Bwindi Impenetrable National Park, Uganda Gorilla and Large Mammal Census, 1997

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COVER PHOTO
Silverback Gorilla by Andrew Plumptre

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Foreword

Gorillas evoke great passion in people. Local people who share their forest have traditionally feared their power, and in many cases strongly desire their lands. Expatriate people who have watched them on film are captivated by their individual, human-like characteristics and their story-book family lives. Government officials and private operators show tremendous enthusiasm for the great economic opportunities based on their tourism potential. Conservationists see them as a high-profile endangered species, a symbol of African forests, under strong threat from expanding human populations and increasing commercial forestry activities. These passions provide a unique and fascinating context for gorilla conservation.

Despite great and varied interests in gorillas, most understanding of the species, and conservation attention brought to it, has focused on one population - the Virunga mountain gorillas. This population, living at the confluence of the borders of Rwanda, Uganda and the Democratic Republic of Congo (formerly Zaire), has been the subject of many scientific studies, numerous television programs and magazine articles, and a long-standing program of intensive conservation management. Only more recently have other populations of gorillas received more attention, including the only other population of mountain gorillas which is found in the Bwindi Impenetrable Forest National Park of Uganda. It is this latter population that is the focus of this report.

Nestled in the southwest corner of Uganda is the Bwindi Forest, first gazetted as a Forest Reserve, now a National Park. Home to a number of little-known animal and plant species, it is now best recognized for its population of mountain gorillas. The subject of tourist visits, national publicity, and conservation support, it is remarkable that these gorillas are yet little-known scientifically. Following earlier work by Dr. Tom Butynski, who initiated surveys of gorillas here and established conservation projects to aid in their survival, it is only in the last few years that others have begun to improve our understanding of Bwindi gorilla ecology and behavior. And beyond gorillas, our knowledge of the forest is far more lacking.

Recognizing the need for further information, particularly information of direct use in current efforts to protect the gorillas and their habitat, a group of dedicated individuals and organizations came together in 1997 to conduct a systematic, precise count of the Bwindi gorilla population, combined with the first general survey of Bwindi's large mammals and vegetation. This represented an unprecedented collaboration among the nations of Uganda, Rwanda and the DRC, and many different conservation organizations. The following report, the *Bwindi Impenetrable National Park, Uganda, Gorilla and Large Mammal Census, 1997* documents the process of conducting these surveys and summarizes the results.

The results of this work will indeed be very useful in targeting Bwindi conservation efforts. The study concludes that this mountain gorilla population appears stable, and is approximately equal in size to the neighboring population in the Virunga mountains. It also points out that there may be some areas of potential gorilla habitat which are little used at present, indicating the possibility of the population increasing if well protected. In addition, areas of illegal human activity were recorded, and habitat use by large mammals documented. It is our hope that this study will thereby be used as a baseline for the design of further, effective conservation management of the Bwindi Impenetrable National Park and its outstanding wildlife.

Amy Vedder
Director, Africa Program

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The Wildlife Conservation Society (formerly the New York Zoological Society and its field division, Wildlife Conservation International) has been dedicated to understanding and protecting the earth's wildlife and ecosystems since 1895. The Wildlife Conservation Society (WCS) has the largest field-based research staff of any international conservation organization, and currently operates more than 250 field projects in over 50 countries throughout Africa, Asia, Central America, South America, and North America. WCS scientists have conducted pioneering, long-term field studies; played direct roles in establishing over 100 national parks and reserves; trained conservation professionals in developing countries; helped to strengthen the local institutions in which they work; and contributed key ideas to on-going debates about resource management and conservation.

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BWINDI IMPENETRABLE NATIONAL PARK, UGANDA

GORILLA AND LARGE MAMMAL CENSUS, 1997

Uganda Wildlife Authority

Wildlife Conservation Society

International Gorilla Conservation Programme

Institute of Tropical Forest Conservation

in collaboration with:

L'Institut Congolais pour la Conservation de la Nature

L'Office Rwandais de Tourisme et Parcs Nationaux

and the

Dian Fossey Gorilla Fund International

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June 1998

Dedication

This report is dedicated to the rangers and guides who gave up time with their families during a period of high insecurity in the Great Lakes Region. In particular it is dedicated to those people who lost members of their family during the census and to those who have lost their lives since that time.

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The census would not have been possible without the extreme hard work and dedication of all the participants, through many long, wet days in steep and difficult terrain. We are extremely grateful to team leaders Banard Akunda, Venance Betowabo, Phenny Gongo, Maryke Gray, David Greer, Robin Heber-Percy, Chad Hudson, Omari Ilambu, Gladys Kalema, Roger Mathews, Godfrey Mayoba, Deo Mbula, Gapira Mutazimiza, Barakabuye Nsengiyumva, Levi Rwamuhanda and Liz Williamson; to guides, guards and trackers Eliphazi Bamuturakyi, Desiderius Bamushobeza, Vincent Banshekura, Vincent Banyoya, Faustin Barabwiriza, Benjamin Bayenda, Francois Bigirimana, Lawrence Bizimana, Jean Bosco Bizumuremyi, Eria Bujakera, Theo Habyalimana, Jean Damascene Hategekimana, Emmanuel Hitayezu, Gadi Kanyangyeyo, Francis Katto, Mumbere Kitawivirirwa, Mathias Mpiranya, Alphonse Muhinzi, David Munyankindi, Jean Nepo Musekura, Edward Mutambuzi, Jean Bosco Ndengejeho, Caleb Ngambeneza, Jean Nkanika, Mundima Nkuba, Mujinya Nsekanabo, Fidele Nsengiyumva, Jean Damascene Ntahontuye, Bararuha Ntajumba, Vincent Nteziryayo, Murengazi Ntibarumidha, Augustin Nzamuranbaho, Elizifani Sahane, Mavunaki Tsongo, Medad Tumugabirwe, Joseph Tumwebaze, James Tumwesigye, Caleb Tusiime and Sande Wilson; to porters too numerous to mention and last but not least to camp keepers and cooks Godfrey Kakuto, Valentine Sigirenda, Peter Musaka, Steven Akabaya, and Wence Tumwijukye.

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Summary

Mountain gorillas are found in just two small, isolated populations in the Bwindi Impenetrable National Park, Uganda, and in the Virunga volcanoes on the borders of Rwanda, Uganda and the Democratic Republic of Congo (formerly Zaire). The Virunga population has been the focus of much research and several censuses over the past 30 years, but is seriously threaten by war and civil unrest in the area. Far less is known about the Bwindi gorillas, although some recent research has suggested that they may even be a different subspecies from the Virunga population.

During October and November, 1997, a census of the Bwindi gorilla population was carried out jointly by Uganda Wildlife Authority (UWA), Wildlife Conservation Society (WCS), International Gorilla Conservation Project (IGCP) and the Institute of Tropical Forest Conservation (ITFC) with the help of personnel from the Karisoke Research Centre (DFGF), Office Rwandais de Tourisme et Parcs Nationaux (ORTPN) and Institut Congolais pour la Conservation de la Nature (ICCN). The aims were to produce an accurate estimate of the gorilla population size and composition, while at the same time surveying the distribution and abundance of other large mammals and illegal human use of the forest. Standard gorilla censusing techniques, developed in the Virungas, were used.

Twenty-eight gorilla groups and seven lone males were found during the course of the census. Using a correction for small infants missed in nest counts, calculated from known groups, produced a total population estimate of 292 individuals. This is a conservative estimate, as there is a possibility that a few small groups could have been missed, (or confused with similar groups nearby, and) and because a conservative estimate was used for the number of infants missed. However, the area was covered intensively in a short period of time, so as to minimise the chance of missing groups, and we are confident that the actual population size could not be much larger. The population estimate obtained here is very similar to the best previous estimate of around 280-300, made in the early 1990s, so the population appears to be stable. As before, most of the gorilla population was found in the central portion of the southern part of the park. None were found in the northern part.

Signs of human disturbance were found in almost all sectors of Bwindi, but no clear relationship could be found between gorilla distribution and particular forms of human disturbance. Although protection in Bwindi has improved in recent years, such disturbance could still have an impact on the gorillas and might have played some role in preventing the population from increasing. Without a better understanding of

gorilla ecology and habitats in Bwindi, it is not possible to assess how far the population could increase, but intial impressions indicate that there are some areas of potential gorilla habitat which are little used at present. Given the small area of the park, the small gorilla population size and the presence (prevalence) of illegal human disturbance which remains,. improved protection should still be an important priority.

Total population sizes could not be calculated for most other mammals because of limited data, although it was possible to map relative densities across the park. We estimate a total of approximately 25 elephants, and between 440-1070 bushpigs. Ungulates were generally more common in the eastern portion of the southern part of the park. Monkeys were found more frequently around the edge of the forest and most species were seen more frequently at lower altitudes, while chimpanzees were more common in the centre of the southern part and in the northern part of the park.

Résumé

Les gorilles de montagne ne se trouvent que dans deux petites populations isolées, dans le Bwindi Impenetrable National Park en Ouganda, et dans les volcans Virunga sur les frontières du Rwanda, de l'Ouganda et la République Démocratique de Congo (autrefois Zaïre). La population des Virunga a été l'objet de beaucoup de recherche et de plusieurs recensements dans les 30 dernières années, mais cette population est sérieusement menacée par la guerre et les troubles civils dans la région. Les gorilles de Bwindi sont beaucoup moins connus, bien qu'une étude récente ait suggéré qu'ils puissent être une sous-espèce différente que les gorilles des Virunga.

Pendant les mois d'octobre et de novembre 1997, un recensement de la population des gorilles de Bwindi a été fait par Uganda Wildlife Authority (UWA), Wildlife Conservation Society (WCS), International Gorilla Conservation Project (IGCP) et Institute for Tropical Forest Conservation (ITFC), avec le Centre de Recherche de Karisoke (DFGF), l'Office Rwandais de Tourisme et Parcs Nationaux (ORTPN) et l'Institut Congolais pour la Conservation de la Nature (ICCN). Le premier but de cette étude étaient de produire un estimé exact du nombre de gorille et de la composition de la population. Le deuxième but était d'évaluer la distribution et l'abondance des autres grands mammifères, ainsi que de l'utilisation illégale humaine de la forêt. Les techniques de recensement des gorilles ont été basées sur les méthodes développées dans les Virunga.

Vingt-huit groupes de gorilles et sept mâles solitaires ont été trouvés pendant le recensement. Une correction pour les enfants manqués dans les comptes de nids a été calculée à partir de la composition des groupes connus. Cette correction a produit un estimé de 292 individus pour le total de la population. L'évaluation obtenue est un minimum, parce que quelques petits groupes ont pu être manqués, et parce qu'une correction minimue a été utilisée pour le nombre d'enfants manqués. Par ailleurs, le parc a été sillonné de façon intensive dans une courte période, afin de minimiser la possibilité de manquer des groupes. Nous sommes donc confiants que la population réelle ne puisse pas être beaucoup plus grande. L'estimé de la population que nous avons obtenu est très semblable à l'évaluation la plus précise faite jusqu'à maintenant (300), et qui avait été faite entre 1986 et 1993. La population paraît être stable. Comme auparavant, la majorité de la population a été trouvée dans le centre de la partie sud du parc. Aucun gorille n'a été trouvé dans la partie nord.

Les signes d'utilisation humaine ont été trouvés dans presque tous les secteurs de Bwindi. Cependant, aucune corrélation n'a été trouvée entre la distribution des gorilles et des formes particulières d'utilisation humaine. Bien que la protection de la forêt de Bwindi ait été améliorée dans les dernières années, l'utilisation humaine de la forêt pourrait encore avoir un impact sur les gorilles. Il est d'ailleurs possible que la pertubation humaine ait joué un rôle dans la prévention de l'augmentation de la population. Sans une meilleure compréhension de l'écologie du gorille et des habitats qui constituent la forêt de Bwindi, il ne sera pas possible de déterminer à quel niveau la population de gorilles peut augmenter. Les indications initiales suggèrent qu'il y a des régions peu utilisées qui sont en fait des habitat potentiel pour les gorilles. Étant donné la petite superficie du parc, une utilisation humaine soutenue et la petite taille de la population de gorille, l'amélioration de la protection doit rester une priorité.

Quant aux autres mammifères, il n'a pas été possible à ce stade de faire un estimé des populations totales puisque les données dont nous disposons sont limitées. Cependant il a été possible de quantifier sur une carte les densités relatives des grands mammifères dans chacun des secteurs du parc. Nous estimons qu'il y a un total de 25 éléphants, et entre 440 et 1070 potamochères. Les ongulés sont généralement plus fréquents dans l'est du parc que dans sa partie sud. Les singes tendent à être à l'orée de la forêt et la majorité des espèces sont vues plus fréquemment à basse altitude. Par contre, les chimpanzés sont plus fréquents dans le centre des parties nord et sud du parc.

1. Introduction

1.1 The park

The Bwindi Impenetrable National Park is a montane forest ranging between 1,160 and 2,607 metres altitude in south western Uganda (0° 53'-1° 08' N; 29° 35'-29° 50'E). This forest was initially gazetted as a forest reserve in 1932 (Howard 1991) and became a national park in 1991 (Butynski & Kalina 1993) because of its population of gorillas and its rich plant and bird diversity (Kingdon; 1973; Hamilton 1976; Keith 1980; Butynski 1984). The park covers an area of 330.8 km^2 comprised of a northern and a southern part (Figure 1) of extremely rugged country characterised by numerous steep-sided hills and narrow valleys, which drain from the highest elevations in the south east to the lower north west of the park. One hundred and twenty species of mammals have been recorded in Bwindi, including 10 primates, although little is known about their abundance and distribution. Bwindi is also rich in several other taxa (Davenport, Howard & Matthews 1996), with at least 324 species of trees (26% of all Uganda's species), 348 species of birds (83% of Uganda's highland forest dependent species), and 310 species of butterflies (36% of Uganda's highland forest specialists). Bwindi is particularly important for albertine rift endemic bird species, containing 90% of all albertine rift endemics and seven red data book species.

The park is surrounded by a high human population, which in 1991 averaged 220 people per km^2, growing at a rate of about 2.7% per year (Gubelman, Schoorl & Achoka 1995). Human use of the park has been extensive in the past with pitsawing for timber causing the greatest damage. An estimated 61% of the forest has been heavily exploited by pitsawyers and an additional 29% has experienced selective logging of the best trees. Consequently only about 10% of the interior of the southern sector is considered to be intact forest (Howard 1991). Since the creation of Bwindi as a national park all pitsawing has been banned. However, multiple use zones have been established for harvesting medicinal plants and for honey collection (from hives placed in these zones). In addition a zone has been established for tourism in the form of guided gorilla visits and forest nature walks (Gubelman, Schoorl & Achoka 1995).

1.2 Gorilla population

Bwindi is best known for its gorilla population, which attracts tourists to the forest and generates much of the current income for the Uganda National Parks and Game Reserves. Until recently the Bwindi gorillas were considered to be the same subspecies (mountain gorilla, *Gorilla gorilla beringei*) as those found in the Virunga volcanos about 25 km south on the borders of Rwanda, Uganda and the Democratic Republic of Congo (DRC). This has been disputed by Saramiento *et al.* (1996), using skeletal measurements.

