckled Tinkerbird *Pogoniulus scolopaceus*	F			1						
Western Green Tinkerbird *Pogoniulus coryphaeus*	FF		1		1	1		1	1	1
Yellow-rumped Tinkerbird *Pogoniulus bilineatus*	F		1		1	1		1	1	1
Yellow-billed Barbet *Trachyphonus purpuratus*	FF		1		1	1		1		
PICIDAE: wrynecks, woodpeckers and piculets.										
Golden-tailed Woodpecker *Campethera abingoni*	F								1	
Cardinal Woodpecker *Dendropicos fuscescens*			1		1	1		1		
Olive Woodpecker *Dendropicos griseocephalus*	FF	1	1	1				1		1
HIRUNDINIDAE: swallows, martins and roughwings										
Black Rough-wing *Psalidoprocne pristoptera*	f	1	1	1	1	1		1	1	1
African Sand Martin *Riparia paludicola*	w			1						
Striped Swallow *Hirundo abyssinica*									1	
Angola Swallow *Hirundo angolensis*	w	1					1	1	1	
MOTACILLIDAE: wagtails, pipits and longclaws										
African Pied Wagtail *Motacilla aguimp*	w				1					
Cape Wagtail *Motacilla capensis*	w	1								
Tree Pipit *Anthus trivialis*	f						1			
Grassland Pipit *Anthus cinnamomeus*								1		

Bird Family and Species	**Category**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Yellow-throated Longclaw *Macronyx croceus*									1	
PYCNONOTIDAE: bulbuls										
Mountain Greenbul *Andropadus tephrolaemus*	FF	1	1	1	1	1	1	1	1	1
Yellow-whiskered Greenbul *Andropadus latirostris*	F		1		1	1	1	1	1	1
Common Bulbul *Pycnonotus barbatus*	f		1	1	1	1	1	1	1	1
TURDIDAE: thrushes, robins etc										
White-starred Forest Robin *Pogonocichla stellata*	F	1	1	1	1	1	1	1	1	1
Archer's Ground Robin *Cossypha archeri*	F/ARE	1	1	1	1	1	1	1	1	1
Robin Chat *Cossypha caffra*	f	1					1		1	1
White-browed Robin Chat *Cossypha heuglini*	f		1						1	
Red-throated Alethe *Alethe poliophrys*	FF/ARE				1	1		1	1	
Rufous Thrush *Neocossyphus fraseri*	FF						1			
Stonechat *Saxicola torquata*		1		1		1		1	1	1
Abyssinian Ground Thrush *Zoothera piaggiae*	FF	1					1			
Kivu Ground Thrush *Zoothera tanganjicae*	FF/ARE	1	1				1		1	
Olive Thrush *Turdus olivaceus*	F		1	1	1	1	1	1		
African Thrush *Turdus pelios*	f		1							
SYLVIIDAE: Old World warblers										
Grauer's Rush Warbler *Bradypterus graueri*	ARE									1
Evergreen Forest Warbler *Bradypterus lopezi*	FF			1						
Cinnamon Bracken Warbler *Bradypterus cinnamomeus*	F	1	1	1	1	1	1	1	1	1
Black-faced Rufous Warbler *Bathmocercus rufus*	FF				1	1				
Dark-capped Yellow Warbler *Chloropeta natalensis*				1			1	1	1	
Mountain Yellow Warbler *Chloropeta similis*	F	1	1	1	1	1	1	1	1	1
Chubb's Cisticola *Cisticola chubbi*	F	1	1	1	1	1	1	1	1	1
Banded Prinia *Prinia bairdii*		1	1	1	1	1		1		1
Collared Apalis *Apalis ruwenzori*	F/ARE	1	1	1	1	1	1	1	1	1
Mountain Masked Apalis *Apalis personata*	FF/ARE		1	1	1	1	1	1	1	1
Chestnut-throated Apalis *Apalis porphyrolaema*	F	1	1	1	1	1	1	1	1	1
Grey-backed Camaroptera *Camaroptera brachyura*	f		1							
White-browed Crombec *Sylvietta leucophrys*	FF		1		1	1		1	1	1
Brown Woodland Warbler *Phylloscopus umbrovirens*	F	1	1	1			1		1	1
Red-faced Woodland Warbler *Phylloscopus laetus*	FF/ARE	1	1	1	1	1	1	1	1	1
MUSCICAPIDAE: flycatchers										
White-eyed Slaty Flycatcher *Melaenornis fischeri*	F	1	1	1	1	1	1	1	1	1
Dusky Flycatcher *Muscicapa adusta*	F	1	1	1	1	1	1	1		
MONARCHIDAE: paradise flycatchers, monarchs										
White-tailed Blue Flycatcher *Elminia albicauda*	F		1					1	1	
White-tailed Crested Flycatcher *Elminia albonotata*	FF		1			1	1		1	
Blue-mantled Crested Flycatcher *Trochocercus cyanomelas*	FF			1						
Paradise Flycatcher *Terpsiphone viridis*	f	1	1		1	1		1	1	1
PLATYSTEIRIDAE: shrike-flycatchers, wattle-eyes, batises										
Wattle-eye *Platysteira cyanea*	f						1			
Black-throated Wattle-eye *Platysteira peltata*	F					1				
Rwenzori Batis *Batis diops*	F/ARE	1	1	1	1	1	1	1	1	1
Chin-spot Batis *Batis molitor*	f	1				1		1	1	
TIMALIIDAE: babblers										
Mountain Illadopsis *Illadopsis pyrrhoptera*	FF		1	1	1	1	1	1		1
Grey-chested Illadopsis *Kakamega poliothorax*	FF		1		1	1		1	1	

Bird Family and Species	**Category**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
African Hill Babbler *Pseudoalcippe abyssinica*	FF	1	1	1	1	1	1	1	1	1
Arrow-marked Babbler *Turdoides jardineii*									1	
PARIDAE: tits										
Stripe-breasted Tit *Parus fasciiventer*	FF/ARE	1	1	1	1		1		1	1
NECTARINIIDAE: sunbirds										
Blue-headed Sunbird *Cyanomitra alinae*	FF/ARE		1		1	1		1	1	1
Olive Sunbird *Nectarinia olivacea*	FF				1					
Scarlet-chested Sunbird *Chalcomitra senegalensis*	f						1			
Bronze Sunbird *Nectarinia kilimensis*	f				1				1	
Malachite Sunbird *Nectarinia famosa*	F							1		
Scarlet-tufted Malachite Sunbird *Nectarinia johnstoni*		1		1			1		1	1
Collared Sunbird *Hedydipna collaris*	F	1	1		1	1		1	1	1
Tiny Sunbird *Cinnyris minulla*	F	1								
Rwenzori Double-Collared Sunbird *Cinnyris stuhlmanni*	F/ARE	1	1	1	1	1	1	1	1	1
Regal Sunbird *Cinnyris regia*	F/ARE	1	1	1	1	1	1	1	1	1
Variable Sunbird *Cinnyris venusta*	f	1				1		1	1	
ZOSTEROPIDAE: white-eyes										
Yellow White-eye *Zosterops senegalensis*	f	1	1	1	1	1	1	1	1	1
LANIIDAE: shrikes										
Fiscal *Lanius collaris*							1	1	1	
Mackinnon's Shrike *Lanius mackinnoni*			1		1	1		1		
MALACONOTIDAE: bush shrikes										
Doherty's Bush Shrike *Telophorus dohertyi*	FF		1		1		1		1	1
Brown-headed Tchagra *Tchagra australis*									1	
Northern Puffback *Dryoscopus gambensis*		1	1	1	1	1	1	1	1	1
Black-Backed Puffback *Dryscopus cubla*	F			1			1		1	
Montane Sooty Boubou *Laniarius poensis*	F	1	1	1	1	1	1	1	1	1
Lühder's Bush Shrike *Laniarius luehderi*	F		1		1	1				
Tropical Boubou *Laniarius ferrugineus*	f					1		1	1	1
ORIOLIDAE: orioles										
Montane Oriole *Oriolus percivali*	FF		1		1	1		1		
CORVIDAE: crows										
Pied Crow *Corvus albus*				1	1	1		1	1	
White-necked Raven *Corvus albicollis*		1	1	1	1		1	1	1	1
STURNIDAE: starlings, oxpeckers										
Narrow-tailed Starling *Poeoptera lugubris*	FF		1		1	1				
Sharpe's Starling *Pholia sharpie*	FF		1							
PLOCEIDAE: weavers etc										
Baglafecht Weaver *Ploceus baglafecht*	f	1	1	1		1	1	1	1	
Strange Weaver *Ploceus alienus*	F/ARE	1	1	1	1	1	1	1	1	1
Vieillot's Black Weaver *Ploceus nigerrimus*	f								1	
Brown-capped Weaver *Ploceus insignis*	F				1			1		
Red-billed Quelea *Quelea quelea*	A								1	
Yellow Bishop *Euplectes capensis*						1	1			
Black Bishop *Euplectes gierowii*	w					1				
Pin-tailed Wydah *Vidua macroura*					1			1		
ESTRILDIDAE: waxbills etc										
Grey-headed Negrofinch *Nigrita canicapilla*	F				1	1		1		
Red-faced Crimson-wing *Cryptospiza reichenowii*	F								1	
Dusky Crimson-wing *Cryptospiza jacksoni*	F/ARE	1	1	1	1	1		1	1	1
Shelley's Crimson-wing *Cryptospiza shelleyi*	F/ARE		1	1	1					

