BIODIVERSITY SURVEYS OF THE CORRIDOR FORESTS EAST OF BUGOMA FOREST RESERVE UP TO BUDONGO FOREST RESERVE

Tree mensuration in a corridor forest – A.Plumptre/WCS

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February 2011

WILDLIFE CONSERVATION SOCIETY

the Jane Goodall Institute

CSWCT

Table of contents

1.0 Executive Summary

This report summarises biodiversity surveys made in late 2010 in corridor forests to the east of Bugoma Central Forest Reserve (CFR) in smaller CFRs and private forests (Corridor forests) between Bugoma and Budongo CFRs. The surveys were supported by the Jane Goodall Institute (JGI) and the Chimpanzee Sanctuary and Wildlife Conservation Trust (CSWCT). The Wildlife Conservation Society (WCS) survey teams worked with many private land owners, and the National Forest Authority to undertake these surveys and we are very grateful for their support and participation.

Three main taxa were surveyed: large and medium sized mammals; birds and trees/shrubs. Recconnaissance surveys of large mammals and birds were made in these corridor forests while randomly allocated points were visited for tree/shrub plots and point counts of birds in the corridor forests.

Many large and medium sized mammal species still occur in the corridor forests including chimpanzees, redtail, grey-cheeked mangabeys, blue monkeys, baboons, vervets and black and white colobus monkeys.

Many bird species that probably require the corridors to link populations in the larger forest blocks were also found in these corridors, particularly the hornbills and tauracos. A few forest raptors were observed in the corridors but not many. No threatened bird species were found in these corridor forests which is similar to findings of a survey made of corridor forests to the south and west of Bugoma (Plumptre et al. 2010). A total of 170 bird species were recorded during these surveys, about 17% of Uganda's total species number.

150 tree and shrub species were recorded in these surveys also with Wambabya CFR being significantly richer in species than the other corridor forests. Wambabya CFR was similar to Bugoma CFR in terms of its species richness. Carbon measurements in 20m radius circular plots showed that these corridor forests had a relatively low biomass of CO_2 per hectare. It is estimated that about 80 tonnes of CO_2 per hectare occurs in these corridor forests, compared to 175 tonnes in the forests to the south of Bugoma CFR and 393 tonnes in Bugoma CFR itself.

The conclusion of the surveys is that the corridor forests east of Bugoma are relatively rich in species and have a conservation value in terms of both species richness as well as providing the function of linking larger forest blocks and hence metapopulations of certain species that require these corridors to maintain viable populations (corridor species). A separate study is assessing the feasibility of REDD funding as a way of providing incentives to conserve these forests and this will also assess whether a premium price could be obtained because of the biodiversity value of these forests. Of all the regions in the Murchsion-Semliki landscape, though, this region will generate least funding from carbon funds and other mechanisms will be needed in addition to REDD funds to conserve the remaining forest.

2.0. Introduction

In 2009 and 2010 Wildlife Conservation Society (WCS) was contracted by UNDP/GEF through WWF to identify critical corridors in the Murchison-Semliki landscape of the Albertine Rift (figure 1). Once this was completed we were also contracted to survey the biodiversity of these corridor forests because of our extensive experience with biodiversity surveys in Uganda. However, due to limited funding available the UNDP/GEF project focused only on the Bugoma Forest Reserve and the central forest reserves and private forests to the south of Bugoma and to the south west towards Itwara Forest Reserve (corridors 12-19; 26,27).

Prior surveys have been made of some of these forests in the past. In 1999 WCS and Jane Goodall Institute (JGI) surveyed Bugoma Forest Reserve and Kagombe Forest Reserve as part of a wider survey of large mammals, particularly chimpanzees in Uganda (Plumptre *et al.*, 1999). Surveys of trees and shrubs, small mammals, birds, butterflies and hawk and silk moths were made of Bugoma Forest Reserve (Davenport, Howard and Matthews, 1996) and Kagombe Forest Reserve (Howard and Davenport, 1996) as part of the Uganda Forest Department's surveys of biodiversity across its forest estate (Howard, Davenport and Kigenyi, 1997). These surveys ranked Bugoma 12th and Kagombe 31st in terms of overall biodiversity importance out of the 65 forests surveyed in the country (Uganda Forest Department, 2002). However none of the other 13 central forest reserves (CFRs) in this landscape (figure 1) or the connecting private forests have been surveyed for their biodiversity. A biodiversity survey was made of this area by WCS and JGI in 2010, with support from the UNDP/GEF project through WWF, which showed it was relatively rich in species and that the corridors were acting as conduits for certain large mammal and bird species (Plumptre *et al.* 2010).

As part of the planning process for the conservation of the Murchison-Semliki landscape in the Albertine Rift, WCS made an analysis of critical corridors in the landscape that if conserved would ensure connectivity between the forest reserves for certain landscape species (Nangendo, Plumptre and Akwetaireho, 2010). The surveys reported here focused on the corridor areas identified in this analysis between Bugoma and Budongo CFRs (figure 1) – corridors 4-10. Landscape species used to assess corridor requirements for the forest corridors included chimpanzees (*Pan troglodytes*), Golden cats (*Profelis aureus*), large and small forest raptors, and under storey birds that are known to move between forests (such as Pittas). These species and species groups were thought to represent the requirements of other similar species (eg. Golden cats would represent other medium sized carnivores such as jackals).

None of the forests to the east of Bugoma CFR had been surveyed in the Forest Department biodiversity surveys of the mid 1990s or subsequently. In order to complete the assessment of the corridor forests in the Murchison-Semliki Landscape there was a need to survey these additional forests. JGI and CSWCT raised funds to be able to support WCS to undertake these additional surveys and the results are presented in this report.

The biodiversity surveys aimed to meet the following objectives:

1. To compare the biodiversity richness of the corridor forests and small CFRs with the main block of Bugoma CFR.
2. To assess whether key landscape species are using the forest corridors at present.
3. To assess the distribution and relative abundance of threatened species in this landscape.
4. To assess the availability of carbon in the landscape from plot measurements of trees.

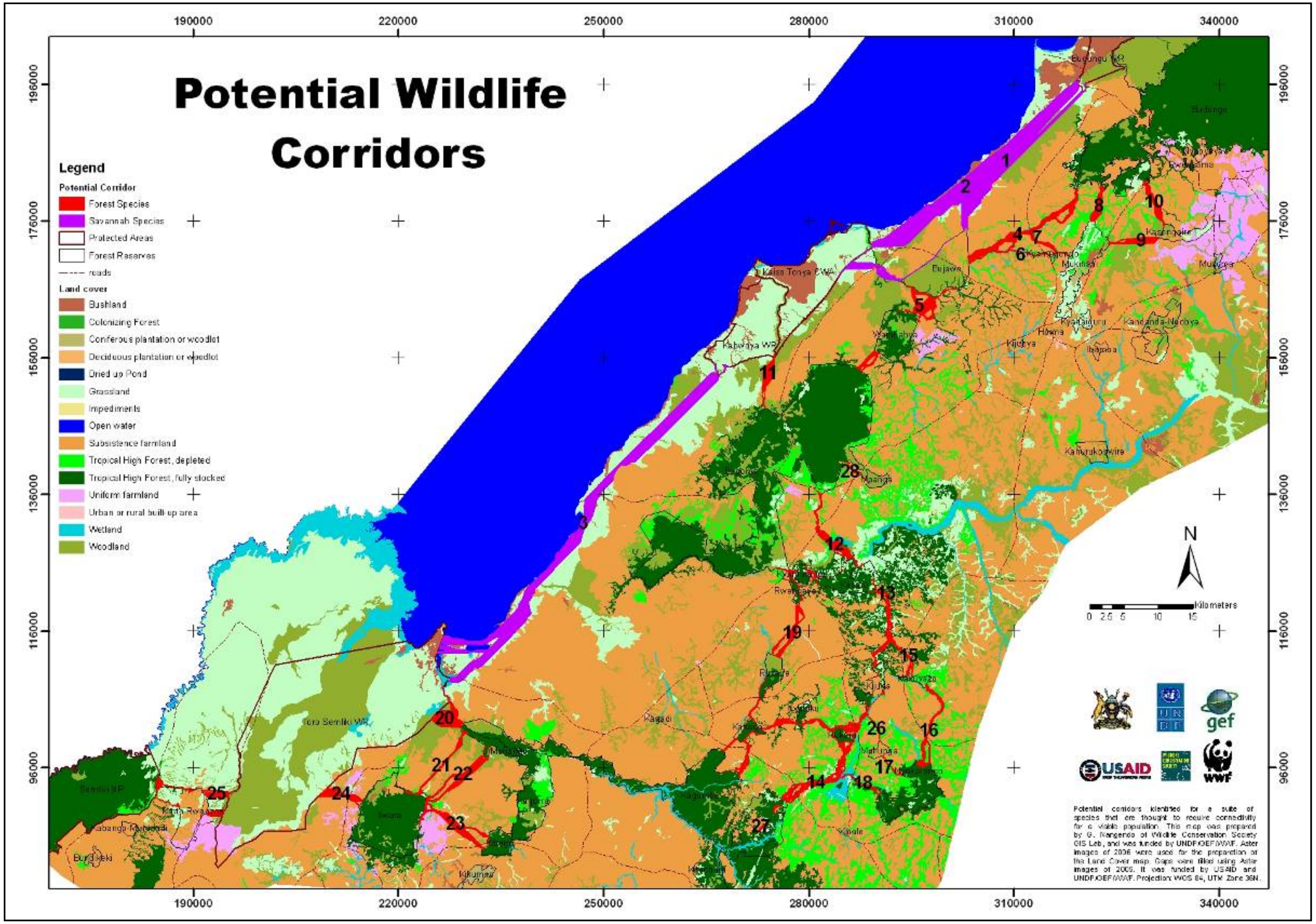


Figure 1. Critical corridors for maintaining connectivity for landscape species in the Murchison-Semliki Landscape of the Albertine Rift.