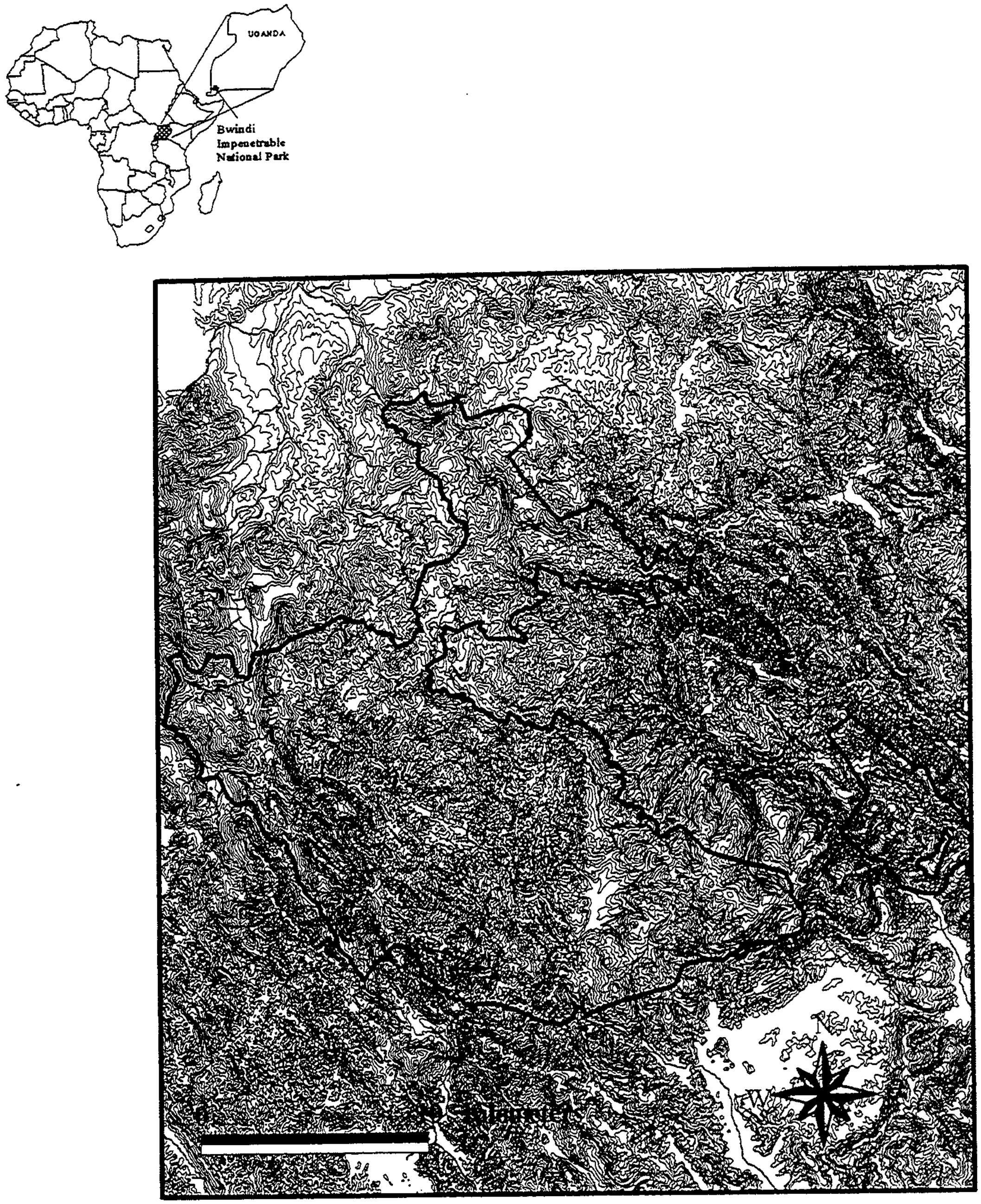


Figure 1. Map of Bwindi Impenetrable National Park showing contour lines and major streams and rivers.

However, their contention that Bwindi gorillas should be given a separate subspecific status is not supported by genetic studies which show very little variation between the two populations (O. Ryder & M. Seaman pers. comm.) and thus the taxonomic status of the population is as yet unclear. Consequently, for the remainder of this report we will continue to refer to Bwindi gorillas as mountain gorillas.

Mountain gorillas are found in only two places: the Virunga mountains and the Bwindi Impenetrable National Park. Both are isolated areas of forest with national park status, but are completely surrounded by dense human populations. It is thought that the Virunga became separated from Bwindi by human cultivation at least 500 years ago, although forest clearance probably started about 4-5,000 years ago (Hamilton, Taylor & Vogel 1986). The Virunga gorilla population has been the subject of much research and several censuses over the last 30 years (Weber & Vedder 1983; Harcourt *et al.* 1983; Vedder 1986; Sholley 1991). Before the outbreak of civil war in the area , the population was estimated in 1989 to be 310 known individuals (Sholley 1991). It is not known how the war has effected the population, although several incidents have been reported in which gorillas have been killed (as many as 13 may have been killed in the Democratic Republic of Congo alone; Sikubwabo & Mushenzi 1997; Stewart 1998), and the future protection of the area is far from being assured.

The Bwindi gorilla population is less studied than that in the Virunga mountains, although given the situation in the Virungas, it is all the more critical that it is effectively conserved. In order to make management decisions for the Bwindi population, accurate information is needed on the status of the population: its size, distribution, composition and rate of growth or decline. This can only be obtained through regular systematic censuses of the population.

Initial estimates of the size of the mountain gorilla population in Bwindi Impenetrable National Park were 116 (Harcourt 1981) and 146 (Butynski 1985). Both these figures were produced by censusing a limited portion of the area, and extrapolating the gorilla density found to the remainder of the area thought to be used by gorillas. More thorough censusing produced estimates of 280-300 in 1987 and the estimate in 1993 was similar (T.Butynski, *pers. comm.*) although a total count in 1994 estimated 257 (Institute of Tropical Forest Conservation, unpublished data) but this lower estimate may be due to missed groups. The latter census was carried out by a single team covering the park over an extended period of time. Because of this, there is a risk that gorilla groups, which range over large areas, were missed. Butynski (*pers. comm.*) repeatedly censused over a seven year period using 5-8 teams up to 1993, monitoring changes in group size and composition. This would have minimised the possibility of missing or confusing groups, and the figure of 280-300 at that time is likely to be the more accurate. In order to census gorilla populations most accurately, a number of teams must cover the area concerned simultaneously in a continuous sweep from one side to the other. This method has successfully been used several times for the Virunga gorilla population (Vedder 1986; Sholley 1991).

This report details the procedure and results of a census carried out jointly by Uganda Wildlife Authority (UWA), the Wildlife Conservation Society (WCS), International Gorilla Conservation Programme (IGCP) and the Institute of Tropical Forest Conservation (ITFC) with help of personnel from the Karisoke Research Centre (DFGF), Office Rwandais du Tourisme et Parcs Nationaux (ORTPN) and the Institut Congolais pour la Conservation de la Nature (ICCN) between October 4th and November 18th, 1997. The primary aim was to produce an accurate count of the gorilla population, with information on the number of groups, distribution, and the age and sex structure of the population. However, given the intensive coverage of the area entailed in such a census, we aimed to use this opportunity to obtain important information for park management on other large mammal populations as well.

Two previous surveys in Bwindi have indicated that human disturbance in the form of pitsawing, hunting and gold mining had an impact on gorilla distribution and use of particular areas (Harcourt 1981; Butynski 1985). Both found that gorillas tend to use the more inaccessible interior parts of the forest, while human activity was more concentrated in the periphery. Since Bwindi was gazetted as a national park, these forms of human disturbance have been illegal, and rangers have succeeded in greatly reducing their prevalence (Butynski and Kalina 1993, 1998). However, no data have been available on the intensity and distribution of disturbance or its impacts on gorillas and other wildlife since gazetting. McNeilage (1995) found a negative correlation between signs of gorilla use and signs of hunting in the Virungas, despite national park status and considerable anti-poaching efforts there. The final aim of this project was to investigate the intensity and distribution of illegal human disturbance in the park and to examine its possible impact on the gorillas and other mammals.

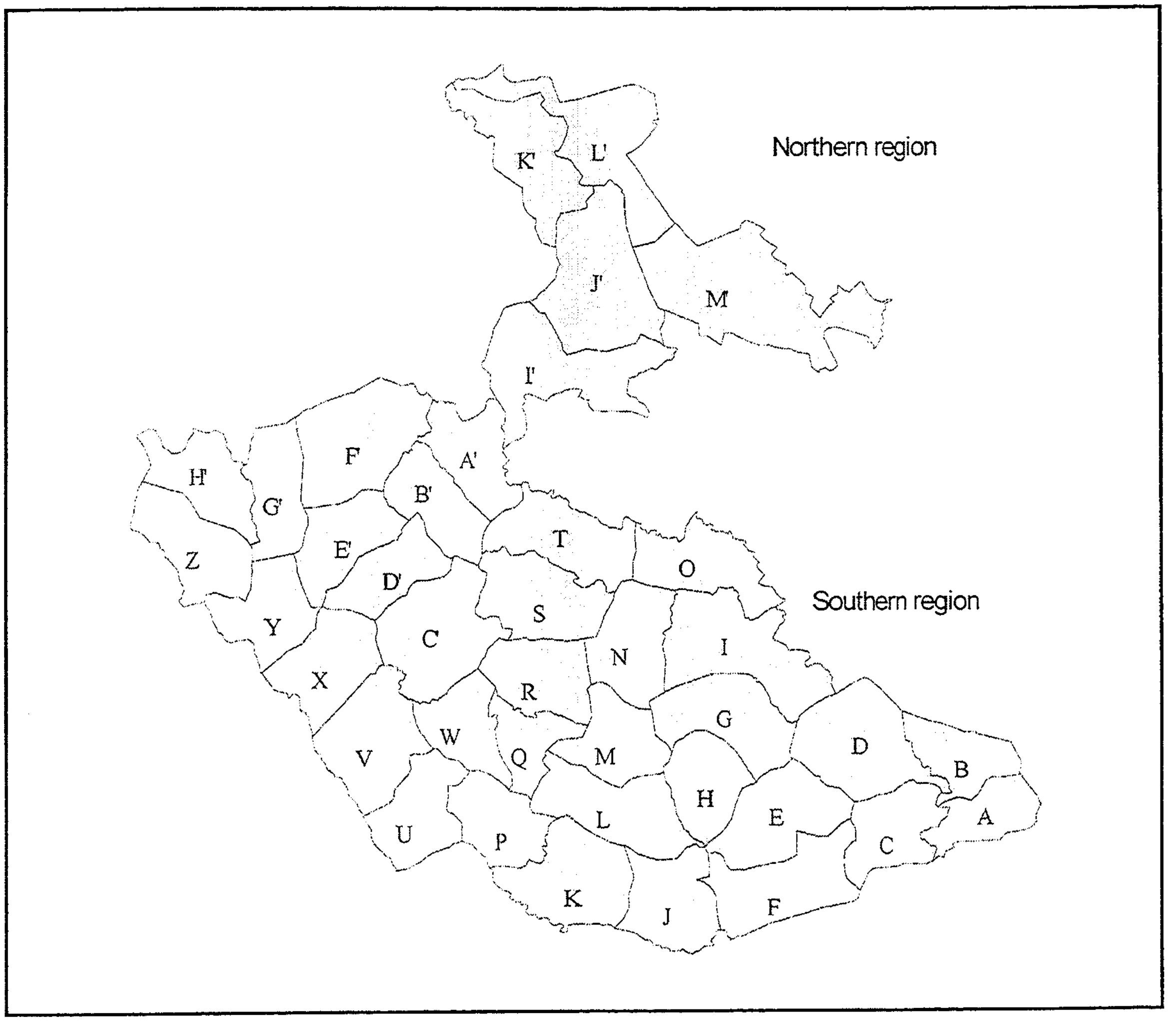


Figure 2. Map of Bwindi showing the sectors used in the census.

2. Methods

2.1 Gorilla census methods

The procedure employed to census gorillas was based on that previously used in the Virunga mountains (Vedder 1986; Sholley 1991). Six teams, each consisting of at least two experienced trackers and one or two team leaders, traversed the park systematically from southeast to northwest. The park was divided into small sectors (between five and ten km^2), centred around base camps and access points (Figure 2). One team was assigned to census each sector, proceeding so that no more than 3 days were left between the completion of work in one sector and the beginning of work in the next, contiguous sector. Two teams generally worked in neighbouring sectors from one basecamp, to allow better coordination of movements and comparisons of findings each day.

Within each sector, census teams walked an irregular network of survey routes, using existing trails and animal paths, and cutting trails as necessary. When recent gorilla trail was found (less than approximately five days old), it was followed until at least three night nest sites were located. The actual pattern of trails walked before finding gorilla trail was largely determined by the terrain, and was sufficiently dense so that no area within which a gorilla group could spend more than five days was left unentered. To achieve this, the distance between adjacent survey routes was never greater than 500 - 700m. Using topographic maps, along with GPS and altimeter readings, all routes walked and gorilla trails followed were mapped. By covering the area in this way, mapping and dating all gorilla trails and nest sites, and by marking nest sites encountered with cut stakes, the risk of missing groups was minimised and repeat counts of the same group were avoided. It was also possible to distinguish similar sized but distinct gorilla groups found close to each other.

At each nest site, nests were counted and dung size measurements used to establish the age-sex composition of the group. Measurements were taken across the widest part of the width of uncrushed dung. As no data are available on dung size classes for Bwindi gorillas, the following dung sizes classes established by Schaller (1963) were used:

Adult silverback male, SB:	> 7.2 cm (with silver hairs in nest)
Adult female / blackback male, MED:	5.5 - 7.2 cm

Juvenile/Subadult, JUV:	< 5.5 cm (in own nest)
Infant, INF:	generally < 4 cm (in mother's nest)

Small, infant-sized dung (i.e. diameter generally < 4cm) in a nest in addition to adult female/blackback male sized dung, indicated an adult female with an infant. Young individuals constructing their own nest were always considered here as the combined category juveniles/subadults, and not infants. In the absence of infant dung, adult female nests could not be distinguished from those of a comparable sized subadult (blackback) male. The presence of longer, silver hairs in the nest combined with dung size was used to confirm the presence of an adult (silverback) male. At least three nest sites were counted for each group to ensure that an accurate, consistent group size and composition was established. Where this could not be established after three nest sites, additional sites were located.

Dung of young infants (less than approximately one year old) was rarely found in nests, and so the number of infants in the population will have been underestimated by these methods. However, the compositions of four groups which have been or are in the process of being habituated for research or tourism are known from direct observations. Nest sites of these groups were also counted in the same fashion so that an estimate the proportion of infants missed by nest counts could be calculated.

2.2 Collection of hair and dung samples

Hair samples were collected from nests for DNA analysis. Hairs were collected from every nest in the park so that it will be possible to determine a genetic profile of all adult individuals. In addition a sub-sample of hairs was collected to be analysed for similarities and differences between gorilla populations in this region.

To avoid contamination, hairs were collected from night nests using forceps. At least 10 hairs were collected from each nest and placed in a separate envelope. Forceps were sterilised between each use in a cigarette lighter flame. Envelopes were sealed with water (not saliva) and stored in sealed boxes with silica gel to absorb moisture.

Faecal samples were also collected for hormonal and parasitological analysis. Samples of dung were collected from each silverback and two other individuals in the group. Dung was collected from the centre of a dung-bolus and stored in 90% ethanol in plastic vials.

2.3 Survey methods for other large mammals

Reconnaissance methods

A recent development in survey methods for forest animal populations is the 'Reconnaissance Method' (P. Walsh, *pers. comm.*). Reconnaisance methods collect encounter rate data, although along existing forest trails resulting in a biased estimate of the encounter rate of animals/signs. Biases could be due to, for example, following animal trails or avoiding thick vegetation. This biased encounter rate is then corrected to a true density using a conversion factor. The conversion factor is calculated by carrying out both reconnaissance censuses and a reduced amount of unbiased line transect censuses at the same sites, to obtain a regression between reconnaissance and transect encounter rates.

Much larger areas can be covered with less effort using the reconnaissance method than would be possible with traditional line transects, which require extensive cutting of straight line transects. Reconnaissance surveys are also compatible with the procedure for gorilla censusing detailed above. While walking access trails in search of fresh gorilla trails, signs of other large mammals were recorded. These included :

1. all observations of animals (primates, duikers, elephants, bushpigs, and giant forest hogs)
2. dung of duikers, bushpigs, giant forest hog, carnivores (as a single grouped category) and elephants
3. nests of chimpanzees and gorillas.

It was not possible to distinguish duiker species from dung so dung of duikers was separated into two categories: large and small pellet sizes (dung was examined during a training program to ensure agreement between observers). In all cases, the perpendicular distance between the reconnaissance route and the sign or animal was measured using a rangefinder (or metre stick for distances less than 10m) although in the final analyses only the encounter rate was used. For primate observations and nests, the number of individuals or nests in each group was counted, and the perpendicular distance measured to the centre of the group.

Ages of nests and dung were recorded so that, if necessary, analyses could focus on a subset of the data based on the degree of decomposition. The approximate age of each nest or nest group was recorded as:

1. *recent* (still contains predominantly green, fresh leaves)
2. *dry* (most of leaves remaining but dry)
3. *old* (nest has lost many of its leaves so that light/ground can be seen through its cup).

Age of dung was categorized as:

1. *fresh* (boli intact, very fresh, moist with odour)
2. *dry* (boli intact, dry, no odour)
3. *old* (some boli disintegrated, others still recognizable as boli)
4. *amorphous* (all boli disintegrated, amorphous mass of dung)

Routes traveled each day were plotted on 1:31,250 scale topographic maps of each sector within the park using GPS positions, contours and other features (maps were digitised by Makerere University Institute of the Environment and Natural Resources). The distance traveled along reconnaissance routes was measured from these maps using a Planwheel map measurer (Forestry Supplies catalogue) and checked against a sample of routes measured on the ground with a hipchain (Topometric Products Limited).