Bird Family and Species	**Category**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Red-headed Blue-bill *Spermophaga ruficapilla*	F			1						
Fawn-breasted Waxbill *Estrilda paludicola*							1		1	
Waxbill Estrilda astrild					1			1	1	
Black-crowned Waxbill *Estrilda nonnula*	f				1		1			
Black-headed Waxbill *Estrilda atricapilla*	F			1	1		1	1	1	1
Bronze Mannikin *Lonchura cucullata*			1							
Black and White Mannikin *Lonchura bicolor*	f							1		
FRINGILLIDAE: finches										
African Citril *Serinus citrinelloi*des	f	1	1	1		1	1	1	1	1
Yellow-fronted Canary *Serinus mozambicus*									1	
Brimstone Canary *Serinus sulphuratus*										1
Streaky Seed-eater *Serinus striolatus*	f	1	1	1	1	1	1	1	1	1
Thick-billed Seed-eater *Serinus burtoni*	FF					1			1	
EMBERIZIDAE: old world buntings										
Golden-breasted Bunting *Emberiza flaviventris*							1			

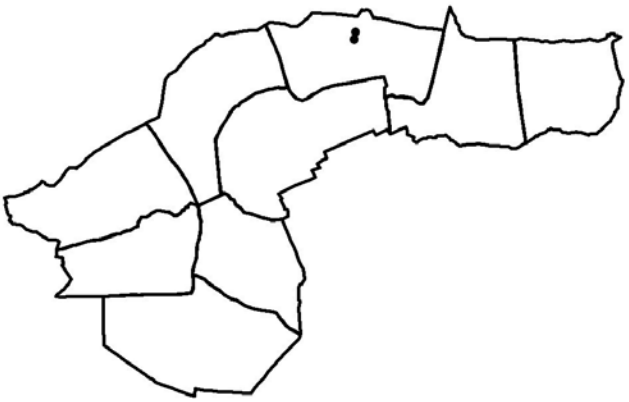
A = NGANDO B = AKABAROZI C= KARISOKE D = RUBINDI E=BUKIMA
F = KAGO G = JOMBA H = KAGANO & NTEBEKO I = MINOGA & MUHAVURA

A Afrotropical migrant – a species migrating within Africa
P Palearctic migrant – species which breed in Europe or Asia
p Species with at least some palearctic populations
FF Forest specialist – species typical of forest interiors
F Forest generalist – less specialized and could be found in small forest patches
f Forest visitor
W Waterbird specialist – normally restricted to wetlands or open waters
w Waterbird non-specialist – often found near water

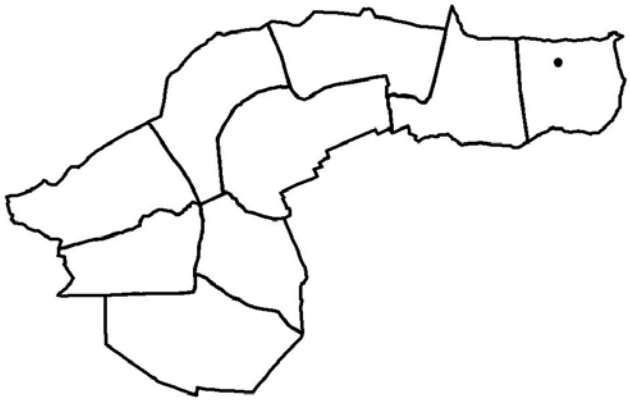
Appendix 4. *Sightings of some of the Albertine Rift Endemic plant species in Virunga Volcanoes*