3.0 Survey Methods

The methods used to measure the biodiversity of these forests focused on three main taxa: large and medium sized mammals, birds, and trees and shrubs as surrogates of total biodiversity. Howard, Davenport and Kigenyi (1997) showed that there was a reasonable correlation between species richness in the five taxa they selected between sites and estimated that birds alone were a good indicator of most other biodiversity in Uganda's forests (Howard *et al.*, 2000).

In the small CFR's sampling points were selected using a stratified systematic design using the software DISTANCE 6.2 (Thomas, *et al.*, 2009). Regularly spaced points at a distance of about 1 km were randomly allocated to each of four habitat types derived from the landcover map that had been compiled by WCS (figure 1). These four habitat types included: mature tropical high forest, degraded tropical high forest, woodland and grassland. A spacing of 1 km was selected as desirable because it seemed to be a good trade off between number of points to survey and distance required to travel between points. DISTANCE generated the GPS positions of the points selected and these were copied to an excel spreadsheet and then entered into GPS units so that field teams could locate the points easily. Each point was given a separate number to allow for tracking of the point data when collected and these were mapped (figure 2).

In Bugoma and Kagombe CFR 3 km line transects were established from a similar design in DISTANCE. In this case coverage probability maps were calculated using transects with different lengths and orientation to determine the best orientation. North-south proved to be the best solution and 36 transects were established in Bugoma Forest and 7 in Kagombe (figure 2).

3.1. Large and medium sized mammals

Reconnaissance walks (Recces) were the primary method used to survey between the points in the small CFRs and private forests in the forest corridors. A team of two Ugandan Field Assistants moved between points, generally in as straight a direction as possible but moving around obstacles such as dense vegetation on the way. As such these are not strict transects and suffer from some bias but it has been found for Uganda's forests that there is a good correlation between reconnaissance encounter rates of chimpanzee nests and densities of chimpanzees (Plumptre and Cox, 2005) and the method allow much longer distances to be covered under the same survey. Recces were used to identify locations where specific species were observed as well as the calculation of encounter rates per km walked. Recces were made between June and November 2010.

Transects established in Budongo and Kagombe were visited several times over a 2-3 month period between August and October 2010 ensuring that each transect was visited every 15 days or less. This has been found to be the shortest time for a chimpanzee nest to decay to a point that it would not be counted. Occasionally a transect might not be visited within this period but the time did not extend beyond 20 days and it is thought that this will not have had much impact on the final result.

All sightings of large mammals were recorded on both recces and transects. In addition the dung of elephants, bushpigs and buffalo were recorded and nests of chimpanzees. On transects perpendicular distances from the centre of the transect were measured to all observations to allow densities to be computed if sample sizes were large enough. All signs of human impact were also noted on both recces and transects. GPS locations were taken using GARMIN 60Csx units for all observations made. The marked nest count method was used to analyse densities of chimpanzees (Plumptre and Reynolds, 1994; 1996).

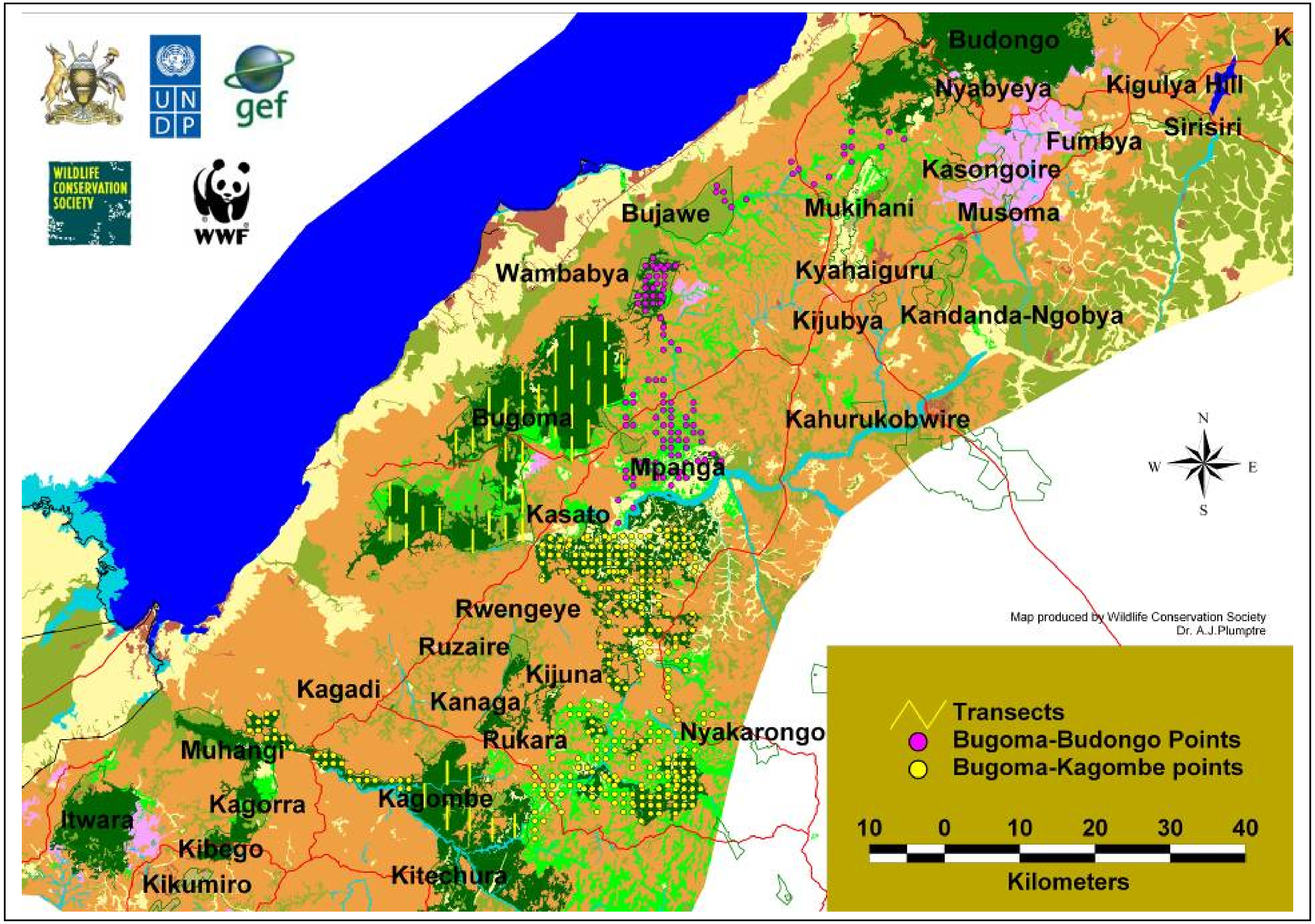


Figure 2. Locations of survey points surveyed in the small CFRs and private forests together with transects (yellow lines). Pink points are sites that were surveyed with funding from JGI and CSWCT and reported here, yellow points and transects were surveyed with UNDP/GEF support (Plumptre *et al.* 2010).

Finally people living in households next to the forests were asked about the species they have observed in the forests and lists were made for each village of these species. A mammal guide (Kingdon, 1997) was used to make sure people's identifications were correct.

3.2. Birds

Point counts of all bird species were made at each sampling point. Two experienced ornithologists who know forest bird calls would visit each point, wait 2 minutes for the birds to settle down and then count all birds seen or heard at the point estimating the distance from the point centre to the bird in distance categories (0-10m, 10-20m, 20-50m; 50-100m; 100-200m, 200-500m).

Additionally all sightings of "corridor birds" (table 1), species for which corridors may be important for populations, were recorded if observed or heard when moving along the recce lines between points.

Bird richness data were analysed using Biodiversity Professional, software developed by the London Museum of Natural History using rarefaction calculations, calculation of Shannon Wiener and Log-Alpha diversity indices and clustering bird communities in different forests or forest types.