<u>Transect methods for correcting reconnaissance counts</u>

Randomly placed transects in two areas (Ruhija - site of the ITFC field station; and Buhoma - site of the park headquarters) were used to calibrate the mammal encounter rates obtained from reconnaissance counts (Figure 3). In each area, eight 3 km transects were cut at the start of the census. These originated from a road or path which was divided into 500 m sections, with one transect started at a random point within each section, running approximately perpendicular to the road (north-south in Ruhija and east-west in Buhoma).

The transects were each surveyed a total of six times. Repeated censuses of the same transects allowed a measurement of the accumulation rate of dung and nests to be measured, as well as increasing the sample sizes of sightings of animals. The first four counts were separated by 10 - 13 days each and included dung and nest accumulation records during each time period. The last two counts were about a month after the previous count and recorded only nest accumulation. During each survey, data were collected on mammal sightings and signs in the same way as on the reconnaissance trails described above. Chimpanzee nests were marked using a stake placed in the ground directly underneath. In this way, the number of new nests made between each survey was measured, from which the number of chimpanzees using the area could be estimated. With dung piles, all dung found during each survey was cleared from the transect, so that only new dung was recorded in subsequent surveys, to give an estimate of the rate of deposition of dung. These methods allow deposition rates, and thus mammal densities, to be estimated without the need for data on dung or nest decomposition rates, which are notoriously variable and time-consuming to measure.

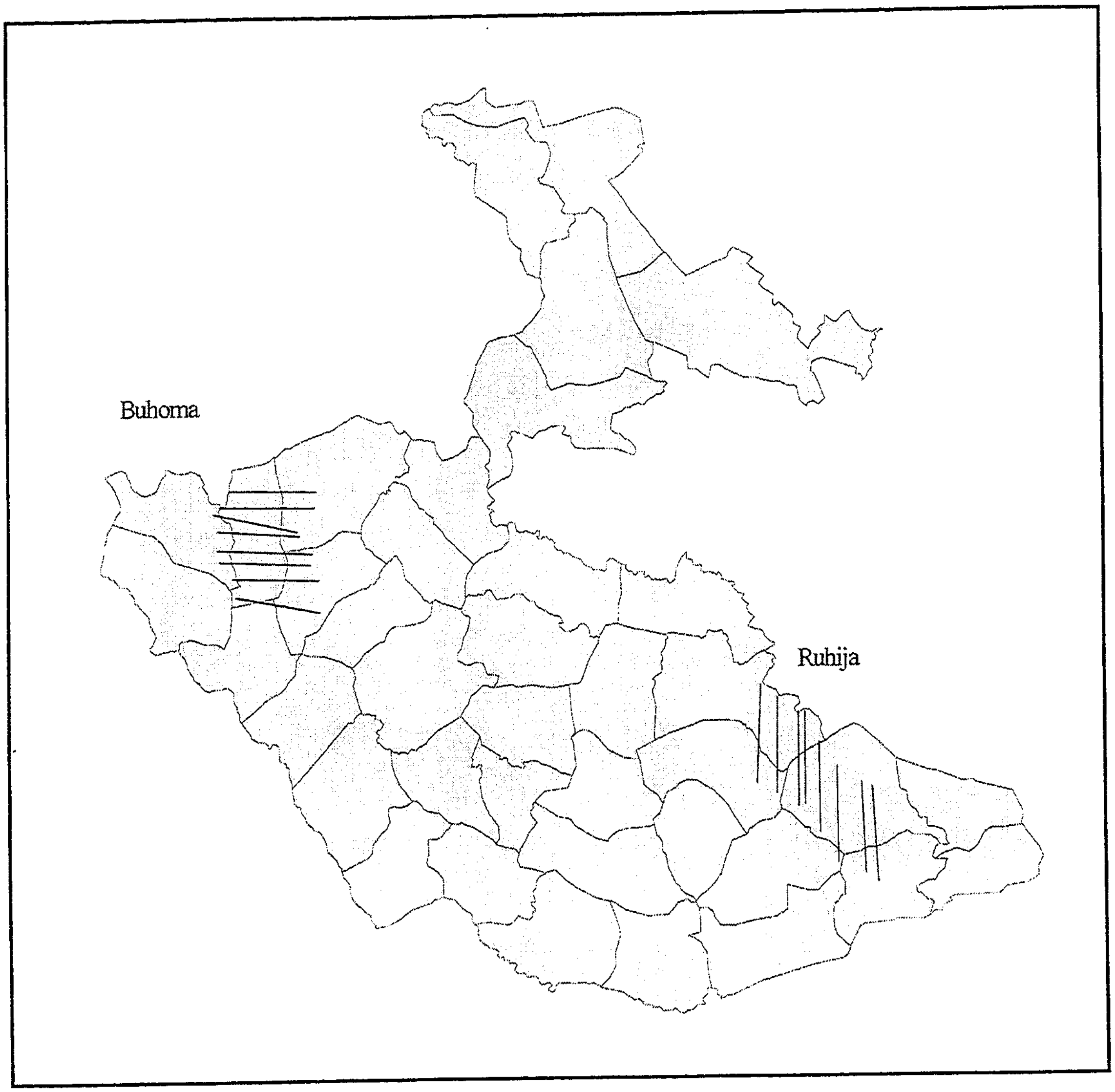


Figure 3. Map of Bwindi showing the location of the 3 km transects which were cut at Ruhija and Buhoma. These transects were used to determine densities of mammals other than the gorillas.

Encounter rates from the transect surveys were compared with those found on the reconnaissance survey trails in the same areas, to calculate correction factors for biases in the reconnaissance trail data. These were then used to calculate densities for the park as a whole from the encounter rates found over the entire area.

2.4 Surveys of human disturbance

While walking reconnaissance trails, all signs of illegal human disturbance were recorded, with the location and estimated age of each. These included:

1. snares
2. pitfall traps
3. human tracks
4. poachers' camps/fire places
5. pit-sawing sites
6. wood and bamboo cutting
7. honey collection (illegally)
8. poachers

In addition, the presence of bee hives was recorded. Signs were analyzed to determine encounter rates per km walked in each sector.

2.5 Vegetation types

A simple vegetation classification system was established, based on obvious structural characteristics and not dependent on the identification of particular tree species. Vegetation type was recorded for all mammal signs and gorilla nest sites, along with a GPS reading where possible. Vegetation types recorded were:

1. Pure Bamboo (PBA) - Stands of bamboo found at higher elevations, not mixed with any other vegetation
2. Mixed Bamboo (MBA) - Bamboo mixed with other trees and shrubs
3. Bracken (BRK) - Areas dominated by large fern found in forest gaps, often on open slopes
4. Swamp (SWA) - Water logged areas
5. Grass (GRA) - Areas dominated by grass (mostly in the northern sector)
6. Closed forest on ridges (CFR), on slopes (CFS), in valleys (CFV) - Closed canopy forest
7. Open forest on ridges (OFR), on slopes (OFS), in valleys (OFV) - Non-continuous canopy forest
8. Herbaceous (HRB) - Open areas without trees, with mixed herbaceous ground cover

3. Training program

The census was divided into two phases of about 3-4 weeks each. Prior to each phase a two day training course was organised for all participants in the census. One day consisted of lectures and practicing the use of equipment, and the second involved a visit to the field to carry out a dummy run of a census. Training was considered to be an essential component of the census to not only ensure consistency between observers and that all the correct data were collected, but also to build the capacity of national staff. Two days is a very short period, however for training and the census relied on the previous experience of team leaders. Teams generally consisted of two leaders: one had prior experience with large mammal inventories; the second was a trainee leader (from Rwanda, Uganda or Congo). 3-5 rangers/trackers assisted each group and were trained in the use of some of the equipment also.

Training was given in the following areas:

1. Use of GPS - the use of the Garmin II plus GPS unit. All participants were trained to determine the number of satellites contacted and how to obtain a fix. During the census, GPS positions were determined for all gorilla nest sites and positions along the reconnaissance trails so that these could be mapped accurately. Training was also given in map reading so that participants could locate themselves on the maps provided.
2. Use of rangefinders - used to measure the perpendicular distances of distant objects (mainly primate groups and chimpanzee nests). Everyone was trained in the use of these but only selected individuals used them in the field thus ensuring accuracy.
3. Use of a compass and altimeter - to obtain location fixes, elevation, and to plan further routes to follow.
4. Training in hair and dung collection procedures - explained to everyone involved in the census so that data could be collected efficiently by all.
5. Training in perpendicular distance sampling techniques and a brief description on how these data would be analysed to obtain density estimates.
6. Training in the use of a hipchain was given to team leaders.
7. Training in the use of data sheets.

4. Results

4.1 Gorilla dung size classes

The applicability of dung size classes from the Virungas to Bwindi gorillas was checked using the sizes of dung from nests measured during the census for which the individual's age-sex class could be determined (Figure 4). Only four nests of mothers with infant dung had dung slightly smaller then the 5.5cm size noted by Schaller. The importance of using silver hairs to confirm adult male nests is underscored by an overlap in adult male and adult female dung sizes in this census - silverback dung could be smaller in Bwindi compared with the Virungas. However, by using the presence of such hairs or infant dung, and with a lower limit of 5.5 cm for adult female dung, we can reliably use the age-sex categories described above.

4.2 Gorilla population

Twenty-eight gorilla groups and seven lone males were found during the course of the census (Table 1). The total number of individuals in the four monitored groups is 56, known from direct observations. A total of 224 gorillas was found from nest counts of the remaining 24 non-monitored groups and seven lone males. Comparable nest counts were obtained for three of the four monitored groups. These three groups were known to include 13 infants (i.e. those sharing nests with their mothers) of which five (38 %) were not detected in the nest counts. Assuming that the same proportion of infants were undetected in the nest counts of the non-monitored groups, in which a total of 32 infants were found, an additional 12 infants would be expected. This then gives a total population estimate of 292 individuals. The number of infants missed might also be expected to be proportional to the number of adult females without infants. An alternative method to correct for undetected small infants would therefore be to use the ratio of infants missed in nest counts to the number of individuals in the MED age-sex class (i.e. adult females without infants along with adult-female sized sub-adult males). This ratio is 6:14 for the known groups, which when multiplied by the total of 74 MEDs in the non-monitored groups, suggests an additional 31 infants could have been missed in those groups. However, given the small number of monitored groups, which may not have been fully representative of the rest of the population, it was decided to use the more conservative estimate of 12 missed infants calculated above, giving a total population of 292.

Groups ranged in size between two and 23 individuals, with a mean of 9.8 (s.d. 6.2) or 10.2 after allowing for undetected infants. The proportion of immatures (i.e. juvenile/ subadults and infants in the age

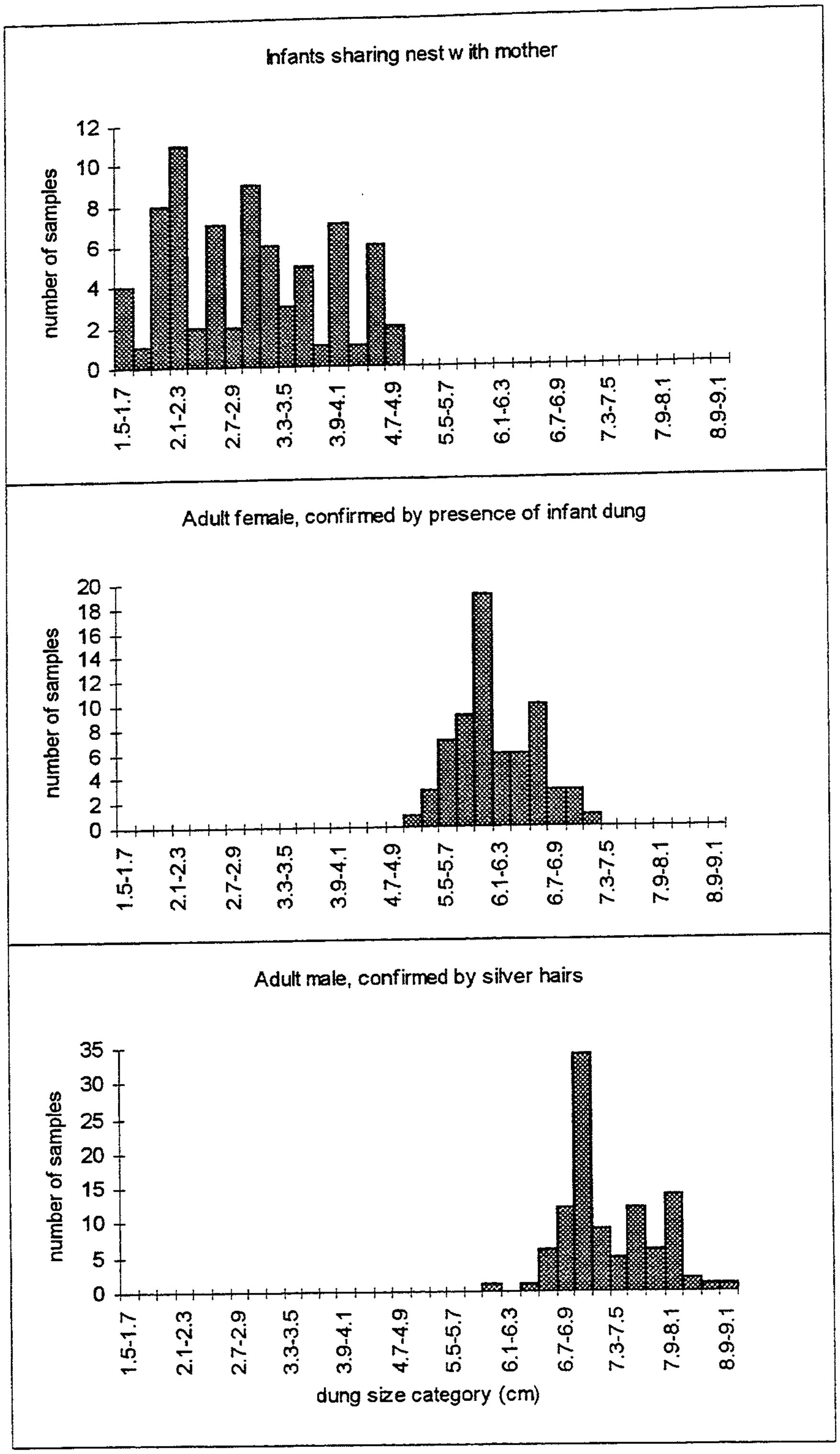


Figure 4. Dung sizes of Bwindi gorillas for individuals whose age-sex class could be determined by other indicators.

Table 1. The composition of all gorilla groups found during the 1997 Bwindi gorilla census. For monitored groups, the known composition is given, rather than that determined from nest counts during the census. Habituation teams have recently started to follow one other group (U1-AP, also known as the Nkuringo group), but it was not yet well enough known to allow group composition to be determined independently of nest counts, and was therefore not include here as a monitored group.

Group ID	Sector	Silverback	Female	Other MED	Juvenile/ Subadults	Infants	Total
Non-monitored groups:							
G1	G	2	1	4	2	1	10
G3	G	2	2	1	1	2	8
G4	G	3	3	5	2	3	16
G5	G	1		2			3
I1	I	1					1
J2/K1-AP	J	1	4	9	2	4	20
K2-AP	K	2		2			4
L1	L	1		1	1		3
L2	L	3	5	5	3	5	21
M1	M	1	3	3	1	3	11
N1	N	1					1
N2	N	1					1
O1	O	1	2	5	1	2	11
Q1	Q	2	1	4	2	1	10
Q2	Q	2		3	1		6
R1	R	2	2	2	2	2	10
R2	R	1		2	2		5
R3	R	1	1	5	4	1	12
U1-AP	U	3	2	5	2	2	14
U1-DG	U	1					1
W1R	W	1		2	1		4
WR3	W	1		2			3
X1	X	1		3			4
C'1	C'	3	3	2	4	3	15
C'2	C'	3	1	3	3	1	11
C'3	C'	1	2	1	1	2	7
C'5	C'	1					1
D'2	D'	1					1
E'2	E'	1		1			2
G'2	G'	1					1
G'3	G'	2		2	3		7
Total		48	32	74	38	32	224
Monitored groups:							
RESEARCH	G2	1	8			4	13
MUBARE	G'1	1	5		6	4	16
KATENDEGERE	F'2	1	1		1	1	4
IBARE	E'1	2	4	7	2	8	23
Total		5	18	7	9	17	56

categories used here) in the population within groups was 37 %. Of the 28 groups, 15 contained one silverback, while eight had two silverbacks and five had three silverbacks. A total of 46 % of groups were therefore multi-male. As reported previously (Harcourt 1981; Butynski 1985), no gorillas were found within the northern part of the park which is separated from the southern part by a narrow neck of forest, traversed by a road. The locations of gorilla groups found in the course of the census are shown in Figure 5. The majority were concentrated in the central regions of the southern section. None were found in the eastern part of the forest.