Alchemilla johnstonii

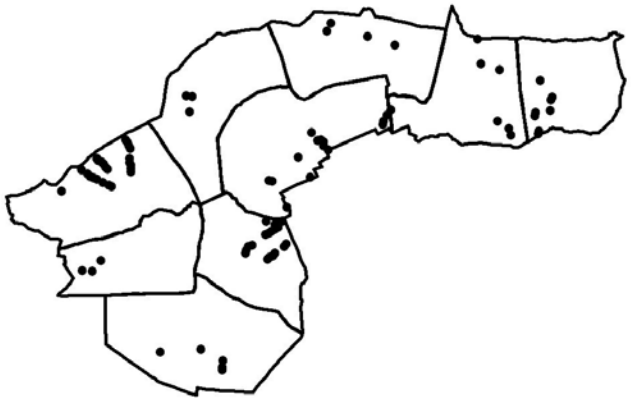
Argyrolobium tomentosum



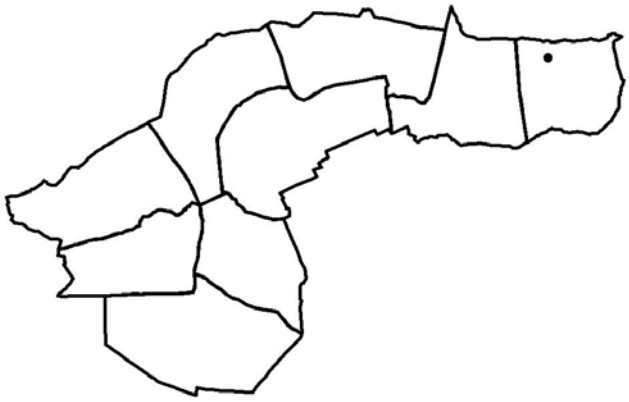
Bidens elliottii



Crassocephalum ducis-aprutii

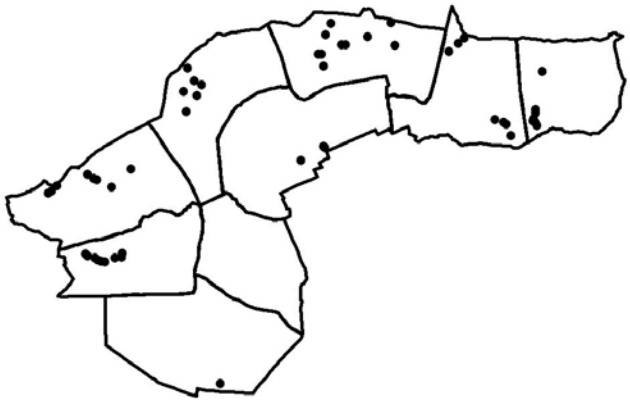


Crotalaria mesopontica

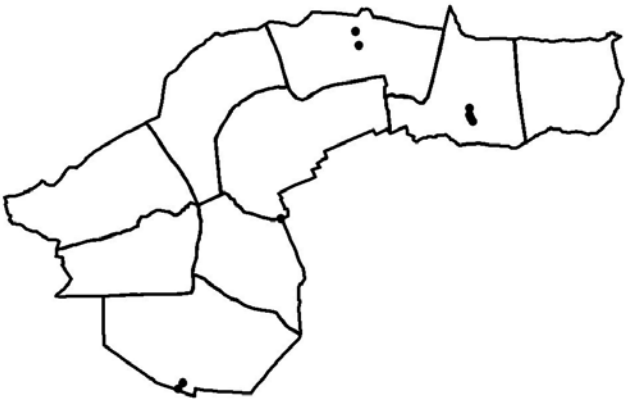


Dissotis ruandensis

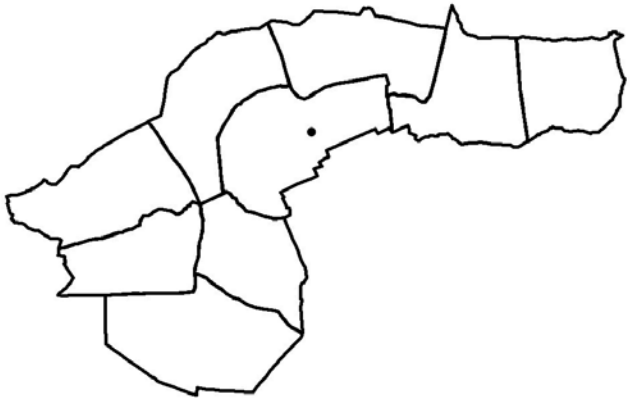
Elatostema monticola



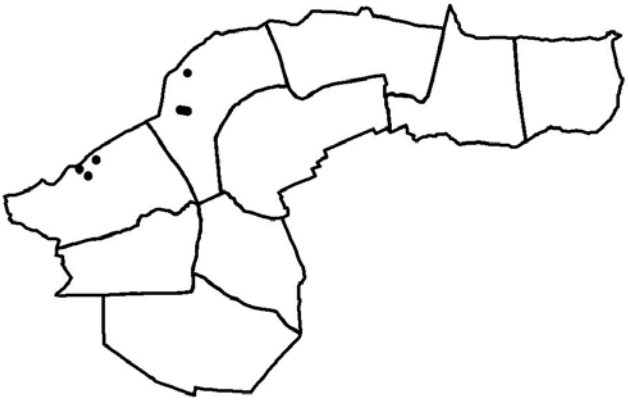
Helichrysum mildbraedii



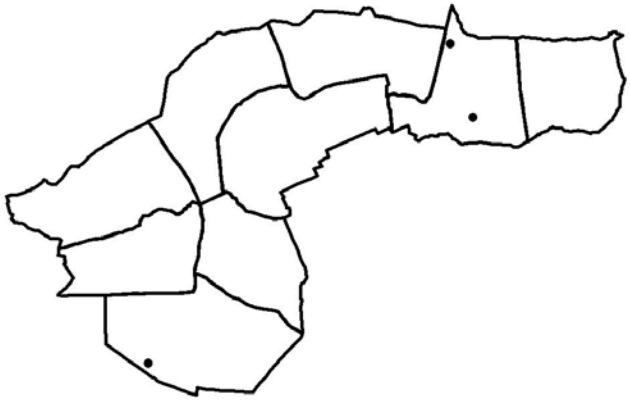
Helichrysum newii



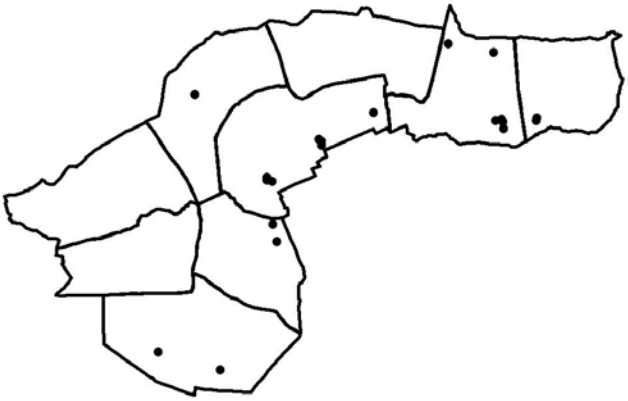
Isoglossa laxiflora



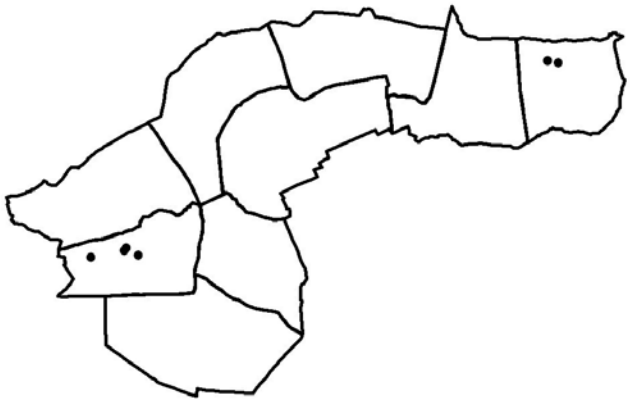
Kyallinga alba-purpurea



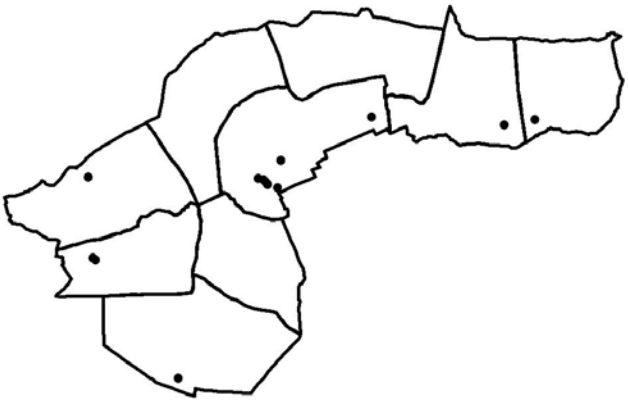
Leucus deflexa



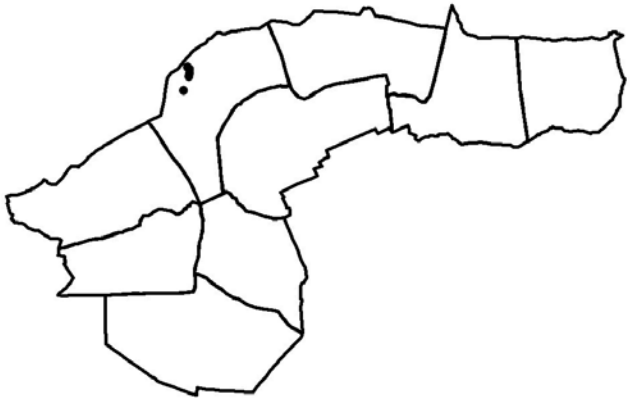
Mendosia gilgiana



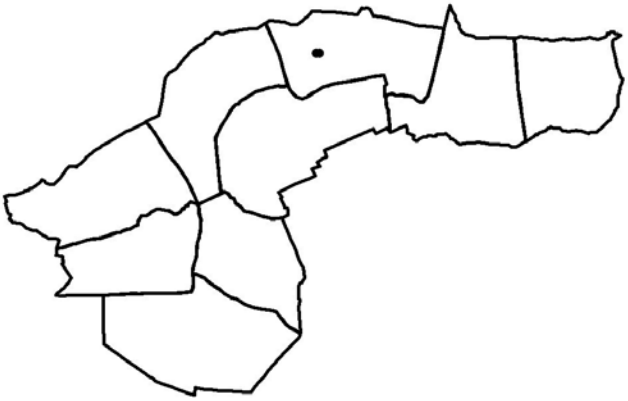
Mimulopsis excellens



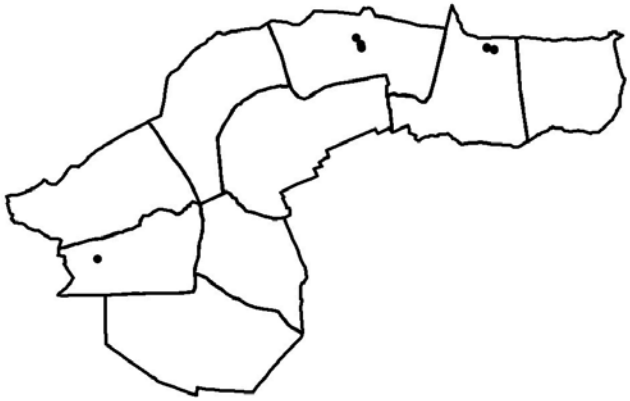
Pavetta oliverana



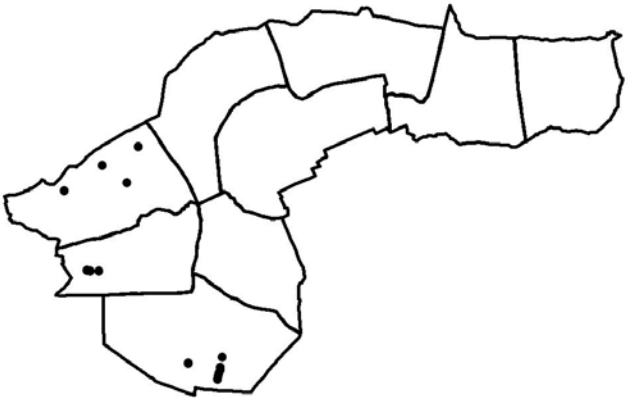
Pavetta urundensis



Pentas zanzibarica

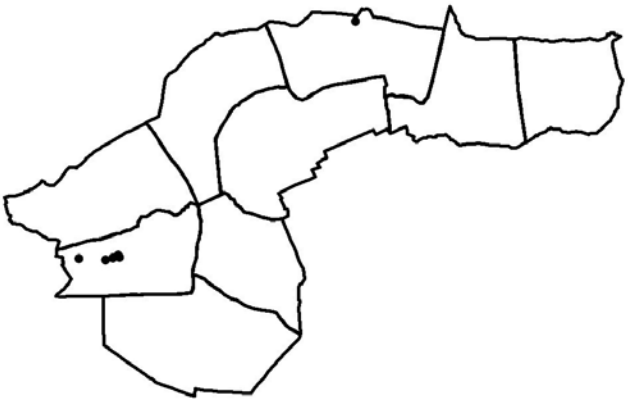


Pilea bambuseti

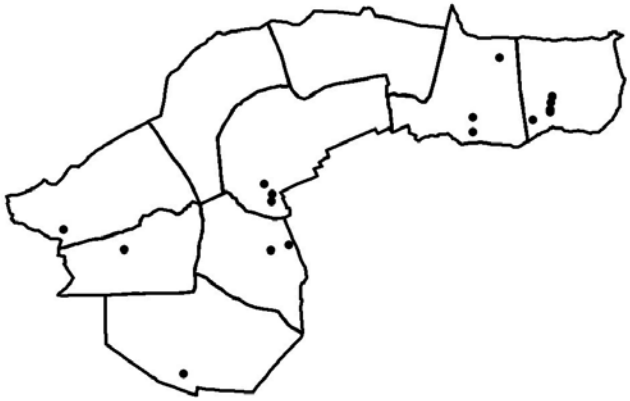


Poa muhavurensis

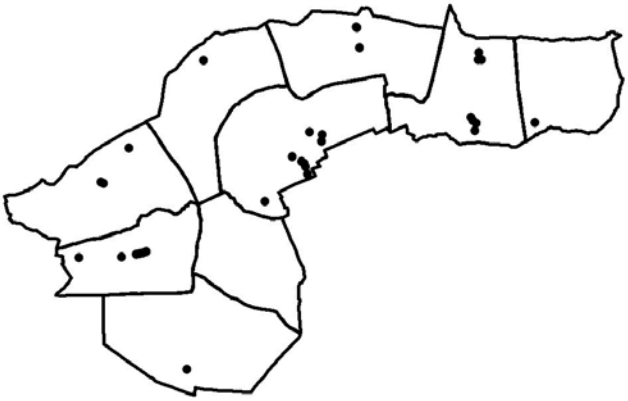
Polygala ruwenzoriensis



Pycnostachys goetzenii

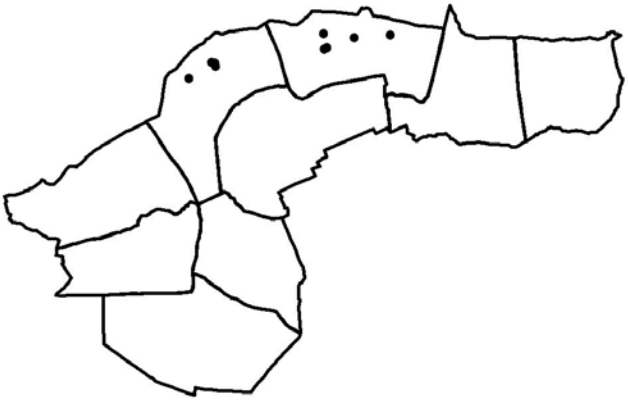


Rubus apetalus

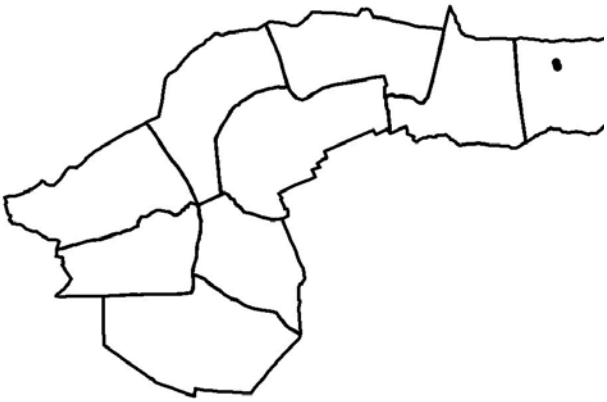


Rumes bequaertii

Rutidea smithii

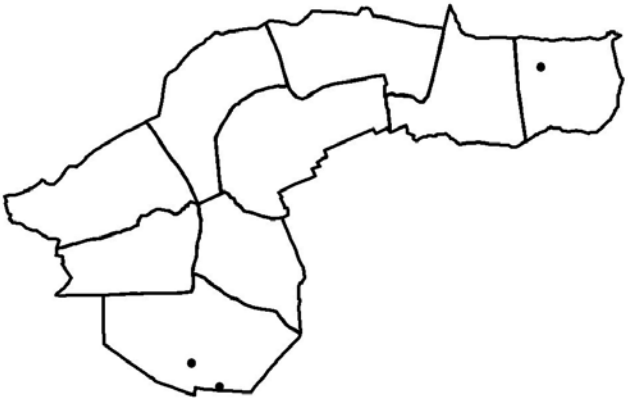


Sagina abyssinica

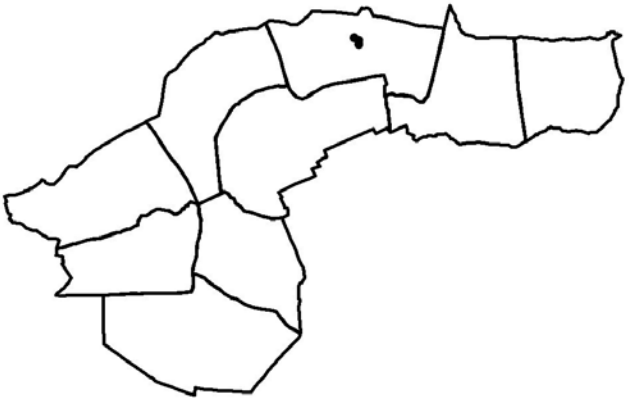


Senecio johnstonii

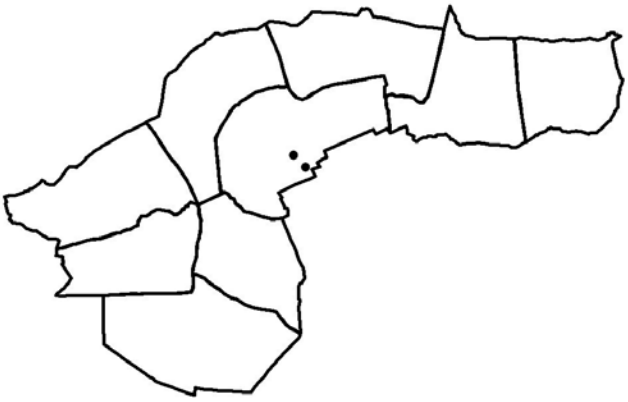
Senecio mariettae



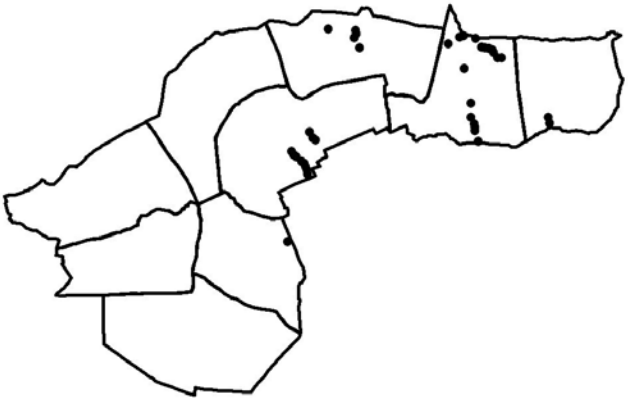
Smithia elliotii



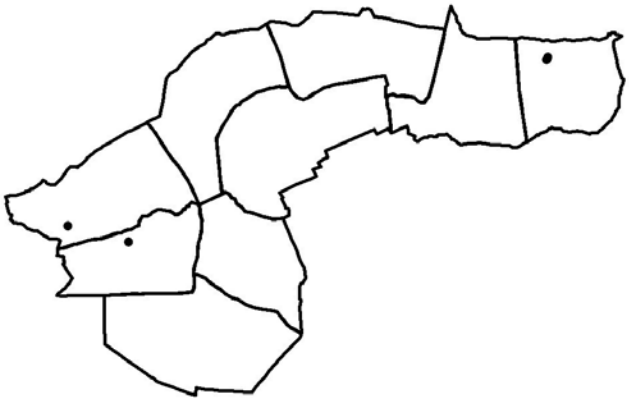
Trifolium purseglovei



Uebelina kivuensis



Vernonia syringifolia



Appendix 5. *The total list of plant species recorded in Virunga Volcanoes arranged in alphabetical order. Albertine Rift Endemics are labelled as ARE under the status column and IUCN listed species are listed according to their threat category.*

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
Acanthaceae	Acanthus pubescens				1			1			1	1	
	Acanthus ueleensis								1				
	Asystasia gangetica				1			1					
	Brillantaisia kirungae								1				
	Brillantaisia owariensis								1			1	
	Brillantaisia subcordata						1						
	Brillantaisia ulugurica				1			1	1	1	1	1	
	Crossandrella dusenii						1			1			
	Eremomastax speciosa				1				1		1		
	Hygrophila abyssinica			1						1			
	Hygrophila acutisepala			1						1			
	Hypoestes forskaolii									1			
