ASSESSMENT OF CORRIDORS IN THE MURCHISON-SEMLIKI LANDSCAPE

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Executive Summary

The Wildlife Conservation Society (WCS) was supported Ander a subcontract from WWF and UNDP/GEF to undertake an assessment of corridors in the Murchison-Semliki landscape. This project will take about a year to complete and this report summarises the achievements of the first two months of work.

The process of assessing the corridors is a twofold process which involves using GIS and Satellite imagery to model the needs of different types of species and then to ground truth the modeling results and to assess the feasibility of creating corridors in different areas of the landscape.

Ecological corridor modeling

WCS took the draft land cover/use map of the Murchison-Semliki landscape developed under the USAID Prime/West project and undertook an assessment of forest loss between 2000-2006 with the help of Woods Hole Research Center. This assessment of forest loss indicated that 308.43 km^2 of forest had been lost in the landscape over this time period, most of it outside protected areas. It is therefore critical that conservation actions are taken quickly to conserve what remains of forests on public land in this region.

We identified eight groups of species (5 forest and 3 savanna) which probably require the continued existence of corridors in the landscape to maintain viable populations. This is because they occur at low densities or are rare and hence their populations are not large in any of the major forest blocks such as Budongo and Bugoma. Requirements for movements in several landscape features for these eight groups was determined by WCS staff and circulated for comment. The final requirements were then modeled with an ARCGIS add-in tool, CORRIDOR DESIGNER (Beier et al. 2008) to assess the optimal routes for movements by the eight groups. Preliminary results of these models are presented here.

Biodiversity and socio-economic surveys

There is a need to ground-truth the modeled corridors to assess a) whether the species identified in the eight groups are currently using the corridors and b) whether people living near the proposed corridors would be willing to help conserve them if some incentive could be given.

To this end WCS designed some survey methods to meet the following three objectives:

- Assessment of the corridor forests for species of birds and mammals that occur at low densities and may need the corridors to reach viable population levels
- Establishment of forest plots to estimate and monitor forest carbon emission reductions under the proposed Reduced Carbon Emissions from Deforestation and Forest Degradation (REDD) financial incentive scheme
- Assess local people's uses of the forest corridors and their willingness to conserve the corridors and an estimate of what it might cost them to do so using socioeconomic surveys

Biodiversity and socio-economic studies were carried out by a team of 12 WCS Research Field Assistants in and around Kasato Central Forest Reserve in Kibaale District, from December 15, 2009 – January 20, 2010. These surveys aimed to pilot the methods and assess whether they would generate the types of information required. The team assessed Kasato forest reserve and the neighboring communal/private forest patches for biodiversity (birds, mammals, trees) and socio-economic values between Dec 15th and Dec 20th. Camera trapping continued up to January 20, 2010.

1. MAPPING THE MURCHISON – SEMLIKI LANDSCAPE

Objective: Create a land cover/use map of the Murchison-Semliki landscape.

Method

ASTER images of 2006 were used for the map preparation (Appendix 1). For a few areas where the 2006 images were not available, mainly around Bugoma forest, 2005 images were used. The images varied in season of the year, which rendered it impossible to make a mosaic that could be used for automated vegetation cover classification. A method that involved physical delineation of the vegetation cover classes had to be developed. Since we were not familiar with all the vegetation cover types that exist in the study area, it was agreed that an already existing vegetation cover map be used as the baseline map. The 1995 land cover/use map made by the Biomass Department of NFA, Uganda, was used as the baseline map for adjusting boundaries where the vegetation cover had changed.

The method used for adjusting the boundaries involved on screen digitizing and renaming areas that had changed from one vegetation cover class to another. The biomass map was overlaid on the ASTER image, boundaries of the different vegetation cover classes were examined for possible changes and areas that had changed were then digitize off. A clip of the map boundaries before and after adjusting is shown below (Figure 1 (a) and (b)).