Table 1. List of bird species that may need ecological corridors in the Northern Albertine Rifts to maintain viable populations

No.	**Species name**		**Conservation status**	**Comments/Remarks**
	Common name	**Scientific name**		
Large birds of prey (osprey, vultures, hawks, eagles etc)				
1.	African Crowned Eagle	*Stephanoaetus coronatus*	R-VU	Predominantly a resident of thick forest or large forest patches. Confined to the forested regions of S and SW where is sometimes common up to 4,000m
2.	Ayres's Hawk-Eagle	*Hieraaetus ayresii*	R-VU	Habitat: resident of woodland and forest, found mainly below 1,500m but occasionally up to 2,300m, considered to be very scarce in the W Uganda forests. Little-known, and probably genuinely scarce
3.	Cassin's Hawk Eagle	*Spizaetus africanus*	Reported as being uncommon and there are few recent records	Resident of dense forest, mainly below 1,500m
Large Frugivores				
4.	Black and White Casqued Hornbill	*Ceratogymna subcylindricus*	Relatively common	Needs mature trees to nest in
5.	White-Thighed Hornbill	*Ceratogymnas cylindricus*	G-LR/nt	The race *albotibialis* of equatorial forests to the W of Uganda, and reaches 1,150 m in the medium-altitude W Uganda forests. There several recent records from Budongo forest.
6.	All tauraco species			
7.	African Grey Parrot	*Psittacus erithacus*	Collected for pet trade	Need forest but fly out to sites around
Falcons and smaller birds of prey				
8.	Greater Sparrowhawk	*Accipiter melanoleucas*		Found in forest

9.	Lesser Sparrowhawk	*Accipiter minullus*		Found in forest
10.	African Goshawk	*Accipiter tachiro*		The race *sparsimfaciatus* is a resident of wooded areas and forest edge. It generally occurs in moister areas up to 2,000m, notably in the S and SW, from the forests of W Uganda to Kampala gardens with large trees but usually avoids drier, more open places
Understorey/Riparian species				
11.	Pel's fishing-Owl	*Scotopelia peli*	R-VU uncommon/rare owl	Found near rivers up to 1,700 m, especially in clumps of large riparian trees with branches overhanging the water, which provide dense shed and riverine forest.
12.	Rufous-sided Broad Bill	*Smithornis rufolateris*	Is less wide spread than the African Broad bill with which it forms a super species	The race *budongoensis* occurs only in primary forests clustered around L Albert-Bugoma, Budongo and Bwamba where it inhabits dense undergrowth
13.	Common Pitta	*Pitta angolensis*	Noted infrequently	It occurs in dense understorey vegetation and thick tangles of climbers in medium-altitude forest up to 1,400m.
14.	Green-Breasted Pitta	*Pitta reichenowi*	Noted infrequently	It occurs in dense understorey vegetation and thick tangles of climbers in medium-altitude forest up to 1,400m. There have been only 4 records since the 1960's, all from the forests of the west.
15.	Green-Tailed Bristle Bill	*Bleda eximia*	Common in Bwamba Forest but, elsewhere it is local and uncommon	It inhabits the understorey, often near ant trails; the race *ugandae* is confined to the medium altitude forests of Bwamba, Bugoma and Budongo.
16.	Nahan's Francolin	*Francolinus nahani*	G-EN, RG-VU.	Habitat: Confined to dense, mature, moist, sometimes swampy medium-altitude forest below 1,500m, Quite common in Budongo and Mabira forests.

Key: G-EN - globally endangered; G-VU - globally vulnerable; G-LR/nt - globally lower-risk, near threatened; R-EN - regionally endangered; R-VU - regionally vulnerable; R-NT - regionally near-threatened;

3.3 Trees and shrubs

At each sampling point in the CFRs and private forests a 20 metre radius circular plot was established with nested circular plots centred on the centre of the main plot. The following measurements were taken:

0-2m radius: Trees/shrubs >1 m tall and less than 4.9cm DBH
0-5m radius: Trees/shrubs 5-9.9cm DBH
0-10m radius: Trees of 10-29.9cm DBH
0-20 m radius: Trees 30cm+ DBH

The name of the tree, the DBH, the height to the first branch and the height to the top of the canopy in metres were measured and recorded.

Tree and shrub richness data were analysed using Biodiversity Professional, software developed by the London Museum of Natural History using rarefaction calculations, calculation of Shannon Wiener and Log-Alpha diversity indices and clustering bird communities in different forests or forest types.

4.0 Results

4.1. Large and medium-sized mammals

4.1.1. Recce walks and transects- mammal locations

A total of 94.0 kilometres of recces were walked in the small CFRs and private forests (figure 3). These recces covered most of the remaining forest fragments in the corridor areas identified in figure 1.

Figure 4 gives the encounter rates of primates observed on the recce walks. This shows that in the area surveyed the Uganda mangabey (*Lophocebus ugandae*) an endemic species to Uganda was only observed in Bugoma CFR and in some forests to the immediate east of Bugoma. Black and white colobus (*Colobus guereza*) were observed throughout the corridor forests east of Bugoma as well as redtail monkeys (*Cercopithecus ascanius*). Nests of chimpanzees (*Pan troglodytes*) were distributed more patchily in the blocks of forest in the corridors, mostly in small CFRs, but were more common in the main forest block of Bugoma. Blue monkeys (*Cercopithecus mitis*) were very rarely observed as was the case in 1999 and only occurred in one of the corridor forests we surveyed.

When local community members were asked which mammal species they observed in their forests most listed the primates in figure 4 with the addition of vervet monkeys and baboons. A few also listed a red duiker (probably *Cephalophus callipygus weynsii*) as well as bushbuck (*Tragelaphus scriptus*) and crested porcupine (*Hystrix cristata*). There were far fewer large mammal species identified by community members in comparison with the corridor forests surveyed to the south of Bugoma. This shows how affected these forests have been by human activities to date and that there is little time left to save what remains.

A map of the location of human impacts on the forests were made using the sighting data (figure 5). Encounter rates of signs of logging (pitsaw sites, felled trees and planks of timber) and the other of poaching sign (snares and pitfall traps) as well as encroachment for farming show that while signs of poaching are sparse, felling of trees for timber is rampant throughout the region (figure 6). In addition encroachment of the forests surveyed between Bugoma and Budongo CFRs was significant in the forest reserves here, more so than in the forests to the south of Bugoma.

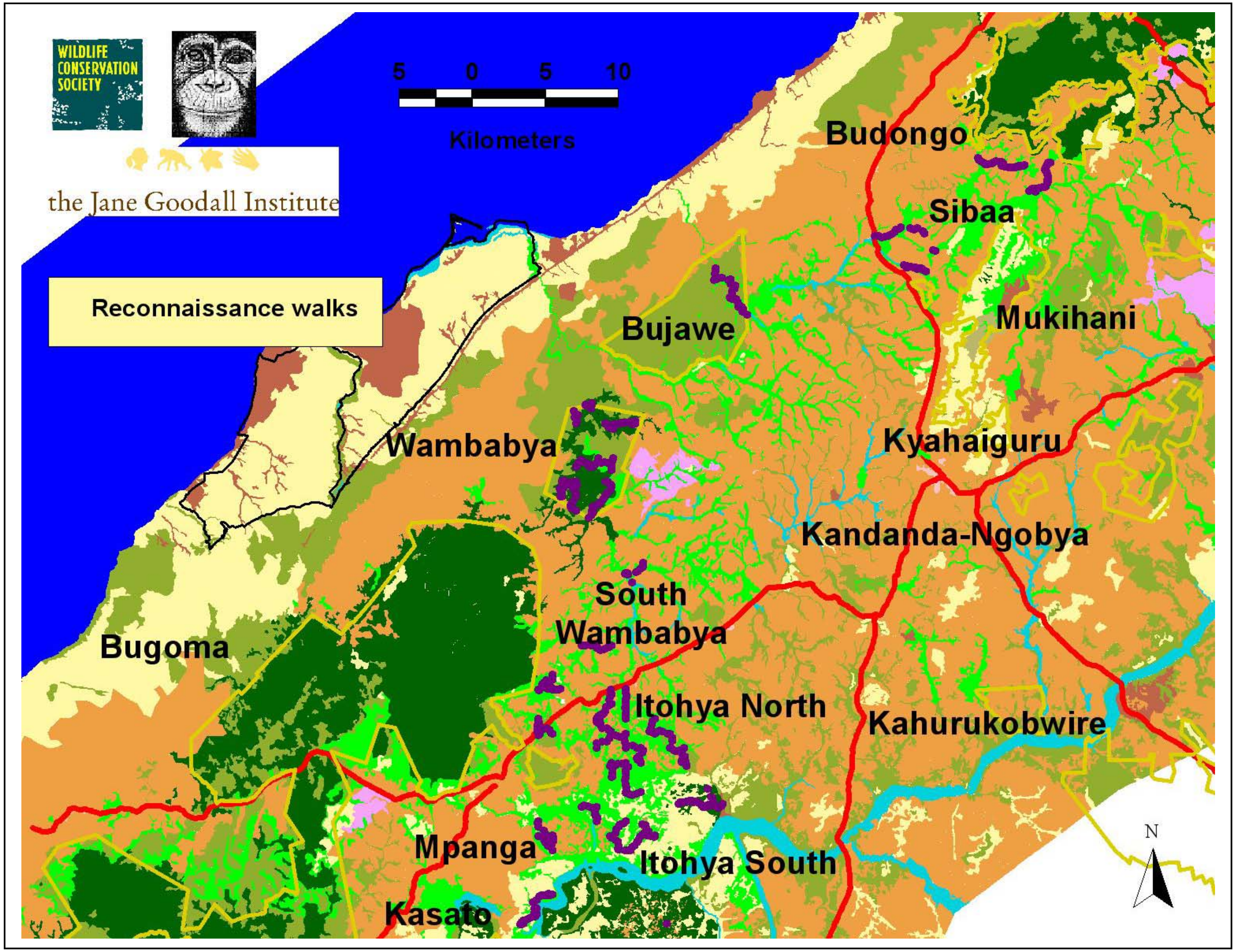


Figure 3. Areas surveyed (purple lines) on recce walks in the small CFRs and private forests.