	Hypoestes triflora			1			1	1	1	1	1	1	1
	Isoglossa lactea								1		1		
	Isoglossa laxiflora	ARE			1			1	1				
	Isoglossa punctata							1			1		1
	Isoglossa vulcanicola	ARE									1		
	Justicia diffusa				1								
	Justicia flava				1				1	1	1	1	
	Justicia phyllostachys										1		
	Mendoncia gilgiana				1								1
	Mimulopsis arborescens			1	1		1	1	1		1	1	1
	Mimulopsis elliotii	ARE							1				
	Mimulopsis excellens	ARE		1	1		1	1		1	1	1	1
	Mimulopsis solmsii			1	1		1	1	1	1	1	1	
	Mimulopsis usambarensis			1									
	Oreacanthus coeruleus				1				1			1	
	Oreacanthus mannii							1					
	Thunbergia alata				1			1	1		1	1	
	Thunbergia hamata			1						1			
	Thunbergia kamatembica	ARE							1		1		
	Thunbergia mildbraediana	ARE							1		1		
	Thunbergia sp1				1								
	Thunbergia sp2							1					
	Thunbergia stuhlmanniana									1			
Adiantaceae	Adiantum poiretii				1			1				1	1

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Cheilanthes farinosa							1				
	Coniogramme africana						1					
	Pellaea doniana								1			
	Pellaea longipilosa				1							
	Pteris burtonii							1	1			
	Pteris dentata				1	1	1	1	1		1	1
	Pteris mildbraedii			1	1	1	1	1	1	1	1	1
	Pteris mohasiensis							1				
	Pteris preussii				1			1		1		
	Pteris pteridioides									1		
Alangiaceae	Alangium chinense						1	1				
Amarantaceae	Sericostachys scandens				1		1					
Amaranthaceae	Achyranthes aspera			1	1	1	1	1	1	1	1	1
	Cyathula achyranthoides					1		1				
	Cyathula polycephala					1				1		1
	Cyathula prostrata								1			
Anthericaceae	Chlorophytum beniense										1	
	Chlorophytum colubrinum										1	
	Chlorophytum comosum									1		
	Chlorophytum filipendulum						1	1		1		
	Chlorophytum micranthum										1	
	Chlorophytum sp 1										1	
	Chlorophytum sparsiflorum				1			1		1		
Apiaceae	Agrocharis incognita			1	1					1	1	1
	Agrocharis melanantha										1	
	Agrocharis pedunculata										1	
	Anthriscus arvensis			1			1		1	1		
	Anthriscus dissectus										1	
	Anthriscus sylvestris			1		1	1		1		1	
	Berula erecta				1							
	Centella asiatica			1			1			1		
	Cryptotaenia africana					1						
	Hydrocotyle mannii			1	1	1	1		1	1	1	1
	Hydrocotyle sibthorpioides					1	1		1	1	1	1
	Oenanthe mildbraedii	ARE						1	1	1		1
	Oenanthe procumbens						1					1
	Peucedanum aculeolatum				1	1			1	1		1
	Peucedanum elgonense											1
	Peucedanum kerstenii				1	1				1	1	1
	Peucedanum linderi			1	1	1	1		1	1	1	1
	Peucedanum runssoricum	ARE			1			1	1	1	1	1