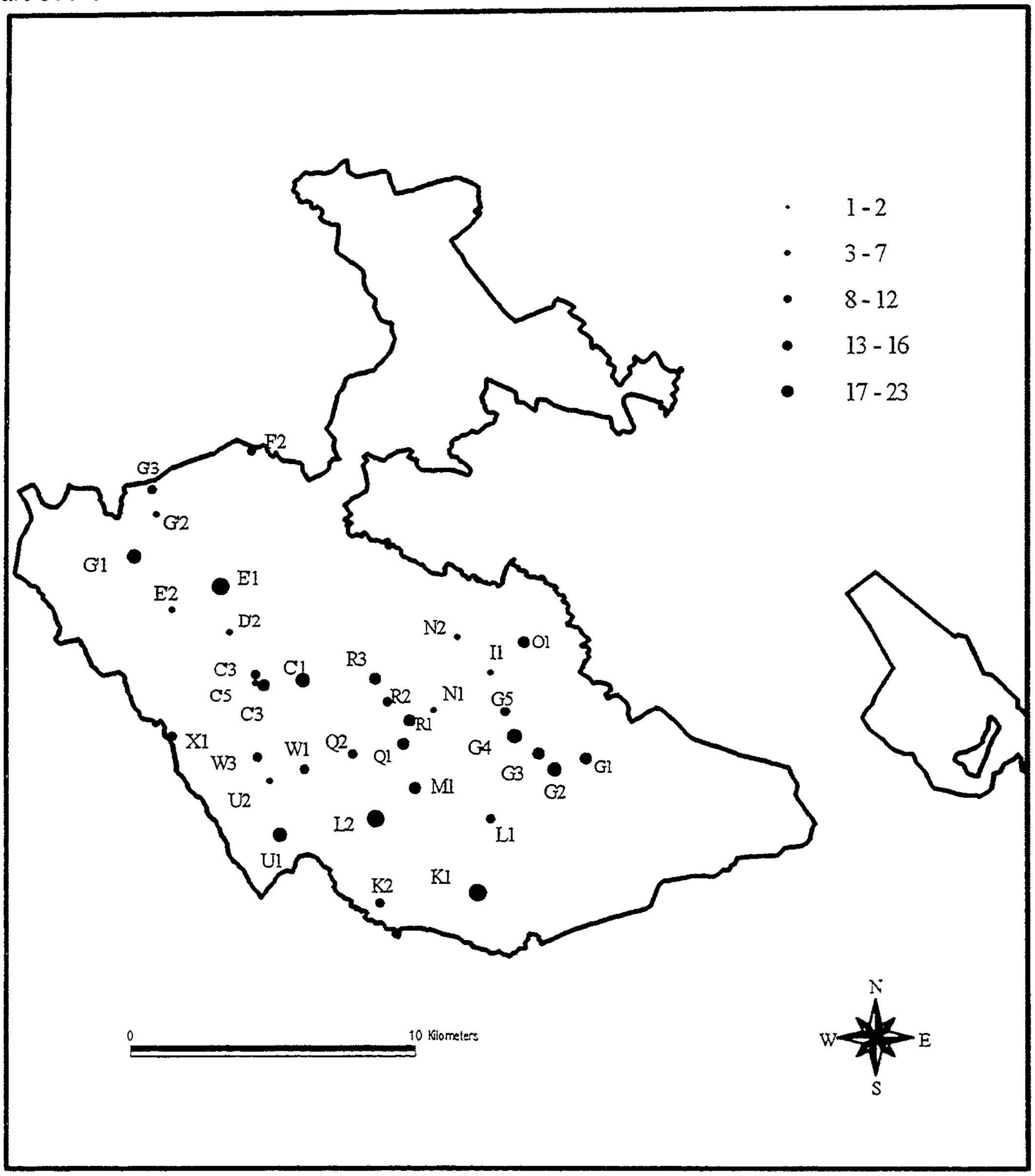


Figure 5. The mean location of the three nest site counts for the gorilla groups in Table 1. Groups are represented with circles of differing radius dependent upon group size (see key).

4.3 Mammal census results

Distances walked

As described above, the distance walked on a sample of survey routes was measured using both a hipchain which measures actual distance traveled on the ground and by measuring the length of trail routes plotted on maps. Hip chains were not used for every route because of the cost and the desire to minimise the impact of the census on the environment. The start and end points of routes walked using a hipchain were marked on the same mapped routes, so that a direct comparison could be made between the two methods of measuring distance. Figure 6 shows a plot of hipchain distance versus distance measured on the map and indicates that there was a good correlation between the two measurements ($r=0.975$, $n=64$, $P<0.001$).

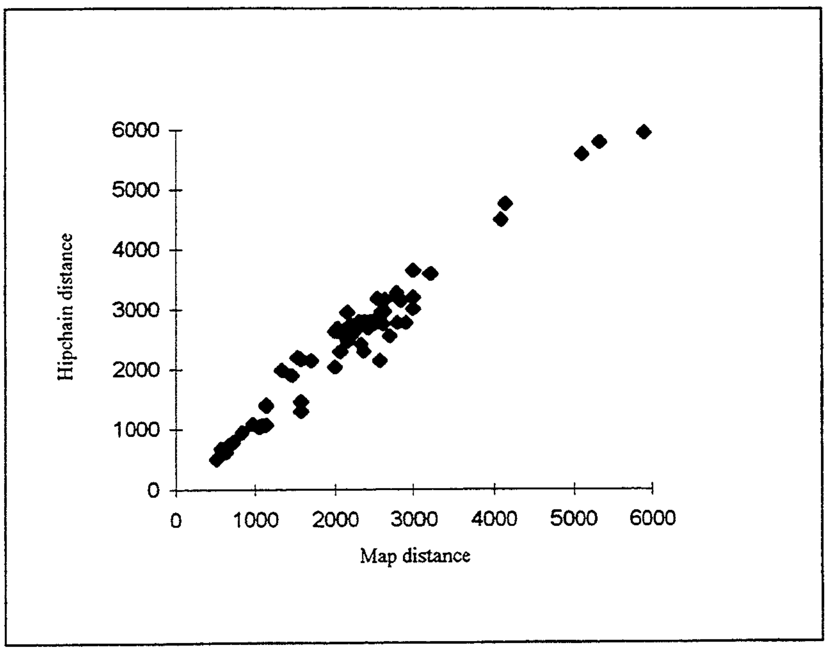


Figure 6. Comparison between distances measured from the map and distances measured by hipchain in the field, over the same stretches of survey route.

The distances measured from maps did not take account of slopes, and would therefore underestimate the actual distance walked on the ground. An alternative map measurement was also tried which took into account the number of contour lines crossed by each stretch of survey trail. However, this measure was no more closely related to the hipchain measurements of actual distance on the ground ($r=0.975$ again) and was not used. Map measurements consistently underestimated slightly the actual distance traveled on the ground. The percentage error was calculated for each stetch of trail where both methods were used ($n=64$),

Table 2. The total distance walked , number of trails walked and average trail length in metres for the mammal census data obtained from reconnaissance counts. For most sectors at least 10 km were covered, apart from the sectors in the north of Bwindi where surveys were less intensive.

Sector	Total corrected distance (m)	No of trails	Average trail length (m)
A	10745	3	3582
B	18006	4	4502
C	18928	5	3786
D	26178	7	3740
E	23747	5	4749
F	21008	4	5252
G	10004	5	2001
H	18010	4	4503
I	26740	6	4457
J	10734	3	3578
K	16028	3	5343
L	21019	6	3503
M	7450	4	1863
N	16866	5	3373
O	14623	6	2437
P	9369	3	3123
Q	18344	4	4586
R	14016	7	2002
S	14839	4	3710
T	17175	4	4294
U	8710	2	4355
V	15702	4	3926
W	8818	5	1764
X	8756	3	2919
Y	13005	3	4335
Z	12292	5	2458
A'	11161	2	5581
B'	16253	4	4063
C'	23739	8	2967
D'	19434	6	3239
E'	4597	1	4597
F'	21019	8	2627
G'	11824	4	2956
H'	8003	3	2668
I'	9262	3	3087
J'	6632	1	6632
K'	5732	1	5732
L'	5991	1	5991
M'	3608	1	3608
Total	548367	157	3493

and a correction factor of 12.4% was calculated from the mean error. Consequently all map distances (including those that were not measured with hipchains) were corrected by multiplying by 1.124. A total of 548.4 km was therefore walked during the census while recording data on mammals and their signs (157 days of walking; an average of 3,493 metres walked per day). Table 2 gives the total distance walked, the number of team days and average distance walked per day in each sector.

Encounter rates

Table 3 reports the number of sightings on the reconnaissance surveys and on the transects at Ruhija and Buhoma. Appendix 1 gives the mammal and human disturbance encounter rates from the reconnaissance surveys in each sector. These data were plotted on maps of the park (Figures 7-10) to give a representation of the relative encounter rate in different sectors. Effectively, the sectors with zero sign were left blank and the remaining sectors were divided into four categories of encounter rate with approximately equal area for each . Therefore the quartile of sectors with the highest encounter rates in each case have the largest circles and the quartile with the lowest values (apart from zero) have the smallest circles. Encounter rates were not converted to densities for these figures, as the relative values would remain the same.

Where sightings were few, the encounter rate could be strongly influenced by the distance walked (e.g. one duiker might be sighted over a 2 km walk, but none seen for the next 2 km, by chance alone) and consequently the encounter rates could vary greatly between sectors. An attempt was made to smooth the data for each sector by calculating the encounter rate using the data in each sector and its adjacent sectors. The total number of sightings in a sector added to those in all adjacent sectors was divided by the total distance walked in all these sectors. These smoothed encounter rates are plotted in figures 11-14. This smoothing procedure also has disadvantages because sectors at the park edge have fewer adjacent sectors so that they can have higher values for encounter rates where sightings are few simply because there is less dilution than you obtain with interior sectors. Care must therefore be taken when interpreting these figures - they give a reasonable indication of where densities are relatively high or low but do not give exact values.

The two sets of figures show that gorilla signs tended to be found in the centre of the southern part of the park, whilst chimpanzees were more common along the northern edge of the southern part of the park and in the northern part of the park. Ungulate signs (dung) are more abundant in the eastern part of the southern sector for all species. Dung probably does not decay at similar rates throughout the park because of variation in altitude and climate. This might artificially inflate encounter rates in certain areas and may

Table 3. The number of sightings during reconnaissance counts and on transects for all animal and human signs recorded during the census. Reconnaissance counts covered 548.367 km, whilst transect counts covered 144 km for live animals, human signs or nests and 72 km for dung.

	Reconnaissance counts	Transect counts	
		Buhoma	Ruhija
Chimpanzees	0	3	0
Gorilla	1	0	0
Blue monkey	62	20	18
L'Hoest monkey	63	14	17
Redtail monkey	72	19	0
Colobus monkey	64	4	1
Baboon	5	0	0
Black-fronted duiker	6	5	4
Red Duiker	1	4	21
Yellow-backed duiker	2	1	3
Unknown duiker	1	0	0
Bushbuck	7	0	0
Bushpig	2	0	3
Elephant	2	0	3
Baboon dung	2	0	0
Monkey dung	46	19	0
Carnivore dung	54	0	0
Chimp dung	29	6	0
Gorilla dung	82	5	6
Elephant dung	2043	23	126
Bushpig dung	800	15	94
Giant Forest Hog dung	5	0	0
Large duiker dung	488	24	83
Small duiker dung	735	76	732
Gorilla nest	1028	12	3
Chimpanzee nest	662	35	25
Wood cutting	29	0	0
Fire place	21	0	1
Hives	8	0	14
Honey gathering	3	0	0
Mines	6	0	0
Pitfall traps	6	0	0
Pitsaw sites	56	0	8
Poacher	1	0	0
Poachers trails	36	0	0
Snares	62	0	0

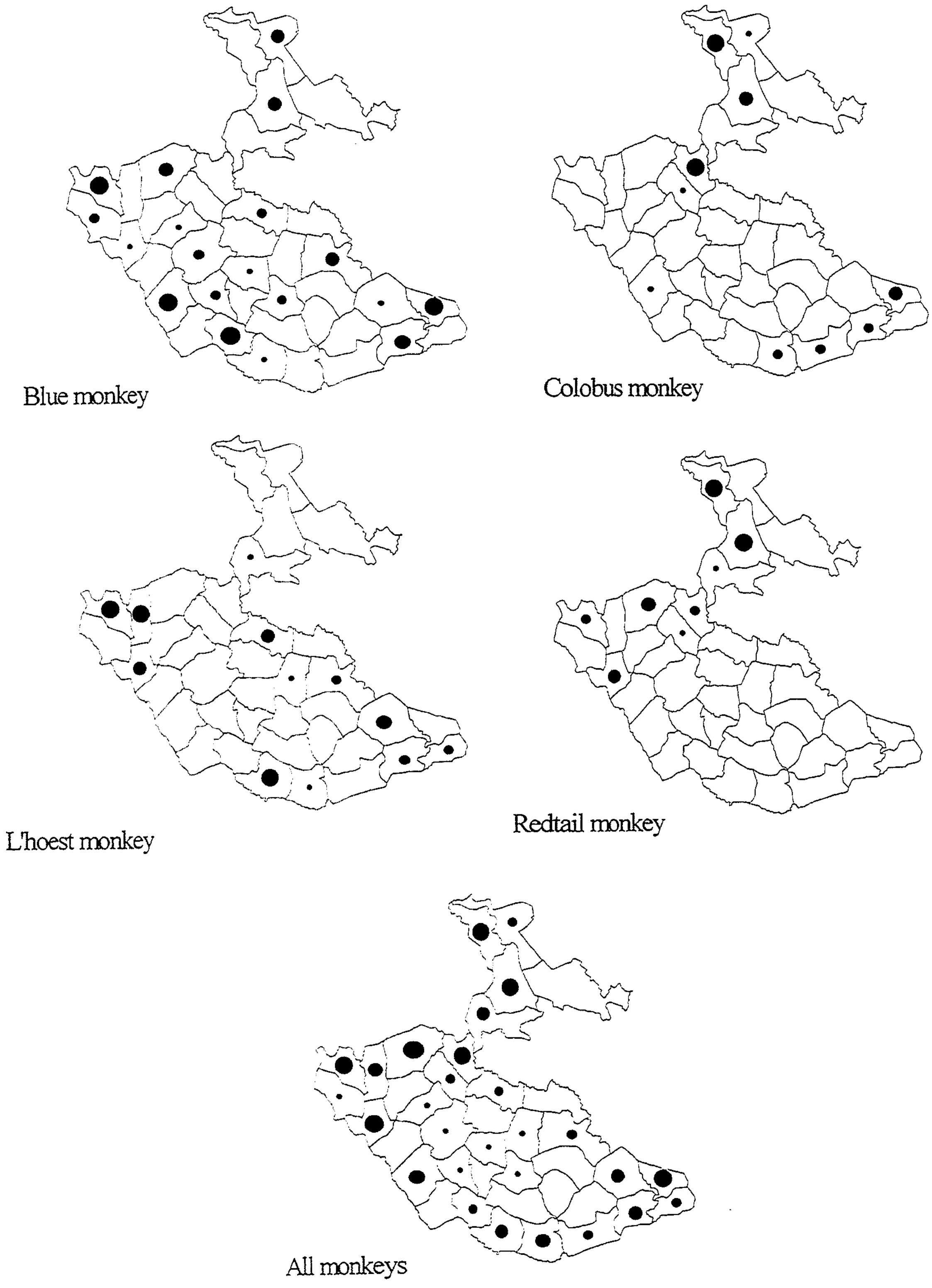


Figure 7. The relative encounter rates of monkey species in Bwindi. Large circle =highest encounter rates, smallest circle = least frequent; blank=not encountered.