(a) (b)

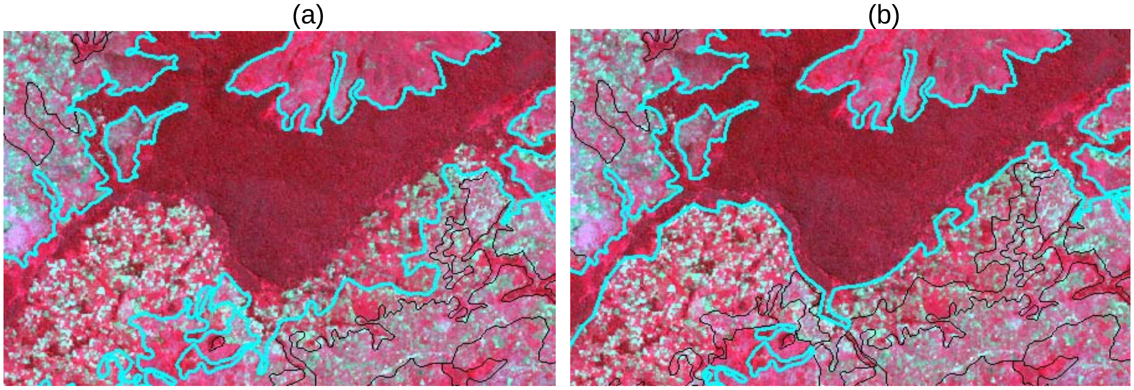

Figure 1: (a) The light blue (highlighted) line shows the 1995 map boundary for the “Tropical High Forest, fully stocked”. Interpreting the background ASTER image, the dark red part shows the area that still holds the fully stocked tropical high forest and the mixed color (spotted) area is the Subsistence farmland. (b) Corrected forest cover boundary: the highlighted boundary (light blue) now passes at the very edge of the Tropical High Forest, fully stocked (deep read on the ASTER image).

To ensure consistency of areas delineated as a specific class, say forest, the principle investigator made a reconnaissance trip to most of the major conservation areas in the Murchison-Semliki landscape. Along the way and within the conservation areas she took GPS readings and recorded the vegetation type at each GPS point. At the office, these points were overlaid on a combination of the ASTER images and the biomass map to check for consistency in vegetation class identification. Thereafter, using the field knowledge and personal experience in image interpretation, she was able to accurately differentiate between vegetation classes on the ASTER images. The final map generated is shown in Figure 2 below

The land cover map was generated under the USAID Prime/West Project.