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Pimpinella keniensis							1		1	1	
	Pimpinella richardsiae	ARE		1							1	
	Sanicula elata			1	1	1	1	1	1	1	1	1
Apocynaceae	Alafia scandens								1			
	Farquharia elliptica								1			
	Landolphia foretiana								1			
	Tabernaemontana stapfiana							1	1		1	
Aquifoliaceae	Ilex mitis		VU	1			1		1	1	1	
Araceae	Arisaema mildbraedii			1			1	1	1	1	1	
	Culcasia scandens							1	1			
Araliaceae	Polyscias fulva				1			1				
	Schefflera adolfi-friderici									1		
	Schefflera goetzenii							1			1	1
	Schefflera kivuensis											1
	Schefflera mildbraedii											1
	Schefflera myriantha								1		1	1
Asclepiadaceae	Cynanchum abyssinicum	ARE									1	
	Cynanchum schistoglossum				1				1		1	
	Ectadiopsis oblongifolia	ARE		1								
	Gongronema angolense									1			1
	Mondia whitei			1	1			1	1	1		1	
	Periploca linearifolia				1							1	1
	Periploca nigrescens			1			1	1		1		1	
	Rhynchostigma racemosum		LR/nt					1					
	Secamone africana							1	1	1		1	
	Secamone punctulata									1			
	Tacazzea conferta				1				1		1		1
	Tacazzea sp 1											1	
	Tylophora cameroonica		VU							1			
	Tylophora conspicua										1		
	Tylophora heterophylla				1	1		1			1		
Asparagaceae	Asparagus africanus							1					
	Asparagus asparagoides			1						1	1	1	1
Asphodelaceae	Kniphofia grantii			1						1	1		1
Aspidiaceae	Polystichum setiferum			1				1		1			1
	Polystichum sp 1											1	
	Tectaria gemmifera			1				1	1		1		
Aspleniaceae	Asplenium abyssinicum							1		1		1	1
	Asplenium aethiopicum			1	1	1		1		1		1	1
	Asplenium barteri			1									
	Asplenium bugoiense				1								

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Asplenium burundense			1				1			1	
	Asplenium centrafricanum							1			1	
	Asplenium cornutum								1			
	Asplenium dregeanum				1					1		1	
	Asplenium elliotii			1								
	Asplenium erectum			1				1	1	1		
	Asplenium friesiorum				1			1		1	1	1	1
	Asplenium inaequilaterale			1				1		1	1		1
	Asplenium kassneri										1	
	Asplenium laurentii									1		
	Asplenium lobatum								1		1		
	Asplenium loxoscaphoides			1			1	1		1	1		
	Asplenium macrophlebium				1					1			
	Asplenium majus									1			
	Asplenium mannii								1	1	1		1
	Asplenium mildbraedii			1								
	Asplenium monanthes			1			1	1	1	1			1
	Asplenium normale			1							1	1
	Asplenium praemorsum			1						1		
	Asplenium rutifolium			1						1	1	1	1
	Asplenium sandersonii			1	1				1	1	1		1
	Asplenium smedsii				1		1			1			1
	Asplenium stulhumanii			1			1						
	Asplenium theciferum			1				1	1	1	1	1	1
	Asplenium Dnn5136			1									
	Asplenium Dnn5137			1									
	Asplenium sp 1										1		
	Asplenium sp 2				1								
Asteraceae	Achyrocline schimperi											1	1
	Achyrocline stenoptera			1			1	1		1		1	1
	Adenostemma mauritianum				1								
	Adenostemma perrottetii				1				1				
	Adenostemma viscosum										1		
	Aspilia congoensis	ARE						1					
	Bidens elliotii	ARE											1
	Blumea adamsii											1	
	Bothriocline hoyoensis											1	
	Bothriocline kungwensis	ARE										1	
	Bothriocline longipes											1	
	Bothriocline ruwenzoriensis	ARE								1	1	1	1
	Bothriocline ugandensis							1		1		1	1

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Carduus nyassanus			1	1	1	1		1	1	1	1
	Cineraria deltoidea			1		1	1		1		1	1
	Conyza gigantea						1			1	1	
	Conyza newii					1					1	1
	Conyza pedunculata			1								
	Conyza schimperi			1						1	1	
	Conyza subscaposa			1		1					1	1
	Conyza tigrensis			1							1	
	Conyza vernonioides			1							1	
	Crassocephalum ducis-aprutii	ARE		1	1	1	1	1	1	1	1	1
	Crassocephalum effusum										1	1
	Crassocephalum goetzenii	ARE									1	1
	Crassocephalum montuosum	ARE		1	1	1	1		1	1		
	Crassocephalum paludum								1			
	Crassocephalum picridifolium				1		1	1			1	
	Crassocephalum rubens				1			1				1
	Crassocephalum vitellinum			1	1		1	1	1	1	1	1
	Crepis carbonaria									1	1	
	Crepis newii								1			
	Dichrocephala chrysanthemifolia						1		1		1	
	Dichrocephala integrifolia			1	1	1	1	1	1	1	1	1
	Dicoma kirkii											1
	Echinops hoehnelii			1	1	1						1
	Galinsoga parviflora				1		1			1	1	1
	Galisonga ciliata					1						
	Gynura amplexicaulis				1		1		1		1	1
	Gynura scandens			1	1	1	1	1	1	1	1	1
	Helichrysum argyranthum	ARE									1	
	Helichrysum brownei	ARE		1		1					1	
	Helichrysum decorum			1		1						
	Helichrysum foetidum			1		1						
	Helichrysum formosissimum			1		1			1		1	1
	Helichrysum forskahlii			1		1	1		1		1	1
	Helichrysum fulgens	ARE				1						
	Helichrysum gaharoense	ARE			1							1
	Helichrysum globosum					1					1	1
	Helichrysum glutinosum					1						
	Helichrysum helothamnus	ARE			1							
	Helichrysum helvolum	ARE		1							1	
	Helichrysum maranguense			1	1	1	1			1	1	1
	Helichrysum mildbraedii	ARE		1		1				1	1	

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Helichrysum nandense			1							1	1
	Helichrysum newii								1			
	Helichrysum odoratissimum			1		1	1		1		1	1
	Helichrysum panduratum						1					
	Helichrysum ruandense	ARE				1					1	1
	Helichrysum setosum									1		
	Helichrysum sp 1										1	1
	Helichrysum sp2											1
	Helichrysum sp 3						1					
	Helichrysum sp 4				1							
	Helichrysum sp 5									1		
	Hypericophyllum angolense											1
	Hypericophyllum compositarum											1
	Lactuca attenuata			1								
	Lactuca glandulifera			1							1	
	Lactuca schweinfurthii										1	1
	Lactuca stipulata	ARE		1								
	Lactuca sp 1				1							
	Melanthera pungens						1					
	Melanthera scandens					1						
	Micractis bojeri	ARE		1		1	1	1		1	1	1
	Microglossa pyrifolia				1	1	1		1	1		
	Mikania capensis			1		1						
	Mikania chevalieri			1	1	1	1	1	1	1	1	1
	Mikaniopsis bambusetii			1	1	1	1	1		1	1	1
	Mikaniopsis kivuensis			1	1		1	1				1
	Mikaniopsis nyungwensis				1							
	Mikaniopsis tedliei			1					1		1	
	Senecio johnstonii	ARE		1	1	1					1	1
	Senecio karaguensis				1							
	Senecio maranguensis				1	1			1	1	1	1
	Senecio mariettae	ARE		1	1	1	1			1		1
	Senecio mattirolii	ARE		1								
	Senecio purpureus			1		1						
	Senecio sabinjoensis	ARE							1	1		
	Senecio subsessilis			1	1	1	1		1	1	1	1
	Siegesbeckia orientalis						1			1	1	
	Solanecio mannii			1	1	1	1	1	1	1	1	1
	Sonchus afromontanus						1	1	1	1	1	
	Sonchus bipontini			1		1			1	1		1
	Sonchus luxurians						1	1	1	1	1	

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Sparganophorus sparganophora	ARE										1
	Sphaeranthus suaveolens										1	1
	Spilanthes costata								1			
	Spilanthes mauritiana								1	1		
	Vernonia adoensis			1								
	Vernonia auriculifera			1	1			1	1	1	1	
	Vernonia biafrae							1	1		1	1
	Vernonia bonariensis			1	1							
	Vernonia calvoana	ARE		1	1	1	1	1	1	1	1	1
	Vernonia glabra					1				1	1	1
	Vernonia hochstetteri							1		1		
	Vernonia ituriensis			1								
	Vernonia kirungae	ARE			1	1						
	Vernonia poggeana						1					
	Vernonia sp 1									1		
	Vernonia sunzuensis	ARE										1
	Vernonia syringifolia	ARE			1					1	1	1
	Vernonia ugandensis									1		
Athyriaceae	Diplazium zanzibaricum										1	
Balsaminaceae	Impatiens burtonii	ARE				1	1		1			
	Impatiens masisiensis	ARE			1							
	Impatiens stuhlmannii			1	1	1	1	1	1	1	1	1
	Impatiens sp 1				1							
Basellaceae	Basella alba				1	1	1	1	1	1	1	1
Begoniaceae	Begonia meyeri-johannis				1		1				1	1
Bignoniaceae	Kigelia africana						1					
Blechnaceae	Blechnum tabulare										1	
Boraginaceae	Cynoglossum amplifolium			1		1			1	1	1	1
	Cynoglossum coeruleum				1							
	Lithospermum afromontanum			1								1
Brassicaceae	Subularia monticola			1								
Burmanniaceae	Tacca leontapelatoides				1							
Urticaceae	Pilea johnstonii										1	
Caesalpiniaceae	Caesalpinia major	ARE							1			
	Cassia kirkii									1		
Campanulaceae	Wahlenbergia krebsii			1					1		1	
Cannaraceae	Rourea thomsonii						1	1		1		
Caricaceae	Carica cundinariensis			1			1					
Caryophyllaceae	Cerastium afromontanum			1			1					
	Cerastium indicum					1						
	Cerastium octandrum			1		1			1		1	1