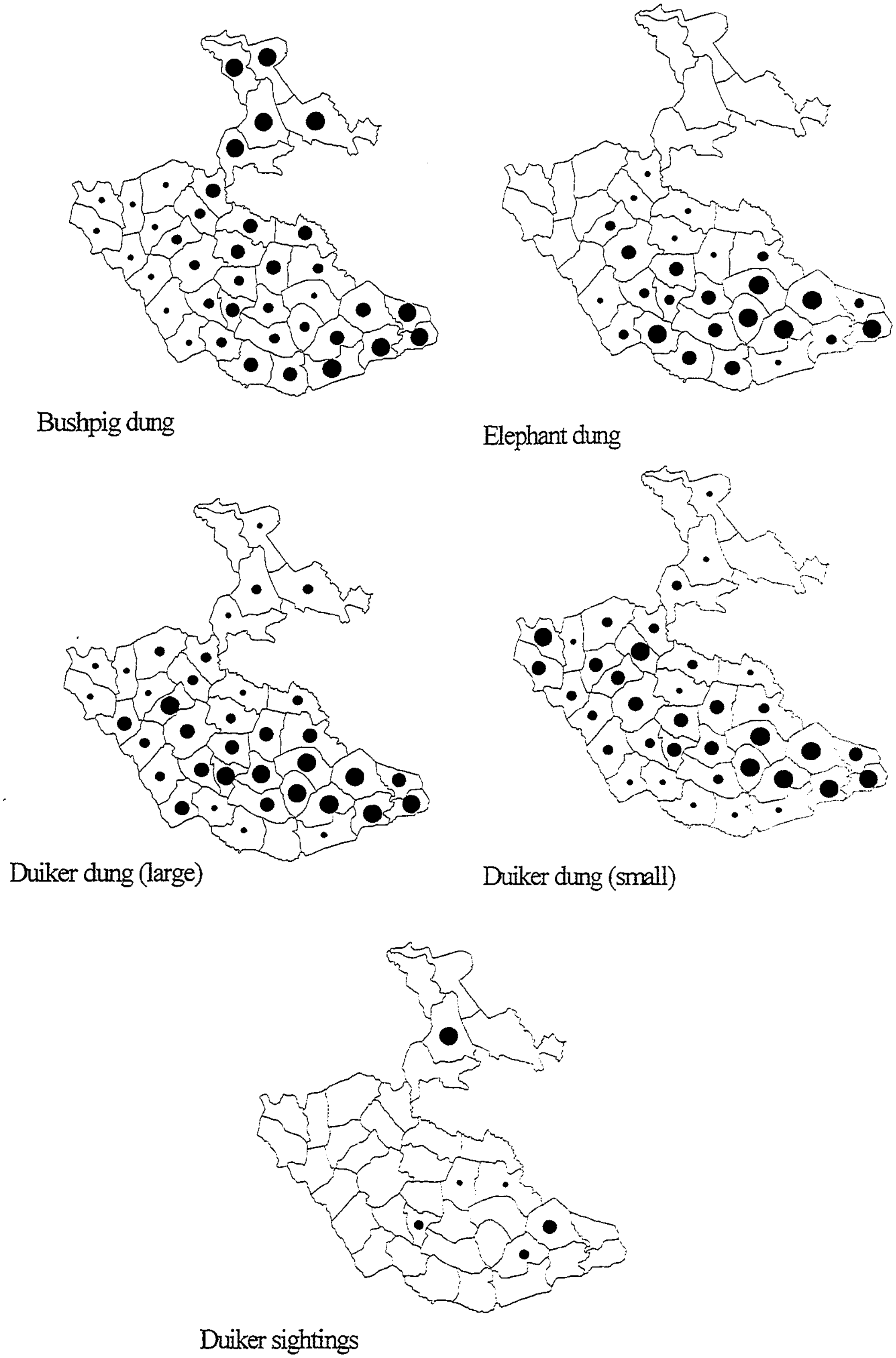


Figure 8. The relative encounter rates of ungulate signs in Bwindi. Large circle =highest encounter rates, smallest circle = least frequent; blank=not encountered.

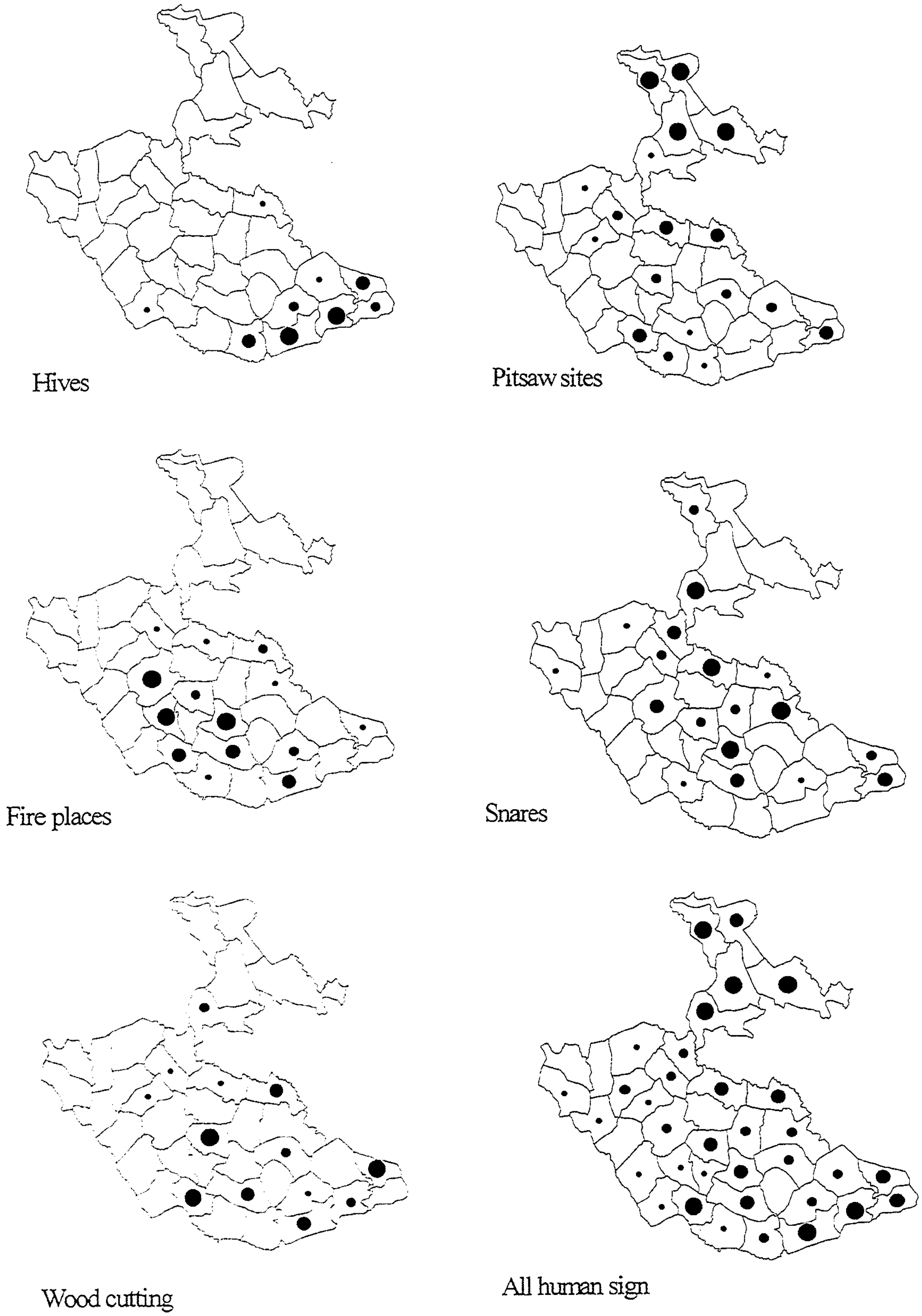
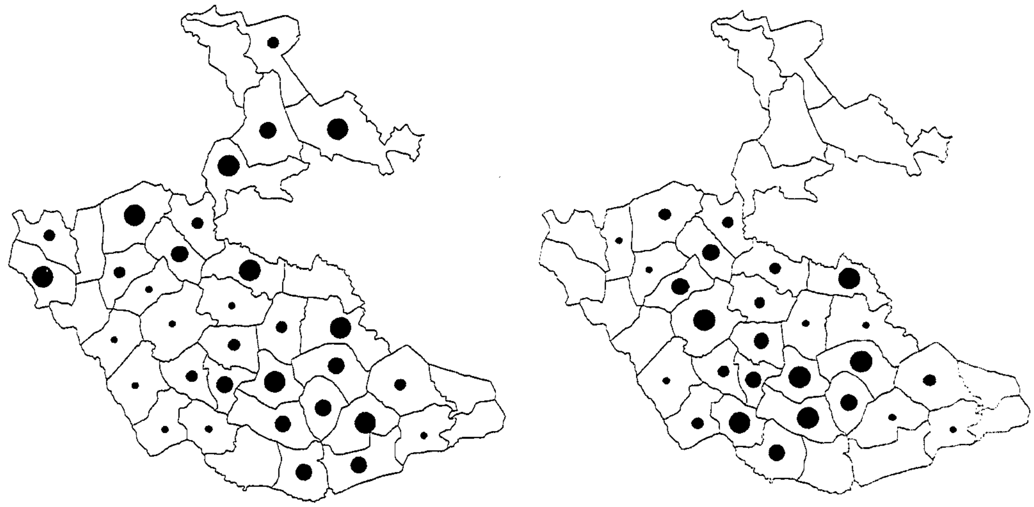
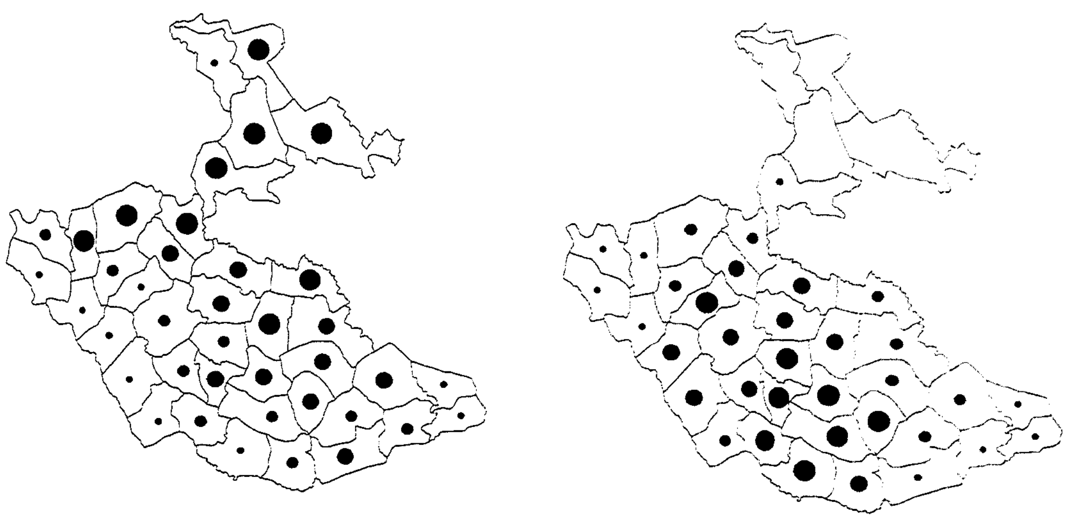


Figure 9. The relative encounter rates of human signs in Bwindi. Large circle =highest encounter rates, smallest circle = least frequent; blank=not encountered.



Chimpanzee nest Gorilla nest

Figure 10. The relative encounter rates of apes in Bwindi. Large circle =highest encounter rates, smallest circle = least frequent; blank=not encountered.



Chimpanzee nest Gorilla nest

Figure 11. The smoothed relative encounter rates of apes in Bwindi. Smoothing was achieved by calculating encounter rates for each sector combined with all surrounding sectors. Circle sizes increase with encounter rate as in previous maps.

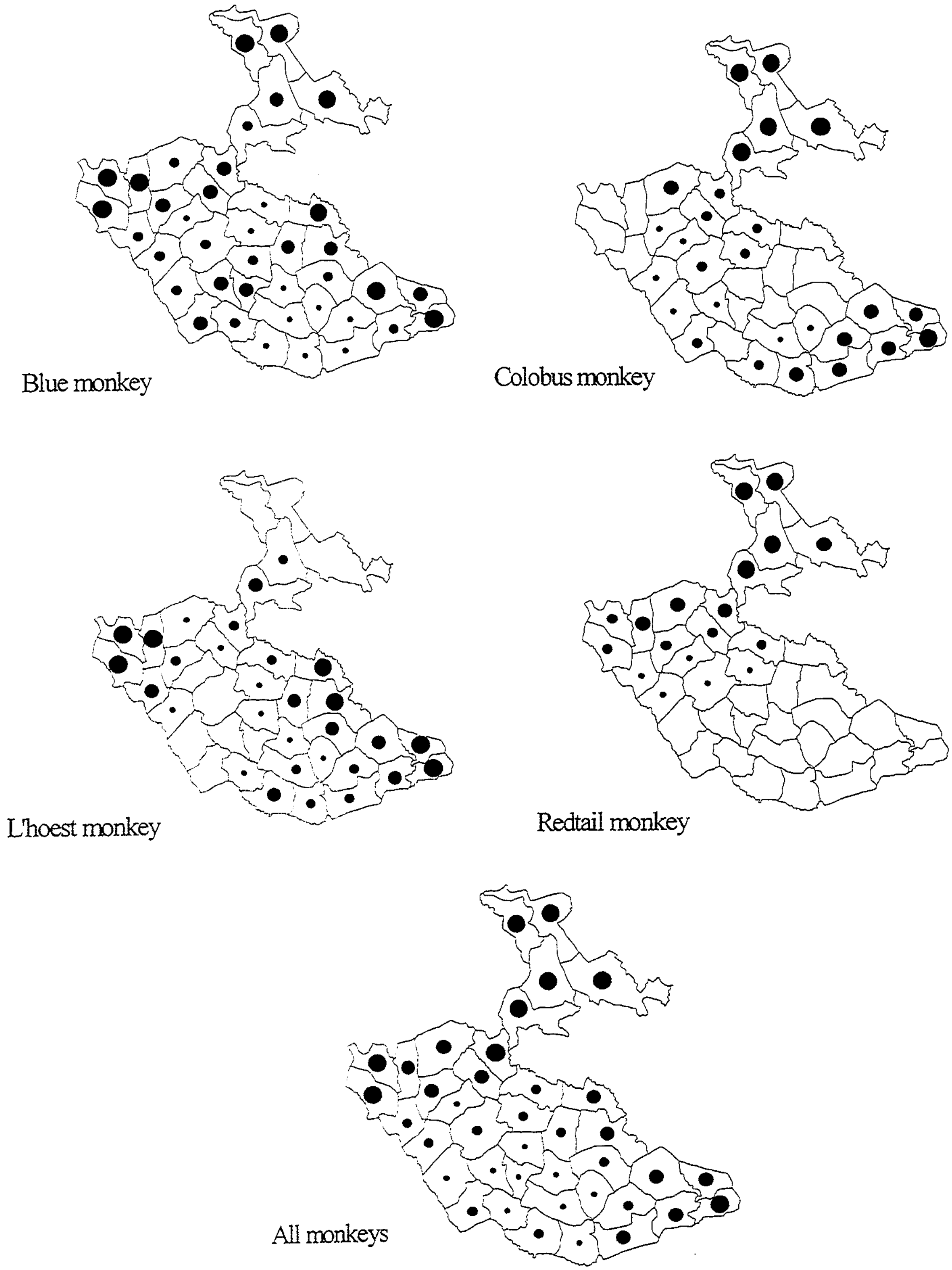


Figure 12. The smoothed relative encounter rates of monkeys in Bwindi. Smoothing was achieved by calculating encounter rates for each sector combined with all surrounding sectors. Circle sizes increase with encounter rate as in previous maps.