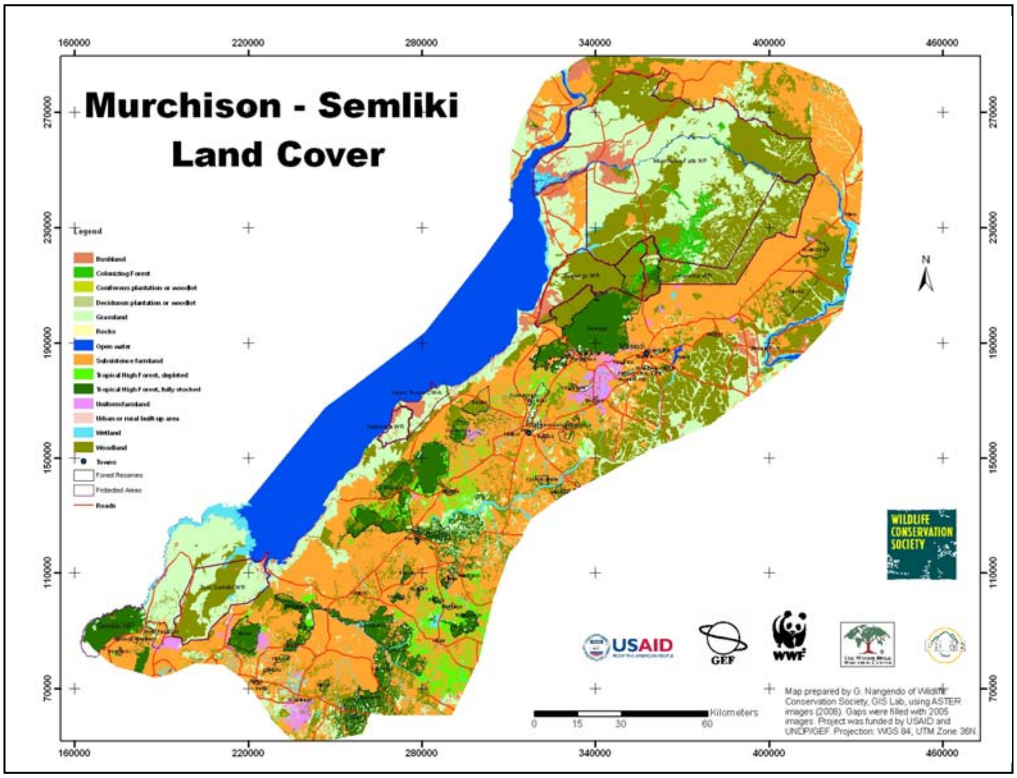

Figure 2: Land cover map of the Murchison Semliki-landscape.

Accuracy

To validate the classification output, aerial photographs and a field visit for ground truthing were used. In March 2007, aerial photographs of parts of the classification output that needed validation were taken. After using the photographs to correct some of the areas, a field visit where most of the remaining areas that were in question was carried out. Because of the vastness of the classified area, there are still a few areas, e.g. the area south of Lake Albert, that were not visited. We have therefore calculated an accompanying certainty map (Figure 3). The certainty map is divided into 3 classes (0-50%, 50-80% and 80-100%). The areas with critically low certainty values are the ones with the 0-50% range.

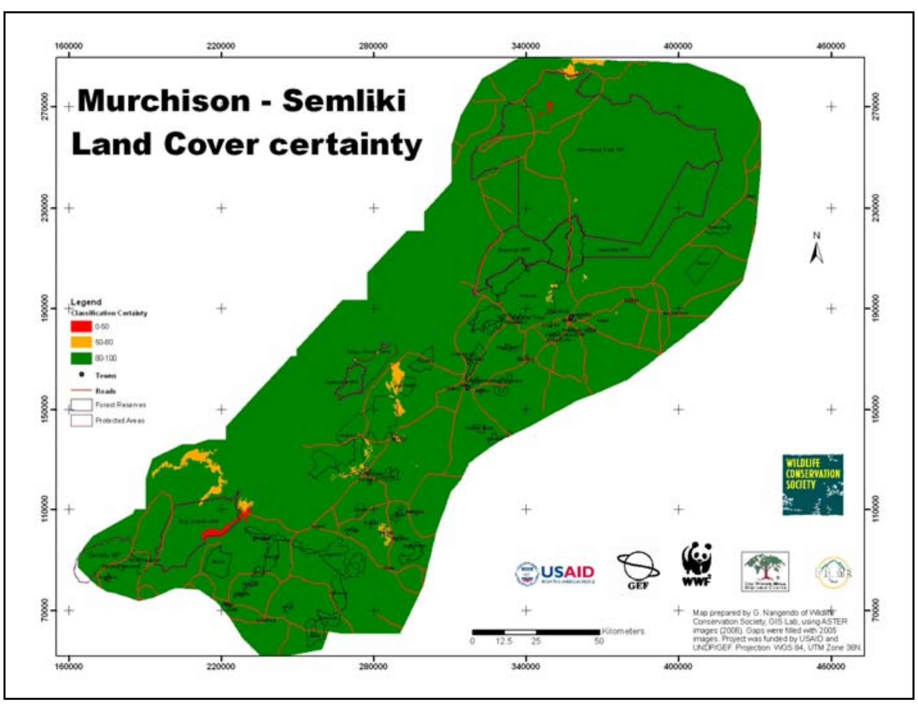

Figure 3: The certainty map showing the levels of classification confidence of the land cover/use map. The areas of lowest confidence levels have values between 0-50% and areas of highest confidence levels have values between 80-100%.