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Drymaria cordata							1			1	1	1
	Sagina abyssinica	ARE		1									1
	Sagina afroalpina											1	
	Stellaria mannii	ARE		1	1			1					
	Stellaria sennii			1	1	1		1			1	1	1
	Uebelinia kigesiensis					1							
	Uebelinia kiwuensis	ARE						1		1	1	1	1
Celastraceae	Maytenus acuminata				1					1	1	1	1
	Maytenus arbutifolia			1									
	Maytenus heterophylla										1		1
	Maytenus indica										1		
Colchicaceae	Gloriosa superba									1			
Commelinaceae	Aneilema aequinoctiale									1			
	Aneilema richardsiae									1			
	Aneilema spekei											1	
	Commelina africana							1	1	1	1	1	
	Commelina benghalensis											1	
	Commelina diffusa			1				1		1	1		1
	Commelina eckloniana									1	1		
	Commelina erecta									1	1		
	Cyanotis barbata							1		1		1	
	Floscopa glomerata	ARE								1			
	Stanfieldiella imperforata							1		1			
Connaraceae	Manotes lomaniensis									1			
Convolvulaceae	Ipomoea cairica							1	1			1	
	Ipomoea hildebrandtii	ARE										1	
	Ipomoea involucrata				1			1	1	1	1	1	
	Ipomoea shupangensis									1			
	Ipomoea tenuirostris							1		1		1	
Cornaceae	Afrocrania volkensii			1	1	1		1		1	1	1	1
Crassulaceae	Bryophyllum pinnatum										1		
	Crassula alsinoides			1		1				1		1	1
	Crassula granvikii			1		1				1	1	1	1
	Crassula inanis											1	
	Crassula schimperi					1				1			
	Crassula vaginata					1							
	Crassula volkensii					1							
	Kalanchoe glaucescens							1					
	Kalanchoe lateritia										1		
Cruciferae	Cardamine africana			1		1		1		1	1		1
	Cardamine hirsuta			1								1	1

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Cardamine obliqua			1			1					1	
	Cardamine trichocarpa			1			1						1
Cucurbitaceae	Coccinia adoensis									1			
	Coccinia mildbraedii			1	1		1	1	1	1	1	1	1
	Kedrostis hirtella				1			1	1		1		1
	Lagenaria abyssinica							1					
	Lagenaria sphaerica			1	1			1	1	1	1	1	1
	Momordica foetida				1			1	1		1	1	1
	Momordica jeffreyana				1			1					
	Momordica runssorica			1									
	Momordica sp 1			1									
	Momordica sp 2									1			
	Momordica sp 3									1			
	Oreosyce africana			1	1		1	1					
	Peponium vogelii	ARE			1						1		
	Raphidiocystis chrysoloma									1			
	Zehneria minutiflora			1	1					1			
	Zehneria scabra			1	1		1	1	1	1	1	1	1
	Zehneria sp 1									1			
Cyatheaceae	Cyathea camerooniana			1							1		
Cyperaceae	Abildgaardia densa									1			
	Abildgaardia oritrephes											1	
	Anosporum pectinatus									1	1	1	
	Carex bequaertii			1			1			1			1
	Carex chlorosaccua						1				1		1
	Carex conferta			1			1	1		1	1	1	1
	Carex johnstonii			1			1	1		1			1
	Carex karisimbiensis									1		1	
	Carex mannii			1			1					1	1
	Carex monostachya			1									
	Carex papillosissima												1
	Carex petitiana			1	1		1			1			
	Carex ramosipes										1		1
	Carex runssoroensis			1			1				1		1
	Carex schimperiana			1			1						
	Carex simensis									1		1	
	Cyperus ajax						1					1	1
	Cyperus articulatus						1	1		1		1	
	Cyperus cremeomariscus											1	
	Cyperus denudatus						1	1		1		1	
	Cyperus dichroostachyus										1		1

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I	
	Cyperus dives				1	1	1		1		1		
	Cyperus renschii										1		
	Cyperus rigidifolius								1		1		
	Cyperus sp 1					1							
	Isolepis costata	ARE		1		1				1			
	Isolepis fluitans			1		1			1		1		
	Isolepis setacea	ARE				1	1		1		1	1	
	Kyllinga alba-purpurea	ARE		1		1					1		
	Kyllinga brevifolia			1							1		
	Kyllinga bulbosa										1		
	Kyllinga chrolotropis								1		1		
	Kyllinga erecta								1		1		
	Kyllinga nigripes					1							
	Kyllinga odorata			1		1	1		1		1		
	Kyllinga peruviana								1				
	Mariscus deciduus										1	1	
	Mariscus karisimbiensis	ARE				1			1	1	1		
	Mariscus longibracteatus								1				
	Mariscus rubrotinctus										1		
	Mariscus soyauxii					1			1				
	Pycreus micromelas										1		
	Pycreus niger			1		1					1		
	Pycreus nigricans										1	1	
	Remirea maritima								1				
	Rhynchospora rugosa					1							
	Schoenoplectus corymbosus						1		1		1		
	Scleria achtenii											1	
	Scleria distans					1							
	Scleria racemosa								1				
Davalliaeae	Davallia chaerophylloides								1				
Dennstaedtiaceae	Histiopteris incisa			1		1	1		1			1	
	Pteridium aquilinum			1	1	1	1		1	1	1	1	
Dichapetalaceae	Dichapetalum angolense								1				
	Dichapetalum ugandense								1				
Dipsacaceae	Dipsacus narcisseanus		VU		1	1				1		1	
	Dipsacus pinnatifidus				1					1			
	Scabiosa columbarica								1				
Dipterocarpaceae	Monotes elegans								1				
Dracaenaceae	Dracaena afromontana						1		1			1	
	Dracaena steudneri								1				
Dryopteridaceae	Dryopteris athamantica				1	1					1	1	

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Dryopteris inaequalis				1			1	1	1	1	1	1
	Dryopteris kilimensis			1				1		1		1	1
	Dryopteris lanuginosa												1
	Dryopteris manniana			1	1	1	1	1	1	1	1	1	1
	Dryopteris pentheri			1	1							1	
	Dryopteris sp				1							1	
Ericaceae	Agauria salicifolia										1		1
	Erica arborea				1							1	1
	Erica kingaensis			1									
Eriocaulaceae	Eriocaulon schimperi						1						1
Euphorbiaceae	Acalypha bipartita							1	1		1		
	Acalypha brachystachya				1						1		
	Acalypha ornata											1	1
	Acalypha villicaulis						1						
	Acalypha volkensii						1						1
	Bridelia micrantha								1				
	Clutia abyssinica									1	1	1	1
	Clutia paxii							1					
	Croton macrostachyus							1	1		1		
	Erythrococca bongensis				1						1		
	Erythrococca trichogyne								1				
	Erythrococca welwitschiana				1				1				
	Euphorbia schimperiana			1	1	1	1		1	1	1	1	1
	Neoboutonia macrocalyx				1			1	1	1	1	1	1
	Phyllanthus amarus										1		
	Phyllanthus nummulariifolius								1		1		
	Phyllanthus ovalifolius							1		1	1	1	
	Phyllanthus polyanthus									1			
	Tragia brevipes							1					
Fabaceae	Adenocarpus mannii												1
	Aeschynomene indica											1	
	Aeschynomene schimperi										1		
	Alysicarpus glumaceus				1								
	Amphicarpaea africana			1								1	1
	Antopetitia abyssinica						1						
	Argyrolobium tomentosum	ARE									1	1	
	Clitoria ternatea											1	
	Crotalaria adenocarpoides	ARE											1
	Crotalaria cylindrica												1
	Crotalaria goreensis										1		
	Crotalaria incana							1		1	1		1

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Crotalaria mesopontica									1	1	1
	Crotalaria mildbraedii				1		1		1		1	
	Crotalaria orthoclada									1		
	Dalbergia lactea						1		1		1	
	Desmodium adscendens								1			
	Desmodium repandum			1	1	1	1	1	1	1	1	1
	Desmodium setigerum								1			
	Dumasia villosa										1	
	Eriosema montanum									1		
	Eriosema nutans									1	1	
	Eriosema scioanum											1
	Lablab purpureus					1						
	Lathyrus hygrophilus				1				1		1	
	Smithia elliotii	ARE					1			1		
	Tephrosia interrupta									1		
	Tephrosia nigrocalyx									1		
	Teramnus labialis								1			
	Trifolium baccarinii			1		1			1			
	Trifolium burchellianum								1		1	
	Trifolium purseglovei	ARE							1			
	Trifolium rueppellianum					1			1		1	1
	Trifolium usambarense			1					1		1	1
	Vicia sativa				1				1		1	1
	Vigna membranacea	ARE					1	1		1	1	
Flacourtiaceae	Casearia battiscombei						1	1				
	Dovyalis macrocalyx			1			1		1		1	1
	Dovyalis macrocarpa			1						1		
	Dovyalis zenkeri							1				
Fumariaceae	Corydalis mildbraedii			1		1	1		1			
Gentianaceae	Swertia adolfi-friderici											1
	Swertia brownii			1		1					1	1
	Swertia eminii			1								
	Swertia kilimandscharica										1	1
	Swertia macrosepala	ARE				1						
Geraniaceae	Geranium aculeolatum				1	1	1		1	1	1	1
	Geranium arabicum			1	1	1	1		1	1	1	1
	Geranium ocellatum					1						
	Geranium vagans					1	1			1		
Hippocrateceae	Bequaertia mucronata								1			
	Campylostemon laurentii								1			
	Pristimera andongensis								1			