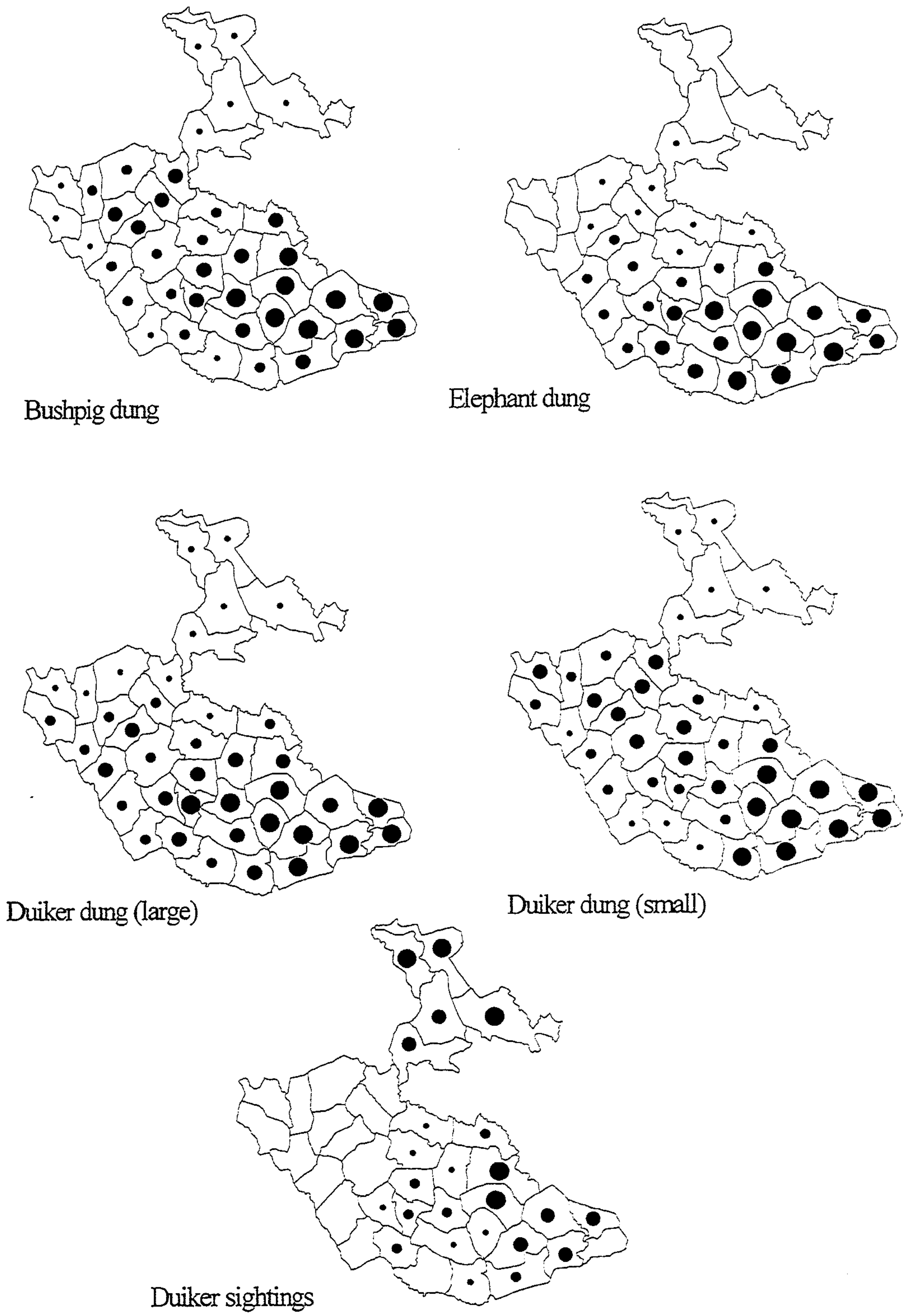


Figure 13. The smoothed relative encounter rates of ungulate signs in Bwindi. Smoothing was achieved by calculating encounter rates for each sector combined with all surrounding sectors. Circle sizes increase with encounter rate in previous maps.

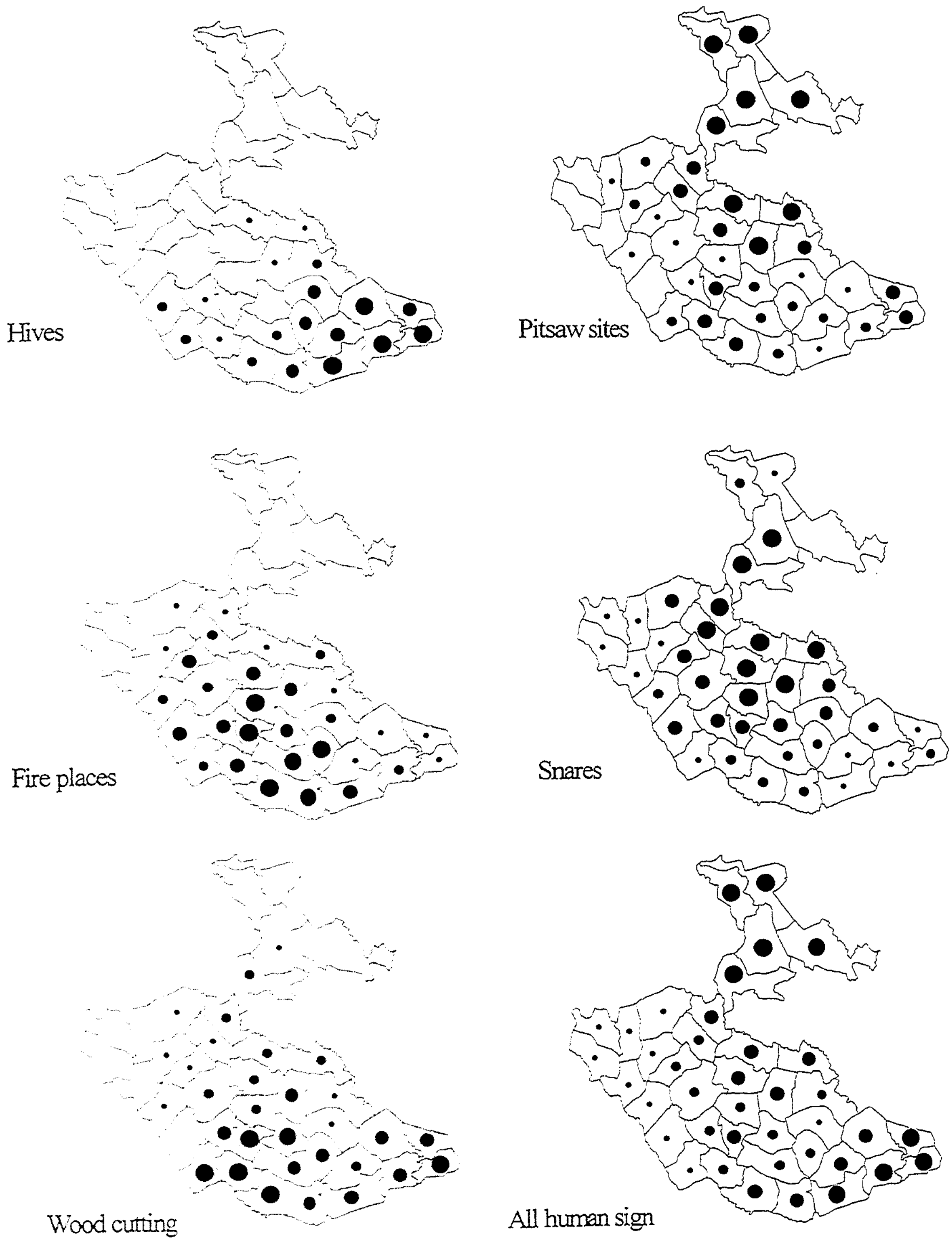


Figure 14. The smoothed relative encounter rates of human signs in Bwindi. Smoothing was achieved by calculating encounter rates for each sector combined with all surrounding sectors. Circle sizes increase with encounter rate as in previous maps.

explain the distribution found, so care must be taken when interpreting these figures (see Discussion). Monkeys tended to be found around the edges of the park and in the northern sector. Encounter rates for most sightings on the systematic transects in the two selected areas were lower than on reconnaissance counts. Several species were rarely seen on the transects because of the shorter total distances walked (144 km at Ruhija and 141.6 km at Buhoma) and the fact that existing paths were not being walked. (paths which were used during the reconnaissance surveys were probably also used by animals to get through the dense vegetation).

4.4 Correlations between reconnaissance and transect counts

Data from pairs of transects were combined to increase sample size for encounter rates when calculating correlations with encounter rates from reconnaissance counts in the same sites. Only those parts of reconnaissance trails that passed near pairs of transects were used in the analyses. Table 4 gives the Spearman rank correlations between encounter rate from the reconnaissances and from the transects, where data were sufficient to calculate a correlation. Despite the distance walked in each of the two transect sites,

Table 4. The results of Spearman rank correlations between reconnaissance counts and transect counts. The sightings of animals were few on transects and correlations could only be calculated for l'Hoest's monkeys for sightings on all six repeated counts of the transects combined. For dung and nests correlations were made between the reconnaissance counts and the first count of the transect (the standing crop count) and also between reconnaissance counts and the encounter rate on the subsequent transect counts (accumulation counts).

Species	r value	P value
All counts/live animals		
L'Hoest monkeys	0.676	0.140
Correlations with first count of transect (standing crop)		
Bushpig dung	0.600	0.210
Small duiker dung	0.886	0.019
Large duiker dung	0.600	0.208
Elephant dung	1.000	0.000
Chimp nests	0.030	0.954
Correlations with accumulated dung/nests		
Bushpig dung	0.430	0.390
Small duiker dung	0.829	0.042
Large duiker dung	-0.174	0.742
Elephant dung	0.895	0.015
Chimp nests	-0.395	0.439

many of the transects had zero encounters so that the correlations between reconnaissance and transect encounter rates were poor. Consequently, for most of the animals it was not possible to calculate correction factors for the reconnaissance data, and thus meaningful total densities for the park.

Table 4 shows only significant correlations between dung of small duikers and elephants. No measure of the decomposition rate of dung was collected because of time constraints, and variability across the park in vegetation and altitude is likely to cause considerable variation in decomposition rates. However, the correlation between reconnaissance trail encounter rates and accumulation rates for dung on transects does allow us to calculate a crude density estimate for the elephants and small duikers in the park as a whole. Defaecation rates were taken from the literature (elephant=17/day (Wing & Buss 1971); Duikers=5/day (Koster & Hart 1988)) to correct dung accumulation density to animal density. For small duikers this correction results in estimates of 6.7 animals/ km^2 for the whole park, 0.078 elephants / km^2 (or about 25 in the whole park). This figure for elephants is similar to the number Babaasa (1994) and Butynski (1986) found.

It was possible, however, to calculate densities of animals in the two transect areas (Table 5). The density of nests/dung produced per day was calculated from the density of the nests/dung (calculated from perpendicular distance data of observations on the repeated censuses) and dividing this by the number of days elapsed between the first and last count (4-5 weeks for dung and 15 weeks for nests - see Plumptre & Reynolds 1996 for an example for nest counts). This effectively removes the need to allow for dung or nest decay rates, which are notoriously variable between seasons and difficult to measure (A. Plumptre in prep.).

As we do not know the defaecation rates of the animals that have been censused using dung counts it was not possibleto convert the dung accumulation densities to population densities accurately. Elephants visited Buhoma during the period of the dung accumulation counts but have not been observed in this part of the park in the past few years, and so the density obtained here was unusually high. Normally the elephants are concentrated in the east of the southern part of the park as shown from the reconnaissance counts (figures 8 and 13; Butynski 1986).

Table 5. The densities of various species from the transect counts at Buhoma and Ruhija. Standing crop densities are the densities obtained from the first count on a transect. Accumulation densities are the densities of signs produced per day calculated from the repeated counts on the transects.

	Buhoma			Ruhija		
Species	Density no/km^2	Standard error	95% limits	Density no/km^2	Standard error	95% limits
Monkeys						
Blue monkey	8.3	2.9	4.1-16.6	11.9	4.6	5.5-25.5
Redtail monkey	26.4	12.5	10.2-68.0	0		
L'Hoest's monkey	8.6	4.1	3.4-21.6	15.8	5.5	8.0-31.2
Colobus monkey	2.9	1.7	0.9-9.7	0.9	0.9	0.1-6.6
Chimpanzee nests						
Standing crop	114.9	27.1	72.0-183.0	23.2	9.8	10.0-56.0
Accumulation	0.68	0.34	0.25-1.80	0.18	0.13	0.05-0.68
Bushpig dung						
Standing crop	125.1	62.7	46-338	441.4	167.2	197-988
Accumulation	1.3	0.7	0.4-4.3	10.6	2.3	6.8-16.5
Small duiker dung						
Standing crop	707.9	258	338-1480	4999	646	3793-6589
Accumulation	6.7	1.5	4.2-10.8	81.6	10.6	62-107
Large duiker dung						
Standing crop	130.3	74.8	41.5-409.1	544.7	150.1	313.2-946.7
Accumulation	3.2	1.5	1.2-8.5	9.8	2.8	5.6-17.3
Elephant dung						
Standing crop	0	0		810	341	329-1993
Accumulation	7.9	2.7	3.9-16.4	2.8	1.8	0.7-10.4

4.5 Habitat associations

Figures 15 and 16 give the frequency of sightings of the more abundant animals in each vegetation type. No attempt was made to measure the availability of these different vegetation types so that it is not possible to analyse preferences. However, a comparison between the histograms in Figure 15 does allow differences to be seen between species. For instance, large and small duiker dung tended to be found on the sides of hills (particularly open forest), whilst elephant and bushpig dung was found more often on the ridges (particularly open forest). Chimpanzee nests were found more often in closed forest than gorilla nests, although both species had most nests in open forest (likely because this was one of the more common habitat types).

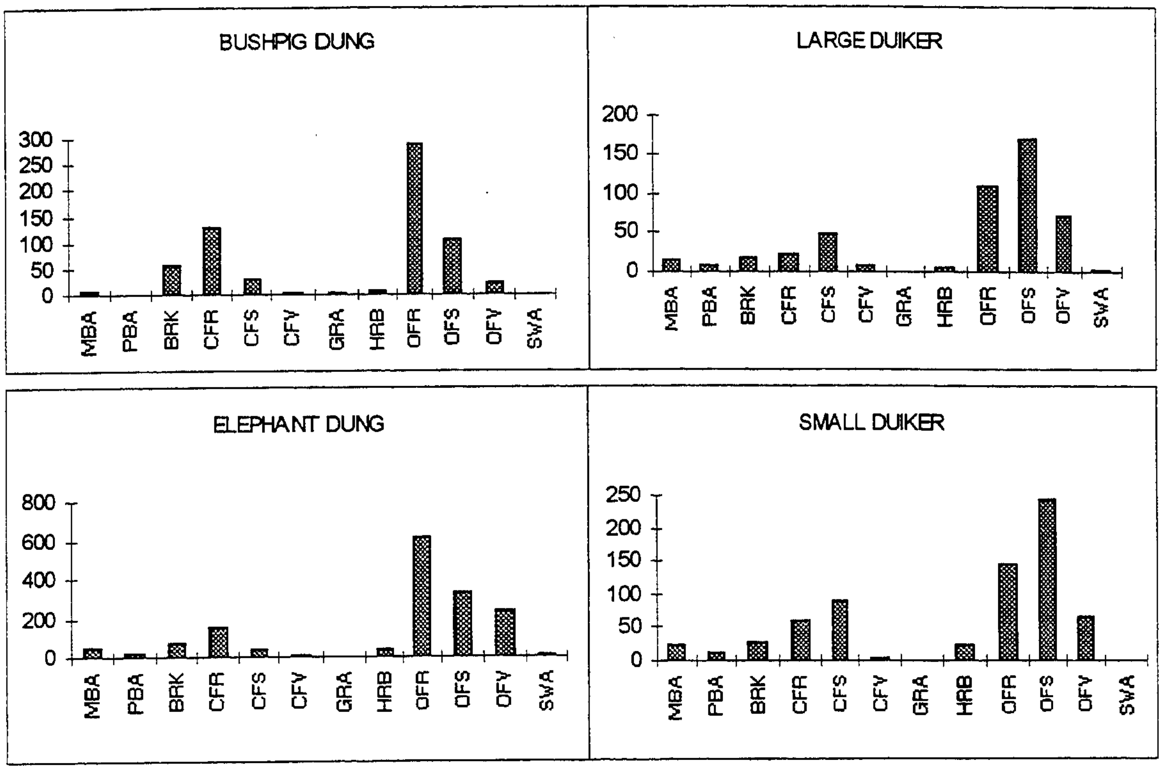


Figure 15. The number of sightings in different habitat types for the most commonly found ungulate dung. (MBA=mixed bamboo; PBA=pure bamboo; BRK=bracken;CFR=closed forest ridge; CFS=closed forest slope; CFV=closed forest valley; GRA=grass; HRB=herbaceous; OFR=open forest ridge; OFS=open forest slope; OFV=open forest valley; SWA=swamp).