Measurements were made of the amount of forest remaining for corridors if the existing laws of Uganda were to be enforced along rivers and streams using this landcover map and the hydrology GIS layer that is available for this region from NFA/Biomass Department. If the law was enforced to maintain a buffer along large and medium sized rivers within the Murchison – Semliki landscape, 1,387 km^2 of forest/ woodland would be conserved. Of this, 968 km^2 of the buffer is outside protected areas.

In addition we measured the amount of forest on private/government land outside protected areas which totals 1,435 km^2 in 2006. This forest is rapidly disappearing as was measured in the next section of this report and there is likely to have been continued loss since 2006 to the present.

Forest cover changes

In this study we used remotely sensed data from the Landsat GeoCover data set (Tucker et al., 2003), and Gap filled SLC OFF Landsat images with a spatial resolution of 28.5 meters. A combination of multispectral transforms of brightness, greenness, wetness (Crist and Cicone, 1984) for the year 2000 and change in brightness, greenness and wetness (Collins and Woodcock, 2003) between 2000 and 2005 data served as input to a supervised neural network classifier to map land cover and land cover changes. A total of 4 two dates Landsat scenes were individually classified to identify land cover and forest change. For each of the scenes a representative set of training sites was visually identified for each of the land cover and land cover change classes and used to train a neural network classification algorithm (Carpenter et al. 1997). The neural network assigns a land cover or land cover change class to each pixel in the dataset. These per-pixel classification results were then aggregated in polygons via image segmentation (Woodcock and Harward, 1992). The segmentation processing groups neighboring pixels into regions (or polygons) on the basis of their spatial location and spectral similarity. A minimum mapping unit of approximately one hectare (11 pixels) was used. The goal of using a minimum mapping unit larger than the spatial resolution of the data is to minimize confusion in the identification of land cover change resulting from minor misregistration of the two dates of imagery. The final results were visually inspected and edited to remove some of the errors in the forest change class. The methods used in this analysis closely follow those outlined in detail in (Woodcock et al, 2001). The resultant map is shown in Figure 4 below.

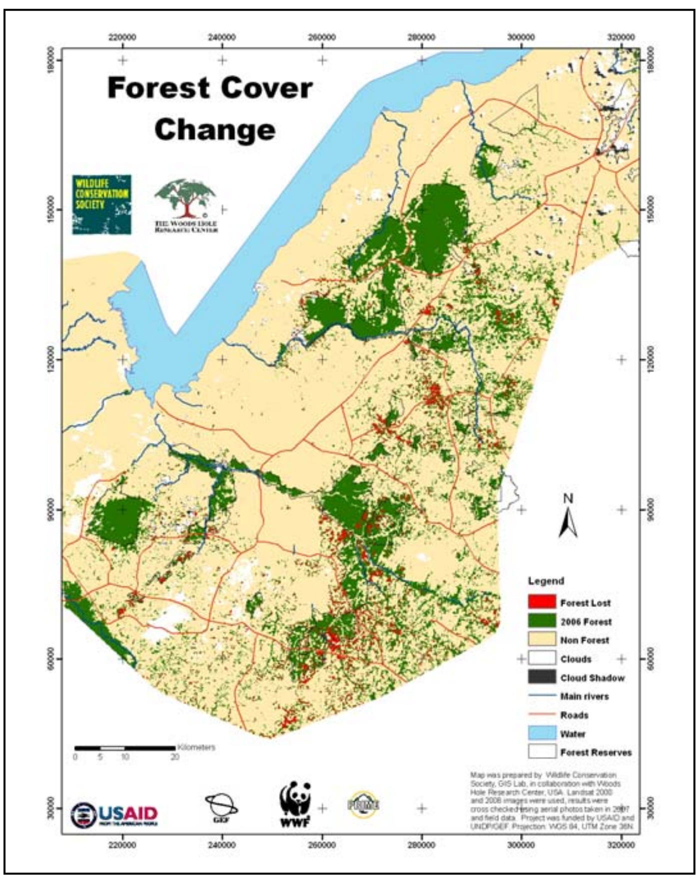

Figure 4: Forest cover changes in the Murchison-Semliki landscape.