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Pristimera plumbea								1			
	Salacia leptoclada								1	1		
Hymenophyllaceae	Hymenophyllum sibthorpioides					1						
Hypericaceae	Harungana madagascariensis					1						
	Hypericum humbertii	ARE		1								
	Hypericum peplidifolium			1		1			1		1	1
	Hypericum revolutum			1	1	1	1		1	1	1	1
	Hypericum scioanum			1		1			1	1	1	1
Hypoxidaceae	Hypoxis kilimanjarica					1						
Iridaceae	Aristea alata										1	
	Aristea ecklonii					1			1		1	
	Gladiolus candidus								1			
	Gladiolus erectiflorus										1	
	Romulea camerooniana					1						
Juncaceae	Juncus dregeanus										1	
	Juncus effusus			1							1	
	Juncus oxycarpus					1	1		1		1	1
	Luzula abyssinica			1			1			1		1
	Luzula sp 1				1							
Lamiaceae	Ajuga alba				1					1	1	
	Isodon ramosissimus			1	1	1	1	1	1	1	1	1
	Leonotis nepetifolia				1			1		1		1
	Leucas alluaudii	ARE		1								
	Leucas deflexa	ARE		1		1	1		1	1	1	1
	Leucas martinicensis									1		
	Ocimum gratissimum						1			1		
	Octomeron montanum						1					
	Plectranthus edulis			1	1	1	1	1	1	1	1	1
	Plectranthus ferrugineus				1							
	Plectranthus fraccidus										1	1
	Plectranthus lanuginosus			1					1		1	1
	Plectranthus luteus								1	1	1	
	Plectranthus mildbraedii				1	1						
	Plectranthus pauciflorus										1	
	Pycnostachys erici-rosenii				1						1	
	Pycnostachys goetzenii	ARE		1	1	1			1		1	1
	Pycnostachys meyeri									1		1
	Salvia nilotica			1		1	1		1		1	1
	Satureja punctata			1		1					1	1
	Satureja simensis			1		1			1		1	
	Solenostemon latifolius								1			

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Solenostemon platostomoides									1		
	Solenostemon shirensis				1							
	Solenostemon sylvaticus				1						1	1
	Stachys aculeolata			1	1	1	1		1		1	1
Lemnaceae	Spirodela polyrrhiza								1			
Lobeliaceae	Lobelia giberroa			1	1	1	1		1			1
	Lobelia mildbraedii			1		1						1
	Lobelia minutula			1		1			1	1	1	1
	Lobelia petiolata				1							
	Lobelia rubescens										1	
	Monopsis stellaroides	ARE		1		1	1		1	1	1	1
Loganiaceae	Nuxia congesta										1	
	Nuxia floribunda							1	1	1		1
	Strychnos aculeata								1			
Lomariopsidaceae	Bolbitis auriculata								1			
	Elaphoglossum deckenii								1			
Loranthaceae	Englerina schubotziana	ARE					1		1		1	
Lycopodiaceae	Huperzia saururus					1						
	Lycopodium clavatum			1		1				1	1	
	Lycopodium ophioglossoides			1								
	Lycopodium saururus			1					1			
Lythraceae	Pemphis acidula										1	1
Malvaceae	Hibiscus berberifolius											1
	Hibiscus diversifolius					1			1	1	1	1
	Hibiscus ferrugineus					1						
	Hibiscus ovalifolius				1							
	Kosteletzkya grantii									1		
	Malva parviflora										1	
	Pavonia kilimandscharica							1		1	1	
	Pavonia senegalensis								1			
	Pavonia urens						1	1	1			
	Sida cordifolia						1					
	Sida ternata			1								
Melastomataceae	Dissotis ruandensis	ARE				1						
	Dissotis senegambiensis									1		
Meliaceae	Ekebergia capensis							1		1		
	Entandrophragma excelsum							1				
	Lepidotrichilia volkensii						1	1		1	1	1
Melianthaceae	Bersama abyssinica				1		1	1		1	1	
Menispermaceae	Stephania abyssinica			1	1	1	1	1	1	1	1	1
	Syrrheonema fasciculatum								1			

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Tiliacora laurentii				1							
	Tinospora caffra			1		1						
	Triclisia sacleuxii								1			
Mimosaceae	Acacia pentagona											1
Monimiaceae	Xymalos monospora				1			1	1	1	1	1	1
Moraceae	Dorstenia alta					1						
	Dorstenia benguellensis					1						
	Dorstenia nyungwensis				1							
	Ficus brachypoda							1				
	Ficus oreodryadum							1				
Musaceae	Ensete ventricosum				1			1			1		
Myricaceae	Myrica salicifolia			1								1	1
Myrsinaceae	Embelia schimperi				1	1		1				1	1
	Maesa lanceolata				1	1		1	1	1		1	1
	Rapanea melanophloeos			1	1	1		1		1			1
Myrtaceae	Syzygium guineense	ARE						1					
Nephrolepidaceae	Arthropteris orientalis							1		1			
Oleaceae	Jasminum abyssinicum				1			1	1				
	Jasminum dichotomum				1				1		1		
	Jasminum pauciflorum					1				1			1
	Jasminum schimperi										1		
	Jasminum sp										1		
	Olea capensis												1
	Olea chrysophylla					1		1		1	1	1	1
	Olea europea		LR/nt		1								
Onagraceae	Epilobium salignum				1					1			1
	Epilobium stereophyllum					1				1		1	
Orchidaceae	Calanthe sylvatica				1								
	Cheirostylis lepida								1				
	Cynorkis kassneriana	ARE								1		1	
	Disa eminii					1							
	Disa erubescens				1								
	Disa katangensis											1	
	Disa stairsii			1									1
	Disperis dicerochila											1	
	Disperis kilimanjarica												1
	Epipactis africana											1	
	Eulophia angolensis									1			
	Habenaria bequaertii	ARE										1	
	Habenaria chlorotica											1	
	Habenaria macrandra									1			

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Habenaria peristyloides										1	
	Habenaria welwitschii									1		
	Habenaria zambesina									1		
	Jumellea filicornoides										1	
	Kryptostoma tentaculigera							1				
	Malaxis prorepens								1			
	Manniella gustavi								1			1
	Nervilia adolphi								1			
	Nervilia subintegra								1			
	Oeceoclades lubbersiana	ARE							1			
	Oeceoclades maculata								1			
	Platylepis glandulosa									1	1	1
	Polystachya bicarinata									1		
	Polystachya cultriformis										1	
	Polystachya dewanckeliana	ARE						1			1	
	Polystachya kermesina	ARE		1					1			
	Zeuxine elongata			1								
Oxalidaceae	Oxalis corniculata				1					1		1
	Oxalis latifolia			1	1			1		1	1	1
	Oxalis obliquifolia								1		1	
	Oxalis procumbens					1			1			
Pandaceae	Microdesimis pierlotiana								1			
Papilionaceae	Parochetus communis			1		1			1			1
Passifloraceae	Adenia bequaertii							1	1			
	Adenia cissampeloides							1	1		1	
	Adenia globosa								1			
	Adenia tricostata									1		
Phytolaccaceae	Phytolacca dodecandra										1	1	1
Piperaceae	Peperomia blanda				1			1				1	
	Peperomia retusa								1	1	1	
	Peperomia tetraphylla							1	1			1	
	Piper capense				1		1	1	1		1	1	1
	Pothomorphe umbellata										1		
Pittosporaceae	Pittosporum mildbraedii			1									1
	Pittosporum viridiflorum			1	1		1			1		1	1
Plantaginaceae	Plantago palmata			1	1		1			1	1	1	1
Plumbaginaceae	Plumbago zeylanica				1				1		1		1
Poaceae	Agrostis kilimandscharica			1									
	Agrostis pilgerana						1			1		1	
	Andropogon amethystinus						1						
	Andropogon distachyos						1						1

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Anthoxanthum nivale				1						1	1
	Brachypodium flexum											1
	Bromus leptoclados			1	1			1	1		1	1
	Bromus unioloides				1							
	Coelachne africana										1	
	Deschampsia caespitosa					1						
	Deschampsia flexuosa						1		1			
	Dichanthium foveolatum					1						
	Digitaria abyssinica				1					1		
	Eragrostis curvula										1	
	Eragrostis olivacea					1					1	
	Eriochloa meyeriana				1				1		1	
	Festuca abyssinica			1							1	1
	Festuca simensis					1					1	
	Helictotrichon milanjianum			1								
	Hyparrhenia cymbaria					1						
	Hyparrhenia diplandra											1
	Hyparrhenia newtonii					1						
	Miscanthus violaceus					1						
	Neyraudia arundinaceae											1
	Oplismenus hirtellus			1		1			1			1
	Panicum adenophorum					1					1	
	Panicum calvum								1			
	Panicum chionachne			1							1	1
	Panicum eickii								1			1
	Panicum heterostachyum					1			1		1	
	Panicum hochstetteri						1		1		1	
	Panicum hymeniochilum					1			1		1	
	Panicum monticola				1			1	1	1	1	1
	Panicum parvifolium								1		1	1
	Paspalum conjugatum					1			1			
	Paspalum paniculatum					1			1			
	Pennisetum thunbergii					1			1		1	
	Pennisetum trachyphyllum					1	1	1		1		
	Poa annua			1		1			1		1	1
	Poa leptoclada					1			1		1	1
	Poa muhavurensis	ARE		1		1						1
	Poa schimperiana			1		1			1		1	1
	Schizachyrium platyphyllum				1							
	Setaria poiretiana	ARE					1				1	
	Setaria pumila			1								