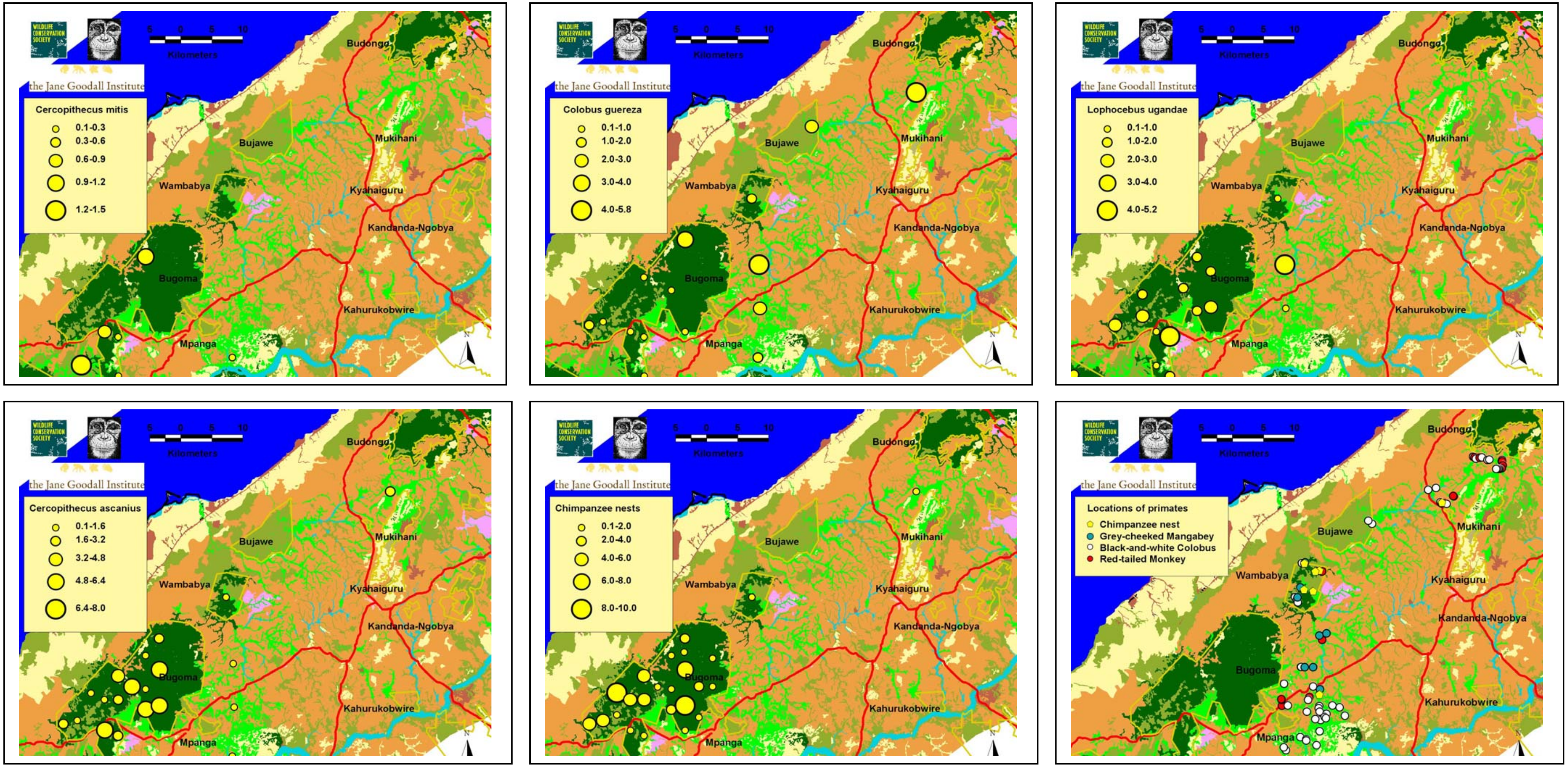


Figure 4. The relative encounter rates per km of reconnaissance walk blue monkeys (top left), guereza colobus (top centre), Uganda mangabey (top right), redtail monkey (bottom left) and chimpanzee nests (bottom centre). The locations of sightings of groups of the common species are given bottom right.

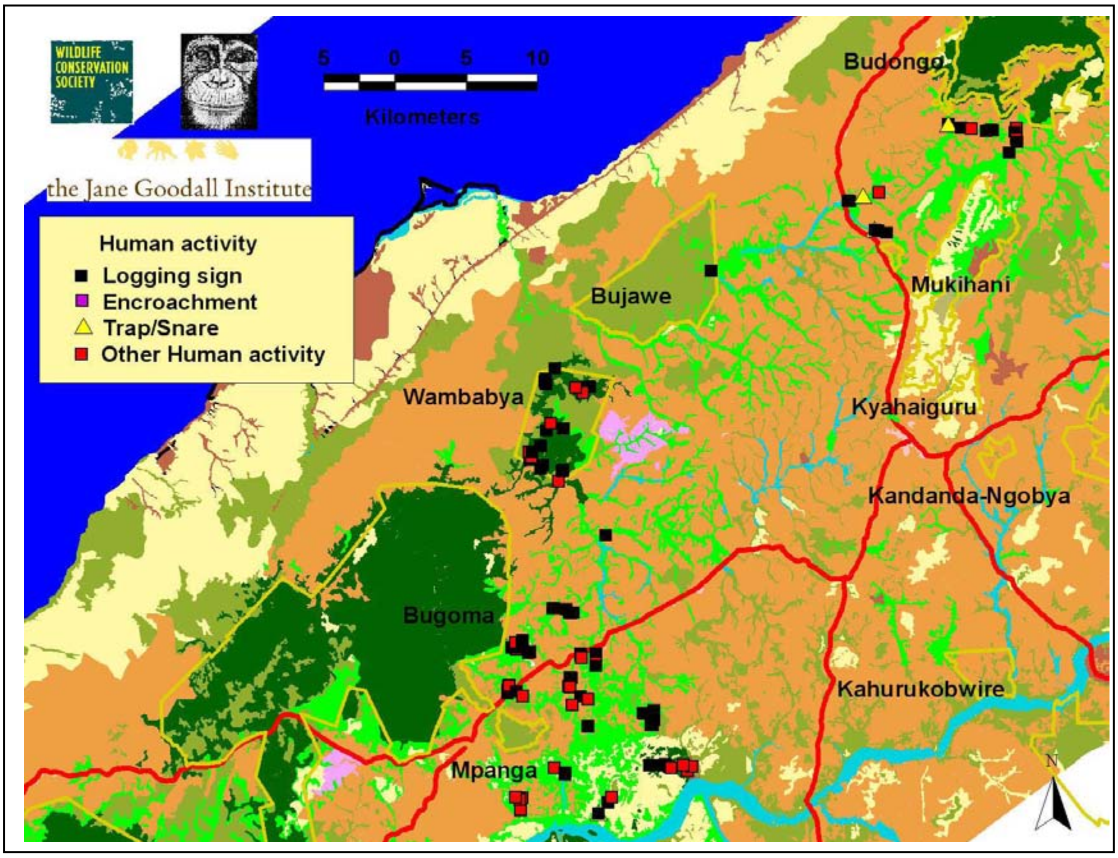


Figure 5. Locations of sightings of indices of human impact.