An assessment of the Large Forest Reserves shows that the southern part of Bugoma Forest registered high forest loss. Much of Matiri and Ibambaro Forest Reserves have been depleted. For areas outside the protected forests, the southern part of the Murchison-Semliki landscape registered higher forest loss than the northern areas. At district level, Kyenjojo registered the highest forest loss of 7.2% (17,000 ha), followed by Kibaale with 4.2% (10,199 ha) and Hoima with 1.0% (3,644 ha) of their land area. In Kyenjojo, the parishes that registered the highest forest loss were Mugongwe, Kijaguzo and Rwibale with 30.5%, 22.3% and 19.7% respectively. 12 of the parishes in Kyenjojo registered forest loss of equal to or more than 10% of their land area. In Kibaale district, the parishes that registered the highest forest loss were Igayaza with 14%, Kabamba with 13.4%, Kibogo with 12.5% and Kicura with 12% loss of their respective land area. Seven (7) of the parishes in Kibaale district registered forest loss of equal to or greater than 10% of their land area. In Hoima district, the parishes that registered the highest forest loss were Igwanjura with 8.2%, Bubogo with 5.2% and Kyangali with 4.4% loss of their land area. Although Igwanjura registered only 8.2%, this is a total land area of 1,337 hectares.

2. MODELING POTENTIAL CORRIDOR ROUTES

Objective: Assess where potential corridors might still be conserved that are important for wildlife in the Murchison – Semliki landscape

Method

Initially WCS the project implementation unit held a meeting to; 1) to select species of birds and mammals for corridor modeling and 2) to assess the geographical data layers that can affect species movement in the Murchison-Semliki Landscape which could be used in models.

We identified eight groups of species or individual species (5 forest and 3 savanna) which probably require the continued existence of corridors in the landscape to maintain viable populations. This is because they occur at low densities or are rare and hence their populations are not large in any of the major forest blocks such as Budongo and Bugoma. The list of birds and mammals were categorized into the following species or species groups:

Forest corridors: Chimpanzees, golden cat, large forest raptors, small forest raptors, and understorey movers.
Savannah corridors: lion, buffalo and martial eagle.

The geographical layers identified for corridor modeling that could affect animal movement were:

- Landcover – map from 2006 imagery
- Presence of a protected area
- Distance from roads
- Distance from settlements
- Distance from rivers
- Patch size that is needed to maintain an animal for the time while moving.

An add-in tool to ArcGIS software called corridor designer (Beier et al, 2008) was used for modeling the potential location of the animal corridors. Variables selected for use in the model were land cover, protected area status, distance from roads, distance from large villages and towns, and distance from rivers. Each of the variables was weighted for resistance to movement of the animal species/species group. Values ranged from 0 (not suitable) to 100 (most suitable). The variables were also weighted in terms of their importance in determining movements of the animal species/species group. Other values assigned when running the model were the patch size (in hectares) required for a population to exist and for breeding. The scores associated with movement and also the weightings were circulated to other stakeholders in the UNDP/GEF project as well as other experts in WCS for comment. The final scores we developed are given in Appendix 2a and 2b.

For each of the animal species/ species group, a habitant suitability map, a habitat patch map, a least cost map and maps/map slices of potential corridors, based on percentage coverage of the corridor in relation to total land area in the landscape (0.1% to 10%), were generated. In Figure 5 we show, as an example of these output maps generated for the Chimpanzee.