4.6 Human disturbance

Signs of human disturbance encountered during the Bwindi census are summarised in Table 3. The most frequently encountered signs were beehives, but the majority of these (68 out of 82) were found within the sectors which cover multiple use zones in which beehives can legally be maintained within the park. Pitsawing sites were common, although most of these were old, pre-dating the gazetting of Bwindi as a national park. Only three new pitsawing sites were encountered, all in the northern part of the park. All gold mining sites and pitfall traps encountered also appeared old enough to predate the park. Snares, campfires, human trails and cutting for firewood or poles were also encountered relatively frequently. The distribution of the principal forms of human disturbance are shown in the maps in figures 9 and 14. Signs of human disturbance were clearly not evenly distributed over the park, and different types of disturbance were concentrated in different areas. Smoothing showed that most human use occurs in the

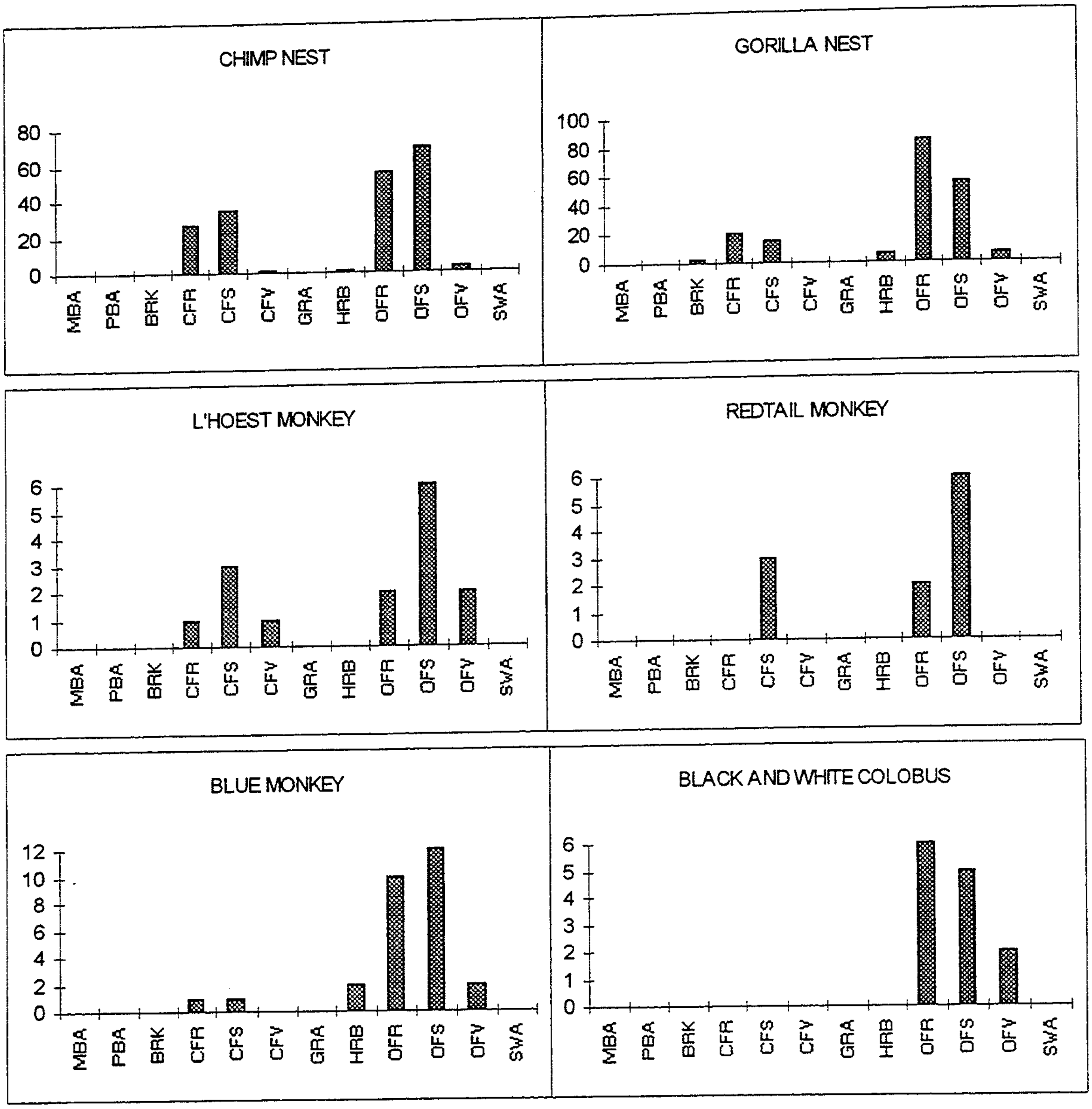


Figure 16. The number of sightings in different habitat types for the most common primates. (MBA=mixed bamboo; PBA=pure bamboo; BRK=bracken;CFR=closed forest ridge; CFS=closed forest slope; CFV=closed forest valley; GRA=grass; HRB=herbaceous; OFR=open forest ridge; OFS=open forest slope; OFV=open forest valley; SWA=swamp).

northern part of the park (illegal use) and in the east of the southern part, in the multiple use zones where at least some human use is legal. Certain activities are more concentrated in the centre of the park, such as wood cutting and poachers camps.

Spearman rank correlations were used to investigate the relationship between signs of human disturbance and large mammals (Table 6). Perhaps surprisingly, gorilla nests were positively correlated with

Table 6. Spearman's correlation coefficients for the relationships between signs of human disturbance and signs of large mammals by sector. Figures in **BOLD** indicate a significance of $p < 0.05$, two-tailed (critical values are 0.33 for n=34, 0.31 for n=39). Gorillas and elephants were absent from the northern section of the park, so those five sectors were excluded from the analysis for these species.

	Gorilla nest	Chimp nest	Bushpig dung	Elephant dung	Small duiker dung	Large duiker dung	Carnivore dung	Blue monkeys	L'Hoesti monkeys	Colobus	Redtail monkeys	Total monkeys
Illegal human sign:	n=34	n=39	n=39	n=34	n=39	n=39	n=39	n=39	n=39	n=39	n=39	n=39
Snares	0.264	0.198	0.279	0.146	0.227	0.061	0.096	0.048	0.014	-0.053	0.141	0.088
Fireplace/poachers' camps	**0.432**	0.069	0.164	**0.352**	-0.018	0.074	0.238	0.196	-0.200	-0.130	-0.277	-0.139
Total poaching signs (snares+fire)	0.323	0.184	0.272	0.238	0.143	0.028	0.088	0.056	-0.020	-0.072	0.061	0.056
Cutting (firewood, poles etc)	0.261	0.040	0.104	0.183	0.097	0.040	**0.378**	0.023	-0.172	0.074	-0.143	-0.100
Pitsawing (new, since park)	-	0.098	**-0.361**	-	**-0.421**	-0.270	-0.240	-0.057	-0.188	**0.322**	**0.385**	0.184
Honey gathering	**0.342**	-0.176	0.153	0.193	0.143	0.241	0.172	0.099	-0.188	-0.167	-0.145	-0.156
Bee hives	**-0.398**	-0.185	0.184	0.252	0.161	0.186	0.335	-0.109	0.112	0.306	-0.273	0.054
Total non-poaching signs	0.014	-0.061	-0.039	**0.414**	-0.040	0.016	0.315	-0.093	-0.121	**0.312**	-0.115	0.030
Human trails (poaching or other)	0.075	-0.097	-0.265	0.056	-0.021	-0.113	0.031	0.232	-0.143	0.141	0.142	0.169
Total human disturbance signs	0.116	0.133	0.092	**0.333**	0.014	-0.070	0.205	0.129	-0.102	0.345	-0.004	0.180

fireplaces/sites and honey gathering, and showed a (non-significant) positive correlation with snares. Gorilla nests were negatively correlated with bee hives. Conclusions should only be drawn from these correlations with some caution: in calculating over 100 correlations as in Table 6, a certain number of falsely significant results would be expected by chance alone.

Proximity to human habitation may have been one factor affecting animal distributions and this could also have affected correlations in table 6. In order to investigate this further, sectors were divided into those sharing a boundary with the edge of the park (exterior) and those completely surrounded by other sectors (interior). As the northern part of the park could not be divided in this way and gorillas were not found there, the five northern sectors were excluded from this analysis. The encounter rates in interior and exterior sectors were compared using Mann-Whitney U-tests (Table 7).

Gorilla nests were encountered significantly more often in interior sectors, as were chimpanzee nests (in the south) and both large and small duiker dung. All monkey species were encountered more often in exterior sectors, but this was only significant for l'Hoest's monkey and all species combined.

The situation with signs of human disturbance is less clear. Honey gathering from trees (as opposed to hives) was significantly more frequent in interior sectors, but only six instances were encountered overall. Beehives were encountered significantly more often in exterior sectors, but most of these were concentrated in the multiple use zones in which they are permitted. These zones do not extend far into the interior of the park. Apart from these two findings, encounter rates for other signs of human disturbance were not significantly different in interior and exterior sectors, although there is a suggestion that poaching signs are generally more common in the interior, while non-poaching signs are generally more frequent in the exterior. While the maps in figures 9 & 14 clearly show that some forms of disturbance are concentrated in particular areas, proximity to the edge of the park is not the only factor involved.

Table 7. Comparisons of encounter rates (number encountered / km) for illegal human signs and large mammal signs between exterior sectors (those with a boundary at the exterior of the park) and interior sectors of Bwindi. Comparisons were made using Mann-Whitney U tests.

	Mean encounter rates per km:		p	sig
	Exterior sectors (n=20)	Interior sectors (n=14)		
Illegal human signs:				
Snares	0.069	0.137	0.276	
Fireplace/poachers' camps	0.022	0.068	0.103	
Total poaching signs (snares+fire)	0.091	0.204	0.211	
Cutting (firewood, poles etc)	0.054	0.053	0.452	
Honey gathering	0.000	0.011	0.045	*
Bee hives	0.222	0.017	0.021	*
Total non-poaching signs	0.276	0.080	0.566	
Human trails (poaching or other)	0.038	0.077	0.137	
Total human disturbance signs	0.405	0.362	0.543	
Large mammal signs:				
Gorilla nest	0.950	3.598	0.005	***
Chimp nest	0.743	1.179	0.032	*
Bushpig dung	1.280	1.615	0.107	
Elephant dung	2.731	5.318	0.108	
Small duiker dung	1.258	1.549	0.042	*
Large duiker dung	0.646	1.181	0.046	*
Carnivore dung	0.083	0.112	0.326	
Blue monkeys	0.149	0.064	0.493	
L'Hoesti monkeys	0.189	0.027	0.026	*
Colobus	0.160	0.021	0.249	
Redtail monkeys	0.168	0.025	0.205	
Total monkeys	0.666	0.136	0.006	**

5. Discussion

5.1 Gorilla population

The gorilla population estimate of 292 individuals obtained for Bwindi during this census is best considered as a minimum. In two cases, neighboring groups were found with similar nest counts, which could not be distinguished on the basis of trails and dates. These have been treated as double counts of a single group, but it is possible that genetic analysis from hair samples could allow these to be distinguished as different groups. The same applies to several lone male nest counts. This could add a maximum of 13 more individuals to the total. It is also possible that a small number of groups could have been missed. It was found during this census that gorilla trails in Bwindi were often more difficult to find and follow than those in the Virungas (many of the team leaders and trackers who participated in this census had considerable experience of gorilla tracking in the Virungas). This was particularly the case in areas of closed canopy with little ground vegetation, which appeared to be much more common in Bwindi than in the Virungas. However, in considering how intensively the area was covered, we feel that it is unlikely that more than two or three small groups could have been missed in this way. The fact that all of the regularly monitored groups, as well as neighboring groups known to trackers and guides, were found during the census, without prior knowledge of their locations, indicates that the census methods did work acceptably well. This census utilized six teams of people who were able to cover the forest in a shorter time than previous censuses, reducing the likelihood of missing groups or counting the same groups twice.

The population estimate obtained here is very similar to Butynski's estimate of 300, made between 1986-1993 (Butynski *pers. comm.*). Within the limits of the methods used, the population appears to be stable. The count of 257 gorillas in 1994 (ITFC unpublished data, compared with an actual count of 280 in this census) is likely to be an underestimate of the whole population as certain areas may not have been thoroughly covered. It is unlikely that the population actually declined and increased again since Butynski's study.

Unfortunately data on the population structure of the whole population are not available from previous censuses. Group size found in this census appears to be higher than the figure of 7.2 in 1984 (Butynski 1985), although the latter is based on a limited proportion of the population (n = 9). The average group size in this study is comparable with that in the Virungas (9.15, Sholley 1991; compared with 9.8 in this census). The proportion of multi-male verses one-male groups is particularly high in Bwindi, 46 % compared with 29 % in the most recent Virunga census (Sholley 1991).

The proportion of immatures in the population found here (37%) is comparable to that found in the Virungas during the 1970s and early 1980s. However, as the Virunga population started to increase, the proportion of immatures increased, up to a maximum of 48 % in 1986 (Vedder 1986). Although direct inferences on population dynamics cannot be made from the proportion of immatures alone (Caughley 1977), these comparisons with the Virungas indicate that the relatively low proportion of immatures in the Bwindi population at present is consistent with a population that is not growing.

Very limited information is available for Bwindi on the availability of different habitat types, their quality in terms of gorilla food availability and gorilla habitat utilisation patterns. It is therefore difficult to assess to what degree the population has the potential to increase beyond the current population size of around 300 individuals. There are clearly areas of the park which are not used by gorillas at present, which might suggest room for expansion. The northern part is generally lower altitude than the south, and shows some differences in habitats which may explain the lack of gorillas there. However, it cannot be concluded that gorillas could not utilise those different habitat types, simply because they do use them at present. In Kahuzi-Biega National Park in eastern DRC, gorillas are found both in a higher sector comparable in altitude to Bwindi, and in an extensive area of lowland forest (Hall *et al.* 1998).

Within the southern part of Bwindi, gorillas are mostly concentrated in the central region. No signs of gorillas were found in the eastern end, which is the highest part of the park and consists of an area of mixed bamboo and herbaceous vegetation. The home ranges of several groups in the Virungas consist almost exclusively of a similar mix of habitats (McNeilage 1995). The vegetation in the western end around Buhoma may also differ from the rest of the southern part, being at lower altitude, but gorillas are found in this area. We cannot be certain that other patterns of variation in vegetation type could not explain why gorillas avoid other exterior parts of the park, but no changes in vegetation towards the exterior were obvious in the course of fieldwork except those at the eastern and western ends.

4.2 Impact of human disturbance on the gorillas

Signs of human disturbance were found in almost all sectors of Bwindi, and such disturbance could have an impact on the gorillas' use of particular areas. Signs associated with poaching were, if anything, more common in the centre, but other forms of disturbance may be more common in the exterior. Certainly the history of pitsawing in Bwindi indicates that it was concentrated at the edge of the park and this may have had some influence on the vegetation. The history of disturbance in particular areas might also underlie gorilla ranging patterns. Both Harcourt (1981) and Butynski (1985) found a similar pattern with gorillas favouring the interior of the forest. Harcourt (1981) found that human use was most common near the periphery. Bwindi was only gazetted as a national park six years prior to this census, and protection of the area has been considerably improved in recent years (Butynski & Kalina 1993, 1998). Butynski (1985) found 89 snares while walking around 200 km of survey trail, while 62 snares were found in over 500 km walked during this census. Although heavy human use may have been reduced in recent years, it may still have a legacy in terms of the areas favoured by gorillas.

5.3 Other mammals

For most of the animals for which data were collected it was not possible to calculate densities for the whole park. This is because there were few sightings of most species along the transects, or along the reconnaissance trails in the same sites as these transects. It was, however, possible to calculate densities at the two sites where transects were located; Ruhija which is representative of the higher parts of Bwindi and Buhoma which is representative of the lower altitude habitat.

Calculating densities of ungulates in Bwindi is difficult because sightings are too few and only dung can therefore be used. It was noticeable that more dung was found along ridges in the park rather than valleys or slopes which will have affected encounter rates from reconnaissance counts, because most trails follow the ridges where the vegetation is dense. Another confounding factor is that it is likely that dung decay might not be uniform across the park. Dung probably disappears more quickly under the tree cover at lower altitudes, because the vegetation is more dense so that dung is not baked by the sun (which results in slow decay rates). Temperatures will be higher at lower altitudes, so that dung beetles are probably more active which would also increase the decay rate.

Estimates of mammal densities from the transect data should, however, be accurate. Censusing accumulated dung over time allows problems of differential dung decay rates to be avoided, and using randomly placed transects avoids the ridge-valley bias. Ungulate dung accumulation was greater in the Ruhija site. It is possible that the transects, once they were cut, were selectively used as paths by ungulates in Ruhija which would inflate density estimates. However, examination of the frequency of sightings for the repeated counts did not show any evidence of increasing use over time.