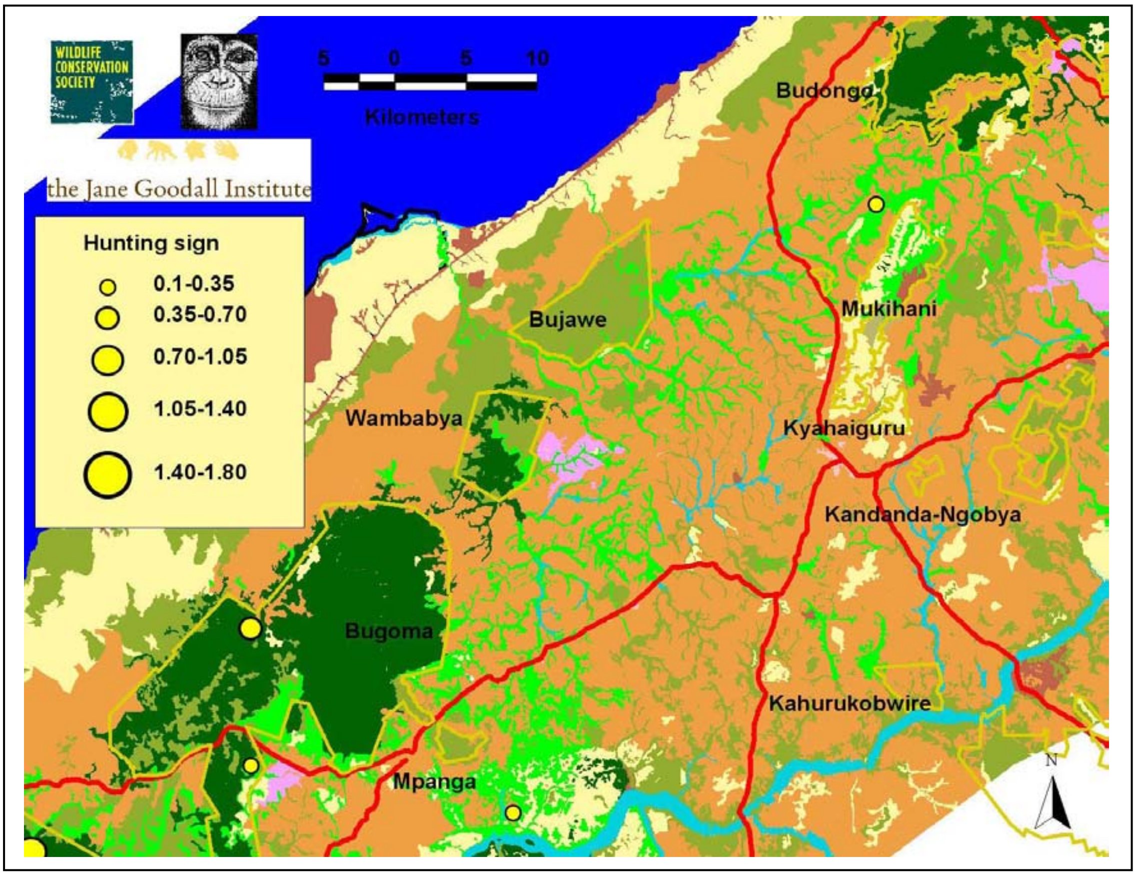
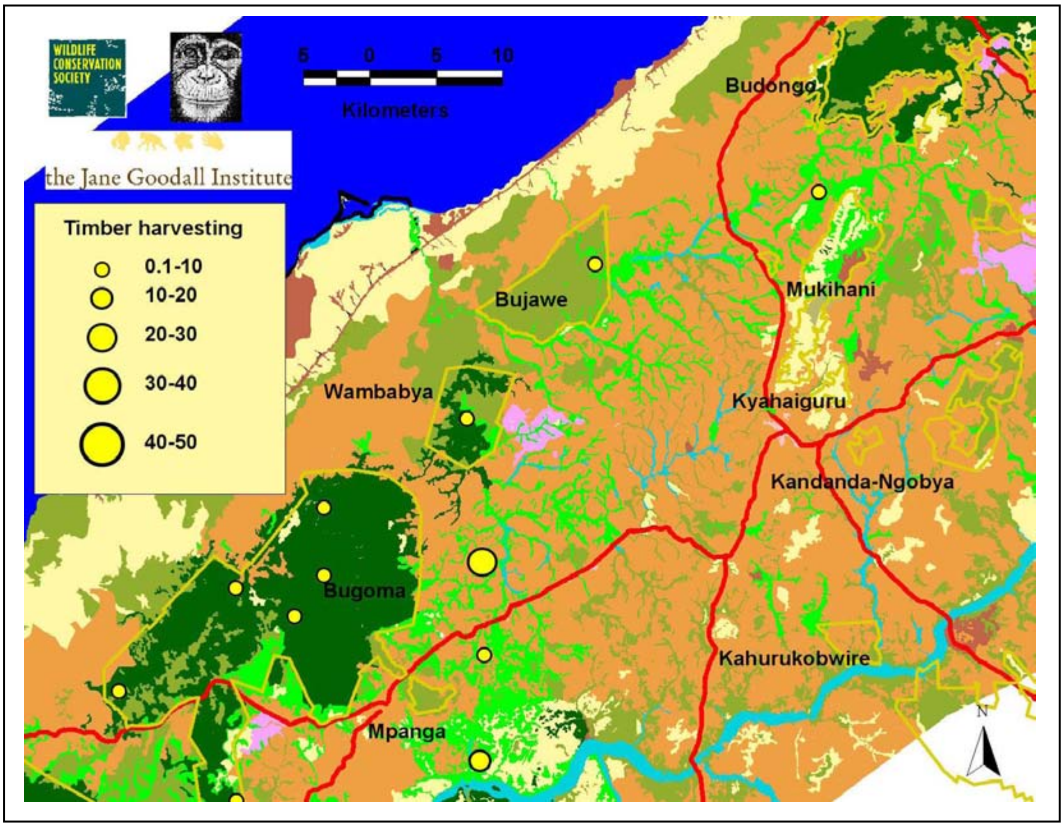


Figure 6. Encounter rates of hunting sign.



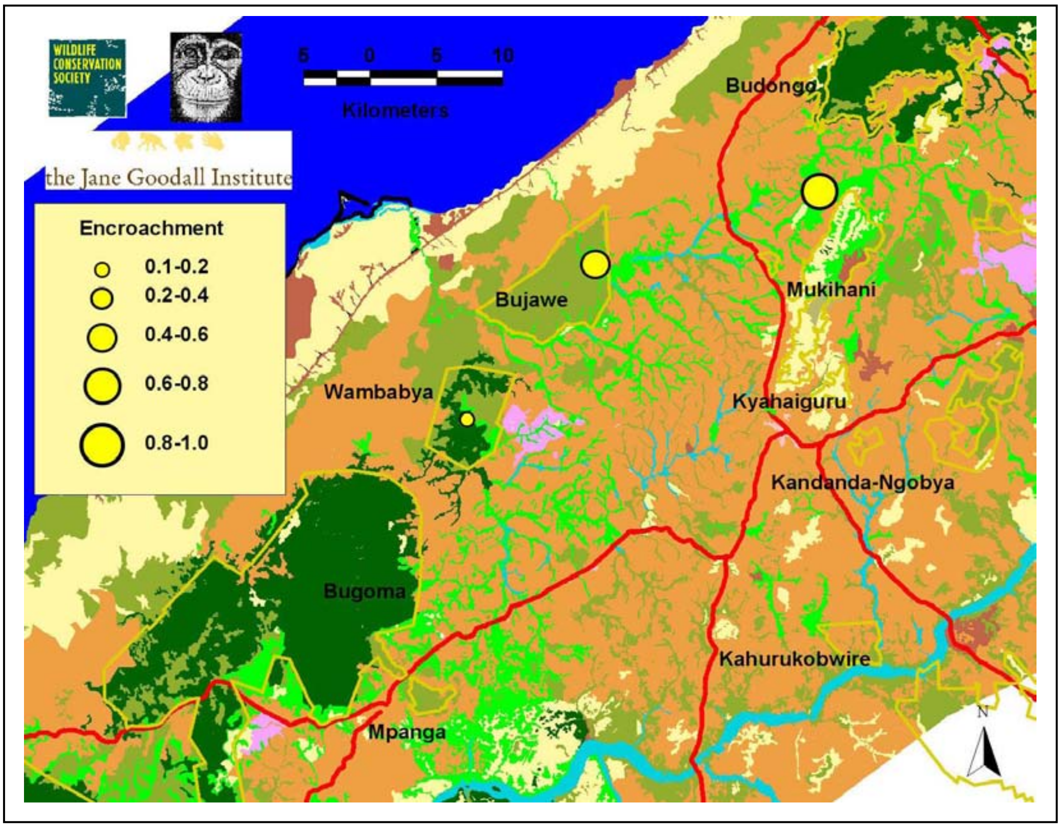


Figure 6 contd. Human threat encounter rates per km walked for poaching/hunting sign (previous page); logging/treefelling sign and encroachment.

4.2. Birds

4.2.1. Species richness

A total of 228 bird species were recorded in the combined surveys in the corridors south and east of Bugoma CFR. 170 species were observed in the areas surveyed in this study to the East of Bugoma CFR. This compares favourably with the 221 species that have been recorded for Bugoma CFR (Plumptre *et al.*,2007) and 121 for Kagombe CFR (Howard and Davenport, 1996). Species richness was higher in the smaller corridor forests (figure 7) than in Bugoma CFR which initially was surprising. Sibaa and Itohya north regions were particularly rich.

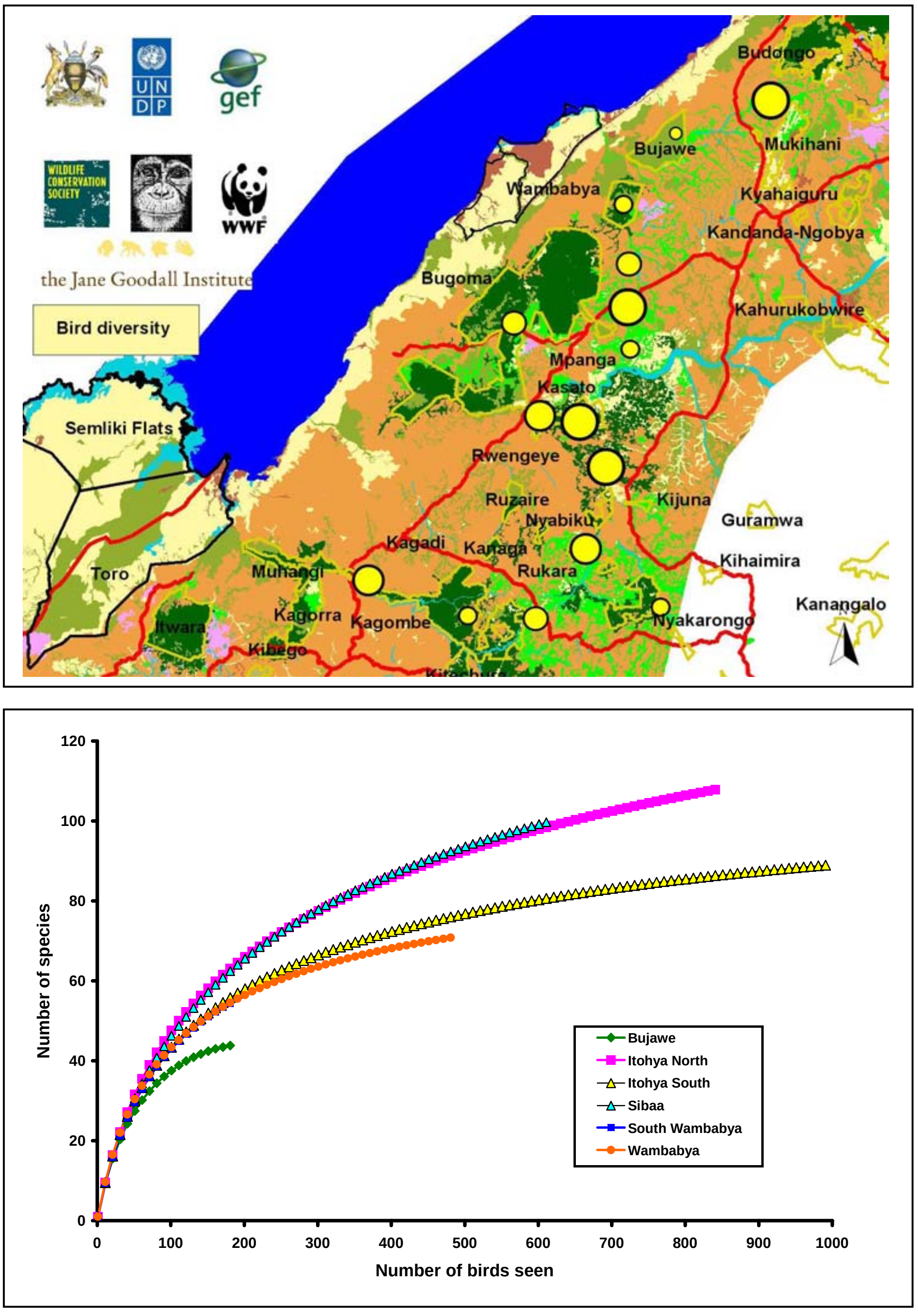


Figure 7. Relative species richness by site (top) and rarefaction curves of these same sites (bottom).