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Sinarundanaria alpina			1	1	1	1	1	1	1	1	1
	Sporobolus africanus										1	
	Sporobolus festivus									1		
	Themeda triandra			1						1		
	Vossia cuspidata								1		1	
Polygalaceae	Polygala kasikensis					1						
	Polygala ruwenzoriensis	ARE			1					1		
Polygonaceae	Polygonum nepalense			1	1	1	1	1	1		1	1
	Polygonum pulchrum					1	1		1			1
	Polygonum setosulum			1	1	1	1		1	1	1	
	Rumex abyssinicus				1							
	Rumex bequaertii	ARE		1		1	1		1	1	1	
	Rumex ruwenzoriensis			1	1	1		1	1			1
	Rumex usambarensis	ARE			1		1			1	1	1
Polypodiaceae	Drynaria laurentii	ARE								1	1	
	Lepisorus excavatus							1		1		
	Lepisorus schraderi								1			
	Loxogramme lanceolata			1				1		1		
	Phymatosorus scolopendria							1		1		
	Pleopeltis macrocarpa			1		1			1		1	1
	Pleopodium simianum				1							
Primulaceae	Anagallis angustiloba										1	
	Ardisiandra sibthorpioides			1			1				1	1
	Ardisiandra wettsteinii			1	1			1		1		1
	Lysimachia ruehmeriana			1	1				1			
Ranunculaceae	Clematis cissampeloides						1					
	Clematis hirsuta			1		1			1	1	1	1
	Clematis simensis			1	1	1	1	1	1	1	1	1
	Ranunculus bequaertii	ARE		1								
	Ranunculus multifidus			1	1	1	1	1	1	1	1	1
	Ranunculus oreophytus			1		1	1					1
	Ranunculus volkensii				1	1			1			1
	Thalictrum rhynchocarpum			1	1	1	1	1	1	1	1	1
Rhamnaceae	Gouania longispicata							1	1	1		
	Rhamnus prinoides			1	1		1	1	1	1	1	1
Rosaceae	Alchemilla cryptantha			1		1			1		1	1
	Alchemilla ellenbeckii	ARE		1	1	1						1
	Alchemilla geranioides			1								
	Alchemilla johnstonii	ARE		1	1	1	1		1	1	1	1
	Alchemilla kiwuensis				1	1	1		1			
	Alchemilla pedata								1		1	

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Hagenia abyssinica		VU	1	1	1			1			1
	Prunus africana		VU	1	1		1					
	Rubus apetalus	ARE		1	1	1	1	1	1	1	1	1
	Rubus kirungensis			1	1	1	1		1	1	1	1
	Rubus pinnatus						1			1	1	1
	Rubus runssorensis	ARE		1	1	1		1	1			1
	Rubus steudneri									1		
Rubiaceae	Anthospermum asperuloides		LR/nt								1	1
	Canthium sp									1		
	Chassalia cristata	ARE					1	1				
	Chassalia subochreata				1			1		1	1	
	Galiniera saxifraga			1	1	1	1	1	1	1	1	1
	Galium aparinoides			1			1		1			
	Galium chloroionanthum			1	1	1	1	1	1	1	1	1
	Galium ruwenzoriense			1								
	Galium simense			1	1	1	1	1	1	1	1	1
	Galium thunbergianum			1		1			1	1	1	1
	Geophila repens								1			
	Hedythyrsus thamnoideus			1								
	Hymenocoleus hirsutus								1			
	Hymenocoleus spA								1			
	Keetia gueinzii						1	1		1	1	
	Keetia purseglovei			1								
	Keetia sp 1						1			1		
	Leptactina platyphylla								1			
	Oxyanthus lepidus								1			
	Pauridiantha paucinervis	ARE					1	1			1	
	Pavetta gardeniifolia								1		1	
	Pavetta oliveriana	ARE					1	1				
	Pavetta ternifolia	ARE			1					1	1	
	Pavetta troupinii	ARE									1	
	Pavetta urundensis	ARE					1		1	1	1	1
	Pentas lanceolata	ARE					1				1	1
	Pentas zanzibarica	ARE			1					1	1	1
	Psychotria bugoyensis				1							
	Psychotria mahonii				1		1	1	1	1	1	1
	Rubia cordifolia				1					1	1	1
	Rutidea fuscescens										1	
	Rutidea rufipilis							1				
	Rutidea smithii							1		1	1	
	Rytigynia kigeziensis	ARE					1			1		

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Rytigynia kiwuensis	ARE									1	
	Spermacoce princeae						1		1	1	1	1
	Spermacoce tenuior								1		1	
	Vangueria apiculata										1	
	Vangueriella orthacantha						1				1	
Rutaceae	Teclea grandifolia								1			
	Teclea nobilis									1		
Sapindaceae	Allophylus abyssinicus				1							
	Allophylus kiwuensis				1							
	Allophylus macrobotrys				1		1					
Sapotaceae	Chrysophyllum gorungosanum								1			
Scrophulariaceae	Celsia floccosa							1		1		1
	Diclis sessifolia								1			
	Harveya liebuschiana								1			
	Micrargeria filiformis					1			1			1
	Sopubia conferta						1		1			
	Sopubia ramosa					1						
Scrophulariceae	Veronica glandulosa			1		1	1		1	1	1	1
	Veronica schimperi			1		1			1			
Selaginellaceae	Selaginella dregei			1		1			1		1	
	Selaginella kraussiana			1	1	1	1	1	1	1	1	1
Simaroubaceae	Brucea antidysenterica			1	1					1	1	
Smilacaceae	Smilax anceps									1		
Solanaceae	Discopodium penninervium			1	1	1	1	1	1	1	1	1
	Solanum aculeastrum				1		1		1	1	1	
	Solanum adoense			1		1		1				
	Solanum anguivi			1		1			1			1
	Solanum cyaneo-purpureum			1	1	1	1	1	1		1	
	Solanum incanum									1		
	Solanum luteum				1							
	Solanum mauritianum						1					
	Solanum pandurifome			1		1	1	1		1		
	Solanum terminale				1		1	1	1	1	1	1
	Solanum welwitschii								1			
Sterculiaceae	Byttneria catalpaefolia								1			
	Dombeya goetzenii				1	1	1	1	1	1	1	1
Theaceae	Ficalhoa laurifolia						1					
Thelypteridaceae	Christella dentata				1						1	
	Christella hispidula			1								
	Pneumatopteris afra						1			1		1
	Pneumatopteris unita										1	

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
Thymelaeaceae	Peddiea fischeri										1	
Tiliaceae	Sparmannia ricinocarpa				1						1	1
	Triumfetta cordifolia							1		1		
Urticaceae	Boehmeria macrophylla					1	1	1		1		
	Droguetia debilis						1					
	Droguetia iners			1	1	1	1	1	1	1	1	1
	Elatostema monticola	ARE		1	1		1	1	1	1	1	1
	Elatostema welwitschii				1		1					
	Girardinia bullosa					1			1	1		
	Girardinia diversifolia					1	1	1	1	1		
	Laportea alatipes			1	1	1	1	1	1	1	1	1
	Laportea ovalifolia			1			1		1	1		
	Parietaria debilis			1		1	1	1			1	1
	Pilea angolensis				1		1	1	1	1		1
	Pilea bambuseti	ARE		1	1		1					
	Pilea johnstonii			1		1	1		1		1	1
	Pilea rivularis			1	1	1	1	1	1		1	1
	Pilea tetraphylla				1		1				1	
	Procris crenata										1	
	Urera hypselodendron			1	1	1	1	1	1	1	1	1
	Urera trinervis						1					
	Urtica massaica			1	1	1	1	1	1	1		1
Verbenaceae	Clerodendrum bukobense				1							
	Clerodendrum johnstonii			1	1	1	1	1	1	1	1	1
	Verbena officinalis						1					
Violaceae	Viola abyssinica			1	1		1		1	1	1	1
	Viola eminii					1					1	1
Vitaceae	Cissus dinklagei							1		1		
	Cissus migeodii						1					
	Cissus oliveri							1	1	1		
	Cissus petiolata								1			
	Cissus planchoniana								1			
	Cyphostemma bambuseti				1		1	1		1	1	
Zingiberaceae	Renealmia congolana								1			
Unidentified plants	Unidentified sp Dnn 104				1							
	Unidentified sp Dnn 109				1							
	Unidentified sp Dnn 27				1							
	Unidentified sp Dnn 44				1							
	Unidentified sp Dnn 5003							1				
	Unidentified sp Dnn 5055										1	
	Unidentified sp Dnn 5162									1		

Family	Plant_Name	ARE	IUCN	A	B	C	D	E	F	G	H	I
	Unidentified sp Dnn 5241									1		
	Unidentified sp Dnn 67				1							
	Unidentified sp Dnn 84				1							
	Unidentified sp Dnn 86				1							
	Unidentified sp 1				1							