Because of the problems with reconnaissance trail location and differential dung decay, the encounter rate data (Figures 8 and 13) should be treated with caution. However, the transect data had greater densities of dung deposition (accumulation count) around Ruhija which is where the encounter rate data from reconnaissance trails also show the higher densities of ungulate dung so that the results do seem to give a reasonable picture of relative distribution. The ground vegetation is densest at higher altitudes in Bwindi which meant that the availability of food for ungulates is likely to be higher here. This probably explains why the ungulate signs were most common in the east of the park, although another explanation could be that there is more cover here to hide from poachers.

Ideally more long term studies should be made of these ungulates to generate a more accurate picture of their density distributions around the park. Bushpigs are of particular importance in park management because they raid crops, creating conflict with surrounding communities. Bushpigs appear to be more frequent in the east of the southern part of the park. One way to confirm this would be to make a study of crop raiding by pigs in villages around the park to test whether the frequency of crop raiding is greater in this region.. The data in Table 5 show that bushpig dung accumulation varied between 1.3-10.6 / km^2. We do not know the defaecation rate of these animals but most ungulate defaecation rates vary between 5-20 dung piles per day for ruminants. A short study of red river hogs at the Bronx zoo in New York produced a figure of 7 defaecations/day ranging from 6-8 although these animals will have been on a very different diet to those in Bwindi. If we assume for now that Bwindi bushpigs defaecate five times per day (the minimum known for ruminants - non-ruminants would be expected to be higher) and there are 10.6 dung piles / km^2 (95% confidence limits: 6.8-16.5) throughout the park (the higher measure from the 2 sites) this would mean that the bushpig population was only 690 animals throughout the park (95% limits: 440-1070). This population estimate is calculated to give the highest possible value given the data we have and realistically it is likely to be much lower. Therefore the bushpig population is unlikely to be very large in the park so great care must be taken with proposed plans to allow villagers to hunt these animals. It is unlikely that the population could withstand any sustained hunting.

Monkeys were found more frequently around the edge of the forest, a finding also reported by Butynski (1984). Redtail monkeys were only seen in the lowest altitude part of the park, which may be because they tend to be more insectivorous than the other monkey species (A. Plumptre unpublished data). The other species occurred at higher altitudes but apart from L'Hoest monkey (otherwise known as the mountain monkey), most species were seen more frequently at lower altitudes. This is likely to be explained by the fact that more fleshy fruiting trees (such as *Ficus* and *Chrysophyllum*) occurred at lower altitudes.

5.4 General conclusions

The gorilla population in Bwindi appears to be fairly stable and has not changed much since 1986-93. It is not clear why the population is not rising. Over a similar length of time (1981 to 1989) the Virunga population increased by about 60 animals (25%). It is known that four animals have been killed in Bwindi since 1990, but it is unlikely that more have been killed given the close monitoring that has gone on since the late 1980s. Very little is known about the diets of these gorillas, their habitat requirements, ranging behaviour or demography. Research (based at the Institute of Tropical Forest Conservation) should regard studies on these aspects of gorillas as a high priority, to obtain a better understanding how much the Bwindi gorilla population could increase, and what is preventing it from doing so.

It is interesting to note that while 62 snares were found during this census of Bwindi, 414 were found during the most recent census of the Virungas in 1989 (McNeilage 1995), including a very high concentration on Mount Mikeno. No such areas of extremely intense poaching were found in Bwindi. However, although protection in Bwindi has improved in recent years, and poaching may be less of a problem than in some areas, there is no room for complacency. Given the small area of the park, the small population size of key species such as the gorillas and the prevalence of illegal human disturbance which remains, improved protection should still be an important priority.

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7. **Appendix 1**. Encounter rates (number per km walked) of all signs/animals recorded on the reconnaissance counts for each sector of the park.

Human sign encounter rate per km of corrected map distance:

Sector	Cutting	Fire place	Hive	Snare	Poachers trail	Poacher	Pitsaw site	Mine	Pitfall trap	Honey gathered
A	0.000	0.000	0.279	0.279	0.000	0.000	0.372	0.000	0.000	0.000
B	0.222	0.056	0.555	0.111	0.167	0.000	0.000	0.000	0.000	0.000
C	0.106	0.000	1.268	0.000	0.000	0.000	0.000	0.000	0.211	0.000
D	0.000	0.000	0.076	0.000	0.000	0.000	0.115	0.000	0.076	0.000
E	0.042	0.084	0.253	0.084	0.126	0.000	0.000	0.000	0.000	0.000
F	0.143	0.095	1.476	0.000	0.000	0.000	0.000	0.000	0.000	0.000
G	0.100	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.000
H	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
I	0.000	0.037	0.000	0.299	0.000	0.037	0.000	0.000	0.000	0.000
J	0.000	0.000	0.373	0.000	0.000	0.000	0.093	0.000	0.000	0.000
K	0.000	0.062	0.000	0.000	0.062	0.000	0.125	0.000	0.000	0.000
L	0.190	0.095	0.000	0.285	0.000	0.000	0.048	0.000	0.000	0.000
M	0.000	0.403	0.000	0.403	0.000	0.000	0.000	0.000	0.000	0.000
N	0.000	0.000	0.000	0.178	0.119	0.000	0.000	0.000	0.000	0.000
O	0.137	0.068	0.068	0.068	0.000	0.000	0.479	0.000	0.000	0.000
P	0.427	0.107	0.000	0.107	0.320	0.000	0.213	0.000	0.000	0.000
Q	0.000	0.000	0.000	0.000	0.055	0.000	0.000	0.000	0.000	0.000
R	0.285	0.071	0.000	0.143	0.143	0.000	0.143	0.071	0.000	0.071
S	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
T	0.058	0.058	0.000	0.582	0.000	0.000	0.349	0.000	0.000	0.000
U	0.000	0.000	0.115	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V	0.000	0.000	0.000	0.000	0.064	0.000	0.000	0.000	0.000	0.000
W	0.000	0.113	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Y	0.000	0.000	0.000	0.000	0.077	0.000	0.000	0.000	0.000	0.000
Z	0.000	0.000	0.000	0.081	0.000	0.000	0.000	0.000	0.000	0.000
A'	0.000	0.000	0.000	0.269	0.090	0.000	0.000	0.000	0.000	0.000
B'	0.062	0.062	0.000	0.123	0.000	0.000	0.123	0.000	0.000	0.000
C'	0.000	0.126	0.000	0.253	0.168	0.000	0.000	0.000	0.000	0.042
D'	0.051	0.000	0.000	0.000	0.051	0.000	0.051	0.000	0.000	0.051
E'	0.000	0.000	0.000	0.000	0.435	0.000	0.000	0.000	0.000	0.000
F'	0.000	0.000	0.000	0.095	0.000	0.000	0.048	0.000	0.000	0.000
G'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
H'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
I'	0.108	0.000	0.000	0.648	0.540	0.000	0.108	0.108	0.000	0.000
J'	0.000	0.000	0.000	0.000	0.754	0.000	0.603	0.000	0.000	0.000
K'	0.000	0.000	0.000	0.174	0.000	0.000	1.047	0.000	0.000	0.000
L'	0.000	0.000	0.000	0.000	0.167	0.000	0.501	0.000	0.000	0.000
M'	0.000	0.000	0.000	0.000	0.000	0.000	2.217	1.109	0.000	0.000
Grand Total	0.053	0.038	0.149	0.113	0.065	0.002	0.102	0.011	0.011	0.005

Encounter rates of dung per km corrected map distance:

Sector	Baboon dung	Bushpig dung	Giant Forest Hog	Carnivore dung	Monkey dung	Gorilla dung	Elephant dung	Small duiker dung	Large duiker dung	Chimp dung
A	0.000	3.388	0.000	0.000	0.154	0.000	17.861	7.545	2.464	0.616
B	0.000	0.944	0.000	0.777	0.500	0.000	2.277	1.444	0.722	0.056
C	0.000	3.487	0.000	0.370	0.158	0.423	3.593	2.113	2.272	0.000
D	0.000	1.986	0.076	0.000	0.115	0.038	6.609	2.712	1.375	0.115
E	0.000	1.895	0.000	0.211	0.421	0.337	20.424	5.685	3.243	0.042
F	0.000	1.238	0.000	0.048	0.190	0.000	0.524	0.333	0.190	0.000
G	0.000	2.599	0.000	0.800	0.100	0.900	19.793	2.099	1.999	0.100
H	0.000	3.220	0.111	0.000	0.167	0.056	10.550	1.777	1.999	0.056
I	0.075	1.982	0.000	0.075	0.075	0.486	3.328	0.972	0.823	0.112
J	0.000	0.122	0.000	0.122	0.122	0.000	4.149	0.488	0.000	0.244
K	0.000	0.811	0.000	0.000	0.000	0.000	5.802	0.062	0.125	0.000
L	0.000	0.904	0.000	0.048	0.000	0.190	4.139	0.856	0.952	0.000
M	0.000	3.758	0.000	0.000	0.134	0.000	5.503	1.611	2.148	0.134
N	0.000	1.364	0.000	0.059	0.178	0.000	0.296	1.245	0.712	0.178
O	0.000	0.957	0.000	0.068	0.000	0.068	0.000	0.479	0.342	0.000
P	0.000	0.000	0.000	0.000	0.000	0.000	7.485	0.213	0.107	0.000
Q	0.000	1.254	0.000	0.055	0.109	0.109	1.581	1.254	1.581	0.000
R	0.000	1.070	0.071	0.071	0.000	0.000	4.138	0.999	1.142	0.000
S	0.000	0.809	0.000	0.067	0.000	0.000	1.078	0.539	0.404	0.000
T	0.000	2.038	0.000	0.000	0.058	0.116	0.233	0.932	0.233	0.058
U	0.000	0.574	0.000	0.000	0.000	0.230	1.148	0.344	0.574	0.000
V	0.000	0.446	0.000	0.127	0.000	0.064	0.127	0.701	0.382	0.000
W	0.000	0.907	0.000	0.000	0.000	0.113	3.629	0.680	0.680	0.000
X	0.000	0.457	0.000	0.000	0.000	0.000	0.000	0.685	0.343	0.000
Y	0.000	0.231	0.000	0.000	0.077	0.000	0.000	0.615	1.000	0.000
Z	0.000	0.732	0.000	0.000	0.000	0.000	0.000	1.139	0.244	0.000
A'	0.000	1.075	0.000	0.000	0.000	0.000	0.179	0.896	0.358	0.090
B'	0.000	0.984	0.000	0.062	0.000	0.185	0.308	1.784	0.308	0.246
C'	0.000	1.179	0.000	0.253	0.000	0.253	6.529	1.390	0.885	0.084
D'	0.000	1.955	0.000	0.000	0.000	0.463	2.521	1.132	1.235	0.000
E'	0.000	0.653	0.000	0.000	0.000	0.000	0.000	1.088	0.218	0.000
F'	0.000	4.615	0.000	0.048	0.048	0.333	0.000	0.904	0.428	0.000
G'	0.000	0.169	0.000	0.000	0.000	0.338	0.000	0.423	0.254	0.000
H'	0.000	0.750	0.000	0.000	0.000	0.000	0.000	1.999	0.250	0.000
I'	0.000	0.432	0.000	0.000	0.000	0.000	0.000	0.972	0.108	0.108
J'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.452	0.302	0.000
K'	0.000	0.523	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
L'	0.000	1.002	0.000	0.000	0.000	0.000	0.000	0.501	0.167	0.000
M'	0.000	0.277	0.000	0.000	0.000	0.000	0.000	0.000	0.277	0.000
Grand Total	0.004	1.472	0.009	0.099	0.085	0.151	3.759	1.352	0.898	0.053

Encounter rates of ungulates per km corrected map distance:

Sector	Elephant	Bushpig	Bushbuck	Black-fronted duiker	Unknown duiker	Red duiker	Yello-backed duiker	Total duiker sightings
A	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D	0.000	0.076	0.076	0.076	0.038	0.000	0.000	0.115
E	0.084	0.000	0.168	0.000	0.000	0.042	0.042	0.084
F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
G	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
H	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
I	0.000	0.000	0.000	0.037	0.000	0.000	0.000	0.037
J	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
K	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	0.000	0.000	0.000	0.059	0.000	0.000	0.000	0.059
O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Q	0.000	0.000	0.055	0.055	0.000	0.000	0.055	0.109
R	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
S	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
T	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
U	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
W	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Y	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
E'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
G'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
H'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
I'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
J'	0.000	0.000	0.000	0.151	0.000	0.000	0.000	0.151
K'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
L'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Grand Total	0.004	0.004	0.013	0.011	0.002	0.002	0.004	0.018

Encounter rates of primates per km of survey route:

Sector	Baboon	Blue monkey	L'Hoests monkey	Black and white colobus	Redtail monkey	Chimp nest	Gorilla	Gorilla nest	All monkey species	All nests
A	0.000	0.000	0.279	0.000	0.000	0.000	0.000	0.000	0.279	0.000
B	0.000	0.944	0.000	0.777	0.000	0.000	0.000	0.000	1.722	0.000
C	0.000	0.158	0.158	0.423	0.000	0.264	0.000	0.158	0.740	0.423
D	0.000	0.076	0.458	0.000	0.000	0.917	0.000	1.070	0.535	1.986
E	0.000	0.000	0.000	0.000	0.000	2.063	0.000	0.295	0.000	2.358
F	0.000	0.000	0.000	0.381	0.000	1.380	0.000	0.000	0.381	1.380
G	0.000	0.000	0.000	0.000	0.000	1.300	0.000	7.497	0.000	8.797
H	0.000	0.000	0.000	0.000	0.000	1.222	0.000	2.776	0.000	3.998
I	0.000	0.187	0.299	0.000	0.000	1.832	0.000	0.411	0.486	2.244
J	0.000	0.000	0.093	0.652	0.000	0.932	0.000	0.000	0.745	0.932
K	0.000	0.062	0.624	0.000	0.000	0.000	0.000	2.433	0.686	2.433
L	0.000	0.000	0.000	0.000	0.000	1.237	0.048	8.469	0.000	9.706
M	0.000	0.134	0.000	0.000	0.000	2.013	0.000	15.973	0.134	17.987
N	0.000	0.000	0.059	0.000	0.000	0.593	0.000	0.949	0.059	1.542
O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.966	0.000	3.966
P	0.000	0.534	0.000	0.000	0.000	0.320	0.000	3.949	0.534	4.269
Q	0.000	0.000	0.000	0.000	0.000	1.363	0.000	1.744	0.000	3.107
R	0.000	0.071	0.000	0.000	0.000	0.642	0.000	2.497	0.071	3.139
S	0.000	0.000	0.000	0.000	0.000	0.539	0.000	1.550	0.000	2.089
T	0.000	0.116	0.349	0.000	0.000	3.202	0.000	1.048	0.466	4.250
U	0.000	0.000	0.000	0.000	0.000	0.115	0.000	1.493	0.000	1.607
V	0.000	0.382	0.000	0.255	0.000	0.573	0.000	0.127	0.637	0.701
W	0.000	0.113	0.000	0.000	0.000	0.907	0.000	1.474	0.113	2.382
X	0.000	0.000	0.000	0.000	0.000	0.457	0.000	0.000	0.000	0.457
Y	0.000	0.077	0.461	0.000	0.769	0.000	0.000	0.000	1.307	0.000
Z	0.000	0.081	0.000	0.000	0.000	1.871	0.000	0.000	0.081	1.871
A'	0.000	0.000	0.000	0.806	0.538	0.717	0.000	1.613	1.344	2.329
B'	0.000	0.000	0.000	0.062	0.369	1.292	0.000	2.461	0.431	3.753
C'	0.000	0.084	0.000	0.000	0.000	0.211	0.000	4.634	0.084	4.844
D'	0.000	0.051	0.000	0.000	0.000	0.412	0.000	3.808	0.051	4.219
E'	0.000	0.000	0.000	0.000	0.000	0.653	0.000	0.218	0.000	0.870
F'	0.000	0.333	0.000	0.000	1.142	4.139	0.000	1.237	1.475	5.376
G'	0.000	0.000	0.592	0.000	0.000	0.000	0.000	0.169	0.592	0.169
H'	0.000	0.375	0.625	0.000	0.750	0.625	0.000	0.000	1.749	0.625
I'	0.540	0.000	0.108	0.000	0.432	10.041	0.000	0.000	1.080	10.041
J'	0.000	0.302	0.000	0.754	1.357	1.357	0.000	0.000	2.413	1.357
K'	0.000	0.000	0.000	1.047	1.221	0.000	0.000	0.000	2.268	0.000
L'	0.000	0.167	0.000	0.334	0.000	0.835	0.000	0.000	0.501	0.835
M'	0.000	0.000	0.000	0.000	0.000	5.820	0.000	0.000	0.000	5.820
Grand Total	0.009	0.113	0.114	0.116	0.131	1.203	0.002	1.868	0.483	3.071

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