However if the types of birds are examined that are found in these forests we find that fewer of them are forest specialists and more are forest generalists or non-forest species (table 2). Apart from Wambabya forest and the corridor forest to the south of Wambabya all other forests to the east of Bugoma CFR are poor in forest specialist and dependent species.

Table 2. The percentage of Forest specialist (FF), Forest dependent (F), forest generalist (f) and non-forest species (produced by Makerere University Biodiversity Databank, Kampala for East African Birds) for each region surveyed. Pink forest were those surveyed for this study while the others were surveyed under the UNDP/GEF project.

Forest	FF	F	f	Non-forest	FF+F
Nyakarongo	15.15	36.36	34.85	13.64	51.52
Kasato	15.04	31.86	34.51	18.58	46.90
Bugoma	13.71	33.06	38.71	14.52	46.77
Kagombe-block	14.47	28.95	40.79	15.79	43.42
Rukara-Muhunga	16.67	26.39	43.06	13.89	43.06
Rwengeye-Kyamurangi	10.00	25.71	41.43	22.86	35.71
Muhangi-Kagombe	11.25	22.50	46.25	20.00	33.75
East of Kagombe	14.29	19.05	42.86	23.81	33.33
Kijuna-Nakuyazo	13.08	19.63	43.93	23.36	32.71
Bujawe	0.00	9.09	52.27	38.64	9.09
Itohya North	10.17	20.34	39.83	29.66	30.51
Itohya South	8.99	21.35	43.82	25.84	30.34
Sibaa	7.00	20.00	34.00	39.00	27.00
South Wambabya	14.55	23.64	41.82	20.00	38.18
Wambabya	18.31	38.03	29.58	14.08	56.34

Comparison of the bird community by site using a Jaccard cluster analysis showed that the bird community in Itohya North and South were similar in species composition while Bujawe is the most dissimilar (figure 8). This is not too surprising as Bujawe is mainly a woodland forest reserve and not a tropical high forest.

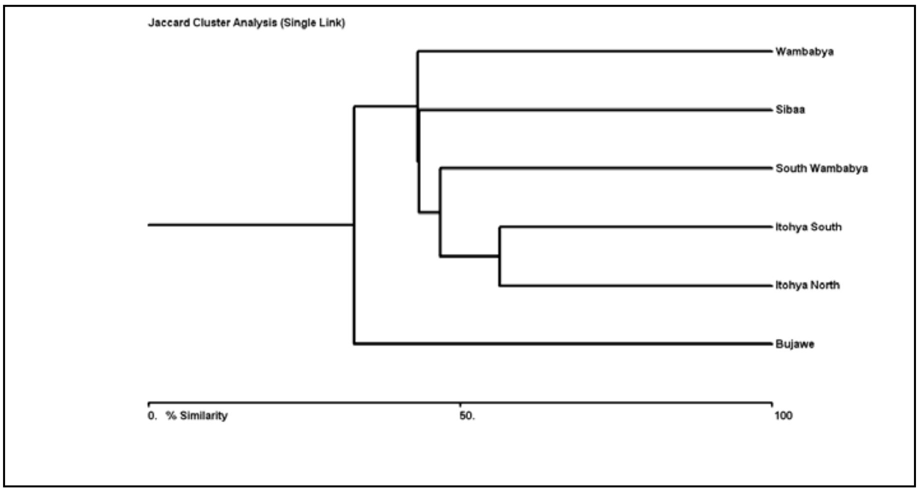


Figure 8. Jaccard cluster analysis of bird species composition in the forest blocks in the corridors east of Bugoma CFR.

If we compare the similarity of all corridor areas together with Bugoma CFR we can see that Sibaa, Bujawe and South Wambabya are the most dissimilar sites in terms of bird species composition (Figure 9). Table 2 shows that Sibaa and Bujawe have nearly 40% of bird species as non-forest species and this highlights why they are so different.

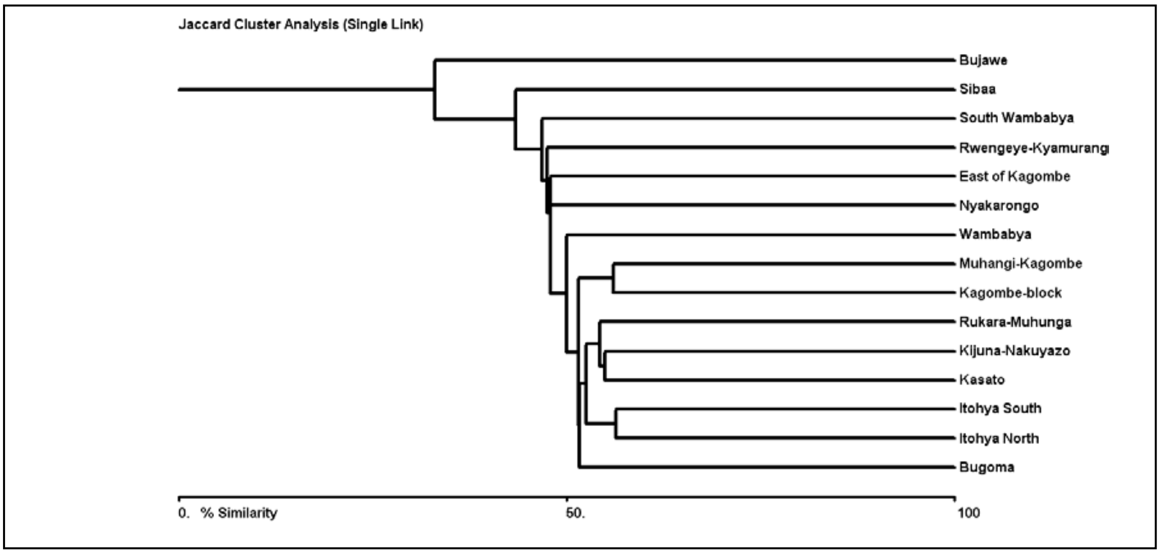


Figure 9. Jaccard cluster analysis of bird species composition in all the forest blocks surveyed in the Murchison-Semliki Landscape.

4.2.2. Corridor and threatened species

Those species that were considered to require the forest corridors were mapped separately (figure 10). These included the hornbills, tauracos, forest raptors (small and large), and understorey species that migrate such as pittas. The majority of these observations were of tauracos and hornbills but a few raptors (greater and lesser sparrowhawks, crowned eagles and African goshawks) and green pittas (*Pitta reichenowi*) were recorded.

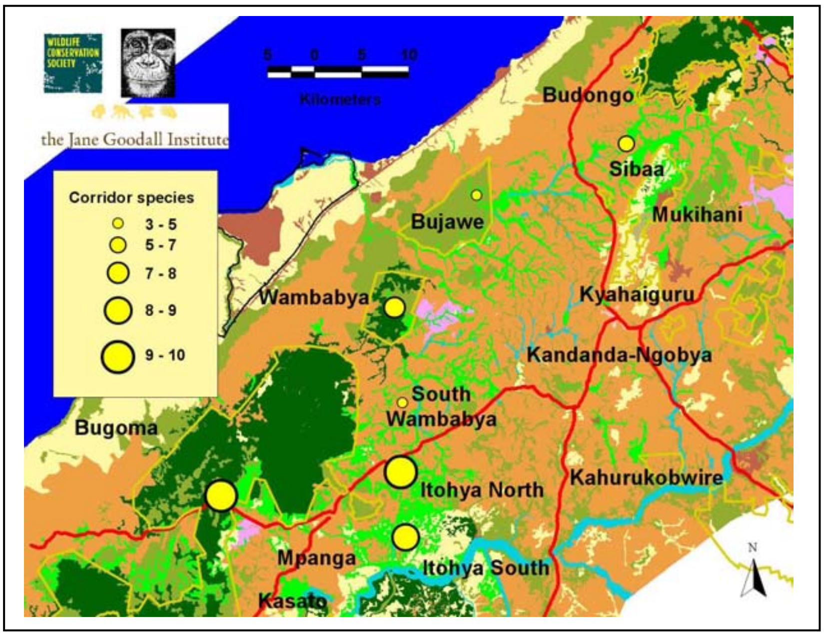


Figure 10. The relative abundance of bird species thought to require linkages between populations in the larger forest blocks (corridor species).

Species classified as threatened by IUCN (Critically endangered, endangered, vulnerable and near threatened) were identified. These species were only found in Bugoma and Kagombe CFRs as well as the Itohya region and included the endangered Nahan's francolin (*Francolinus nahani*) which was only found in Bugoma and the near threatened Grey Parrot (*Psittacus erithacus*) also seen in Bugoma and Itohya, and White-naped pigeon (*Columba albinucha*) seen in Kagombe CFR and a new species for this forest.

4.3 Trees and shrubs

4.3.1. Tree and shrub species richness

Ninety one 20 metre radius plots in the corridor forests to the east of Bugoma were visited although 28 of these turned out to have been converted to agricultural land. The data presented here are for the 63 plots that had some trees and shrubs. A total of 150 tree and shrub species were recorded which compares relatively well with 224 species recorded from Bugoma CFR (Davenport, Howard and Matthews, 1996). Tree species diversity (Fisher's alpha) was relatively high in Wambabya CFR and the Itohya region (figure 11). Combining the data from the surveys to the south and to the eats of Bugoma a total of 233 tree and shrub species were identified.

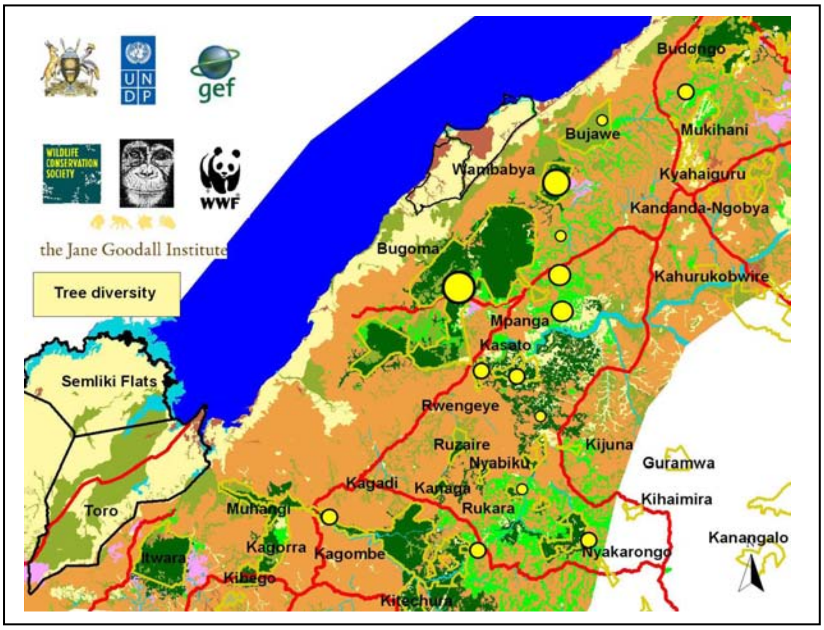


Figure 11. Tree and shrub diversity (Fisher's alpha) in Bugoma and the corridor forests to the east of Bugoma.

Species accumulation curves also show that Wambabya is much richer in species composition than the other forests regions (figure 12).

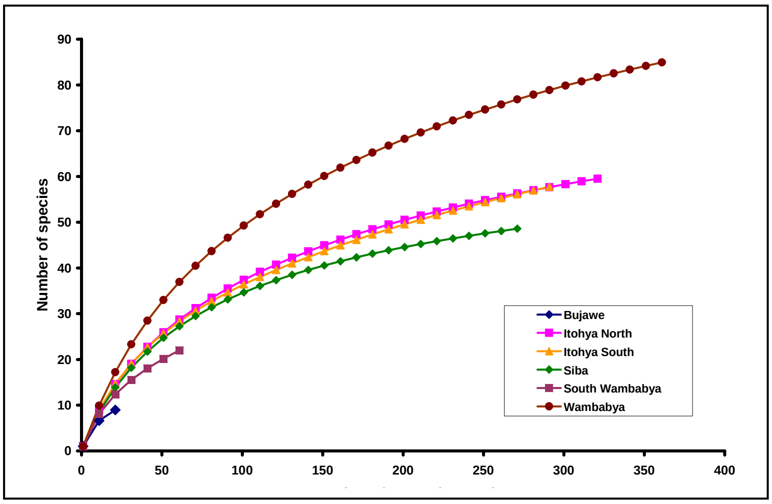


Figure 12. The rarefaction (accumulation) curves for each forest region in the corridors to the East of Bugoma.

Not surprisingly the species composition of Bujawe is most dissimilar to the other sites surveyed (figure 13), and it ranges between 4-10% similar to the other sites surveyed. This is primarily because it is a woodland reserve. South Wambabya is surprisingly different, however, with only 10-15% similarity in tree and shrub composition with the other sites. Comparison with all the other corridor forests surveyed under the UNDP/GEF project shows that Bujawe, South Wambabya and Siba regions are the most dissimilar in tree and shrub composition (figure 14).

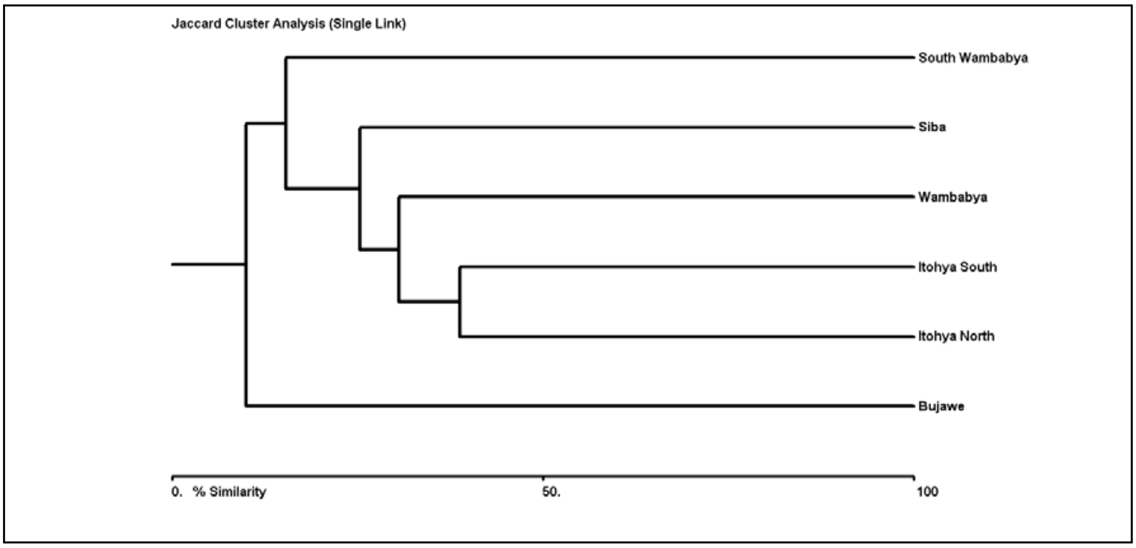


Figure 13. Cluster analysis using Jaccard's coefficient of similarity between the blocks of forest surveyed.

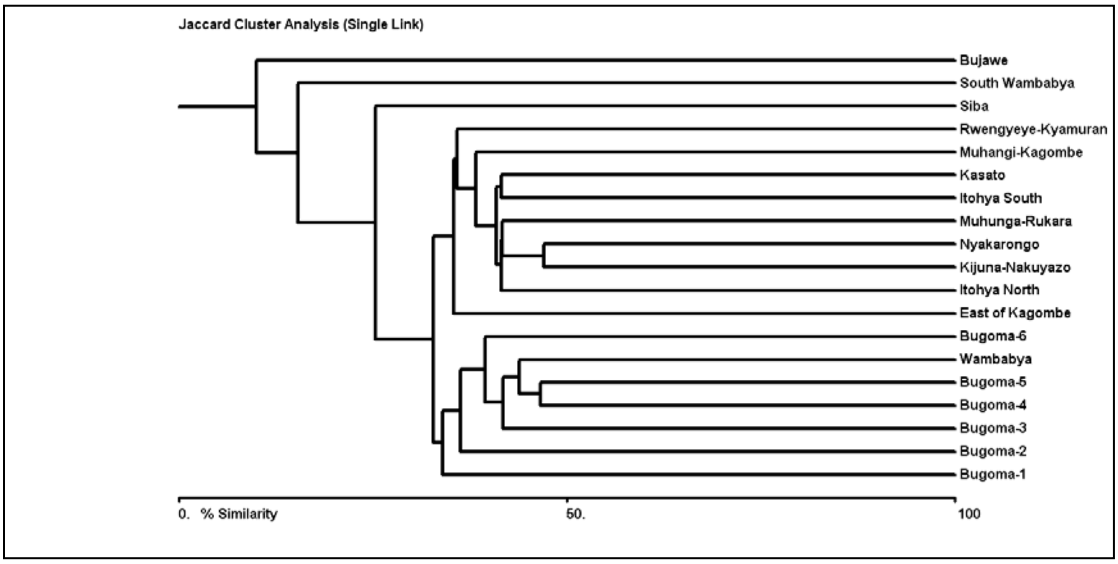


Figure 14. Cluster analysis of all corridor forest sites in the Murchison-Semliki landscape.

4.3.2. Carbon measurements

In each of the plots surveyed the diameter at breast height (DBH) of all tree and shrub species was measured to obtain an estimate of the availability of carbon. Although the details of the carbon measurements and the assessment of the feasibility to obtain REDD funding for these corridors is the subject of a separate report we present here the main findings about the carbon.

Carbon was calculated using one of the more recent equations that has been suggested:

Biomass of tree (tonnes) = $e^{(-2.9946 + 0.9317 \ln(DBH^2 \times \text{tree height}))}$
Biomass of CO_2 (tonnes)= (tree biomass/1000)x 44/12

The relative abundance of carbon at the plots shows that the largest amounts are in the Bugoma CFR and parts of Wambabya CFR and the Itohya region (figure 15). Most of the corridor plots though had low values.

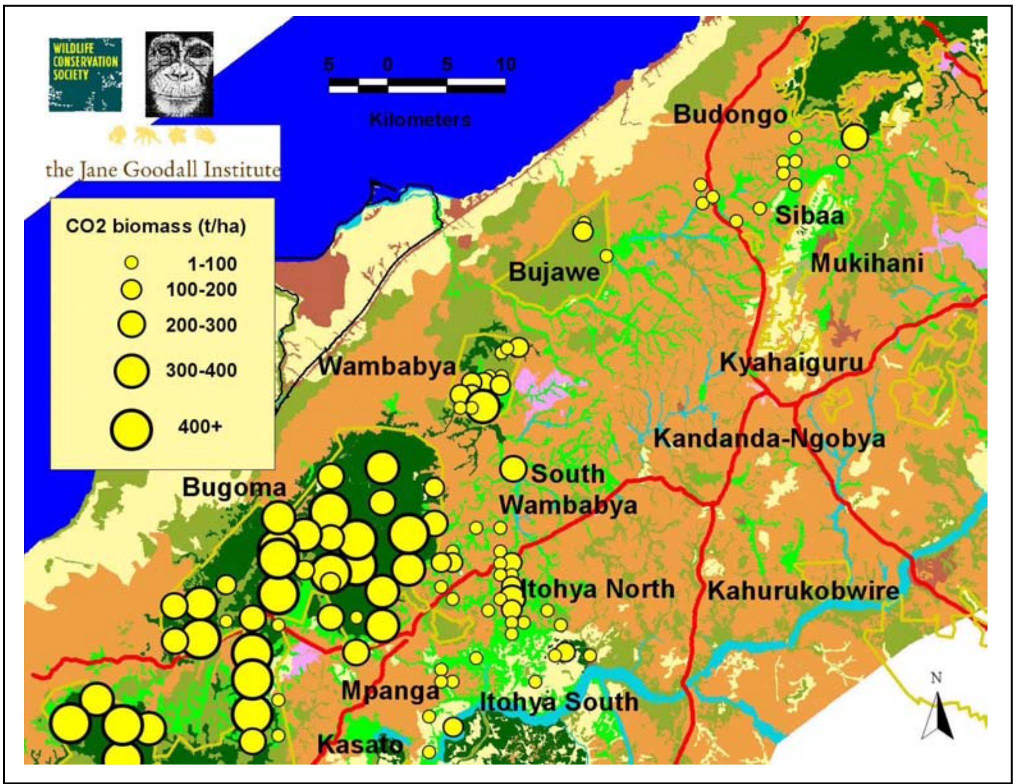


Figure 15. Measures of CO_2 biomass per hectare for the 91 plots measured in the corridor forests to the east of Bugoma as well as plots within Bugoma measured in the UNDP/GEF survey.

The average carbon biomass for Bugoma CFR, the eastern corridor forests and the southern corridor forests differ greatly (Table 3). The eastern corridor forests have a very low carbon value compared with Bugoma CFR. This means that it will be difficult to generate much funding by conserving these forests unless the additional CO_2 absorbed by the forest as it regenerates can be calculated and estimated as part of the REDD+ package.

Table 3. The mean biomass and standard error of CO_2 per hectare in the Bugoma CFR and the corridor forests to the south and south west of Bugoma (measured under the UNDP/GEF project) and to the east of Bugoma (this project).

	Number of plots	Mean tCO2e/ha	St. err. tCO2e/ha
Bugoma CFR	46	393	39
South of Bugoma	89	175	12
East of Bugoma	63	81	9

5.0. Biodiversity and the Conservation value of the corridor forests

This report summarises data collected on the large mammals, birds and trees in the Central Forest Reserves and connecting forest corridors on private land in Hoima, Biiso and Masindi Districts in western Uganda. In particular it assesses the conservation value of the forests and the value of maintaining the connectivity that still remains between the forest reserves. It also assesses changes that have taken place in large mammal and bird species abundances in the larger forest blocks in the landscape. We here summarise the main findings from the results presented above.

5.1. The importance of the forest corridors for biodiversity conservation

These surveys have demonstrated that the corridor forests are of conservation value. Species richness of birds in particular is reasonably high in these forests with about 17% of Uganda's birds. While this is partly due to the higher numbers of edge and non-forest species in the corridor forests, the number of forest specialist and forest dependent species were relatively high in the Wambabya and Itohya forests.

Notable species of conservation concern using these corridors included both threatened species such as Chimpanzee and White-naped Pigeon, as well as corridor species including Great Blue Tauraco, Black-billed Tauraco, Ross's Tauraco, Black and White Casqued Hornbill, White-thighed Hornbill, African Goshawk, African Crowned Eagle, Greater and Little Sparrowhawk, and African Grey Parrot. However, none of the understorey species identified as possibly needing the corridors were found in the corridor forests, although Nahan's Francolin and Green-breasted Pitta were recorded from Bugoma Forest Reserve.

Therefore many of the species that were identified as potentially requiring connectivity between forest blocks were recorded using these corridor forests. The main exception was the understorey species group. This is likely to be due to the much greater human impact on the corridor forests leading to forest degradation. At many of the sites we visited the forest had been degraded by harvesting large trees so that the forest canopy was not intact and there was a lot of understorey vegetation. This degradation is partly reflected in the lower carbon values calculated at the plots we surveyed in the corridor forests (figure 15). Understorey species require closed canopy and shade in the understorey and rarely will cross even small gaps in the forest or openings such as those caused by roads. It will be important to monitor understorey species in future in the larger forest blocks to determine if their numbers are declining.

Few threatened species were found in these corridors, however, and their value for these species is probably limited. However, if they can provide a corridor between larger forest blocks there is a potential for these threatened species to use them to move between the larger blocks. Only one individual needs to move per generation as a general rule and therefore this doesn't have to be very frequent in long-lived species such as chimpanzees.

Human impacts in the corridor forests were high, particularly for timber harvesting. Trapping of large mammals appears to be low which may be due to the fact that more people are making money from harvesting other forest products or because large mammal numbers have declined so much that hunting is not very productive any longer. However, Bugoma CFR appears to be under better management now with much less illegal activity than in 1999.

Other CFRs were also being heavily affected by people and while the field teams were surveying many forests were in the process of being converted. Nangendo, Plumptre and Akwetaireho (2010) estimated that over 300 km^2 of forest had been lost in the Murchison-Semliki landscape between 2000 and 2006 and recent estimates for the same region between 2006 and 2010 indicate that another 150 km^2 has been lost. Therefore in the past 10 years an area greater than Budongo Forest Reserve has been lost to agriculture in this landscape. Despite this threat there are still species using these forests as corridors between different forest blocks but they are becoming increasingly isolated and fragmented.

5.2. Conclusions

The results of these surveys show that the corridor forests east of Bugoma CFR are rich in biodiversity, they contain many of the species that may require connectivity to remain viable in the larger forest blocks, and they are likely to be playing a functional role in terms of connecting meta-populations of these species. There is a need to find incentives for land owners who have forest on their land in the corridors to conserve these forests in order to maintain these functional roles.

Carbon funding through the REDD+ process may provide one incentive to landowners in the corridor region to conserve forest on their land. WCS is currently working on developing a feasibility analysis for REDD+ in this region under contract to WWF with the UNDP/GEF project for the Conservation of Biodiversity in the Albertine Rift Forests of Uganda. Given the biodiversity identified during these surveys it is likely that any REDD project that aims to provide incentives to conserve the forest should be able to add a premium to the price of the carbon because of the biodiversity found here. The idea of selling carbon at a higher price for forest with high biodiversity is yet to be accepted fully but it is a concept that is currently being discussed in international fora. The survey data summarized here will be used in the REDD+ feasibility assessment that WCS is making to assess its potential to promote a premium to be added to the price of carbon. The carbon values found for these forests were lower than the larger forest blocks and the corridors to the south of Bugoma but still have the potential to generate some funding. If the corridor forests could be conserved to a point where the structure of the forest recovers to a more intact nature and the carbon biomass increased as a result then it is likely that farmers could receive significantly more funding provided a mechanism to measure the absorption of carbon can be used to increase the price per hectare of forest conserved.

These corridor forests are disappearing quickly, however, and if these findings are not acted upon soon there will be little corridor forest left to conserve and most of these species will become extinct in this region. There is a need for the Ministry of Water, Energy and the Environment, the District Environmental offices and the National Forest Authority to move ahead quickly with the national REDD processes to enable these corridor forests to receive funding as soon as they can to offset the current incentives to destroy the forest for agriculture.

Acknowledgements

We are grateful to the National Forest Authority and to the owners of private forest in the corridors for permission to undertake the surveys reported here. We are also grateful to the Chimpanzee Sanctuary and Wildlife Conservation Trust, Jane Goodall Institute and Wildlife Conservation Society for financing the work. We would like to thank all the field assistants, cooks and porters who worked on the surveys.

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