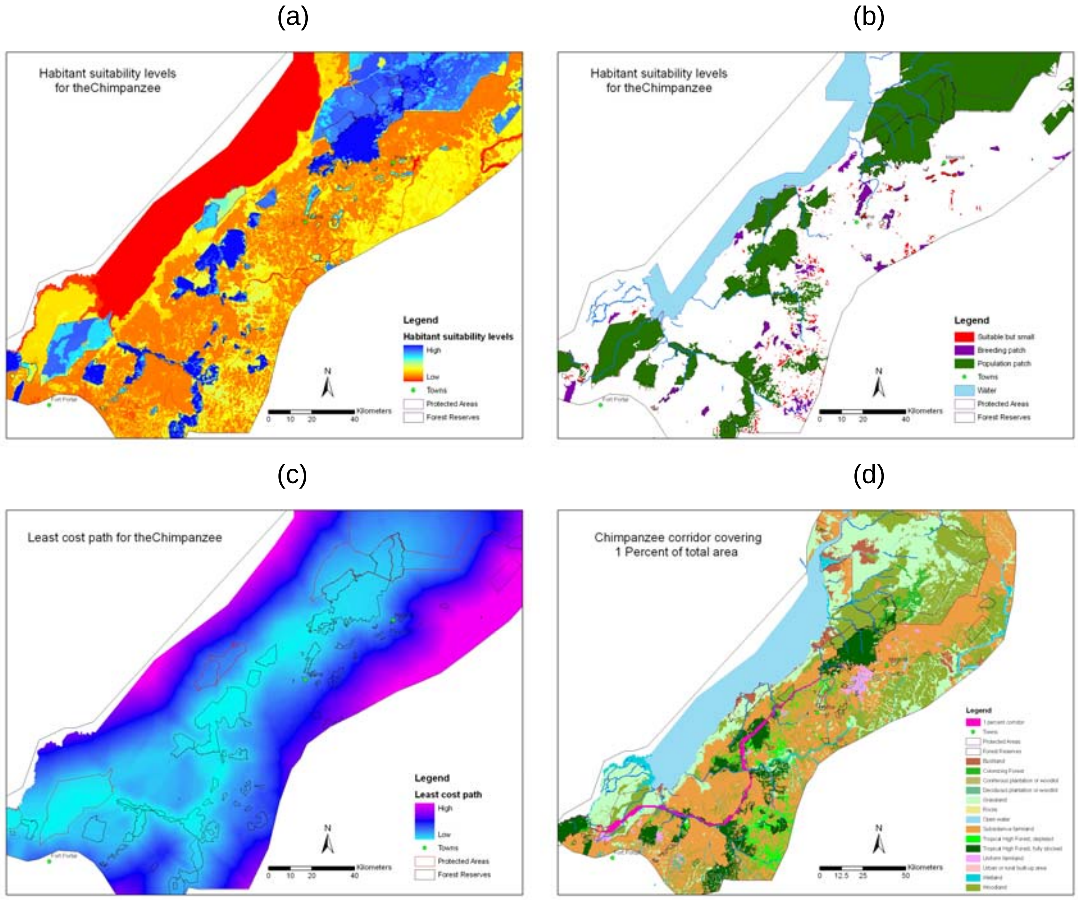

Figure 5: Outputs from the corridor modeling: (a) The levels of suitability for the chimpanzee survival and movement. Dark blue areas are the most suitable and red least suitable. (b) Patches that are suitable for a population of the Chimpanzee to survive about 10 years (green), where breeding can still occur (purple) and suitable for living in but smaller than a population or breeding area (red). (c) Least cost path. The light blue areas offer least resistance for the movement of a Chimpanzee (d) A one percent (1%) potential corridor for the Chimpanzee that would link Budongo Forest to Semliki Wildlife Reserve

For this report we present a corridor layer generated by combining the one percent (1%) layers of all the animal species/species group (Figure 6). This is a preliminary output. It will require fine tuning through evaluation of its location, running additional models for the areas that may have been left out and undertaking a sensitivity analysis of the weighting of some of the variables and rerunning the model to see if the output would capture new areas as potential corridors.

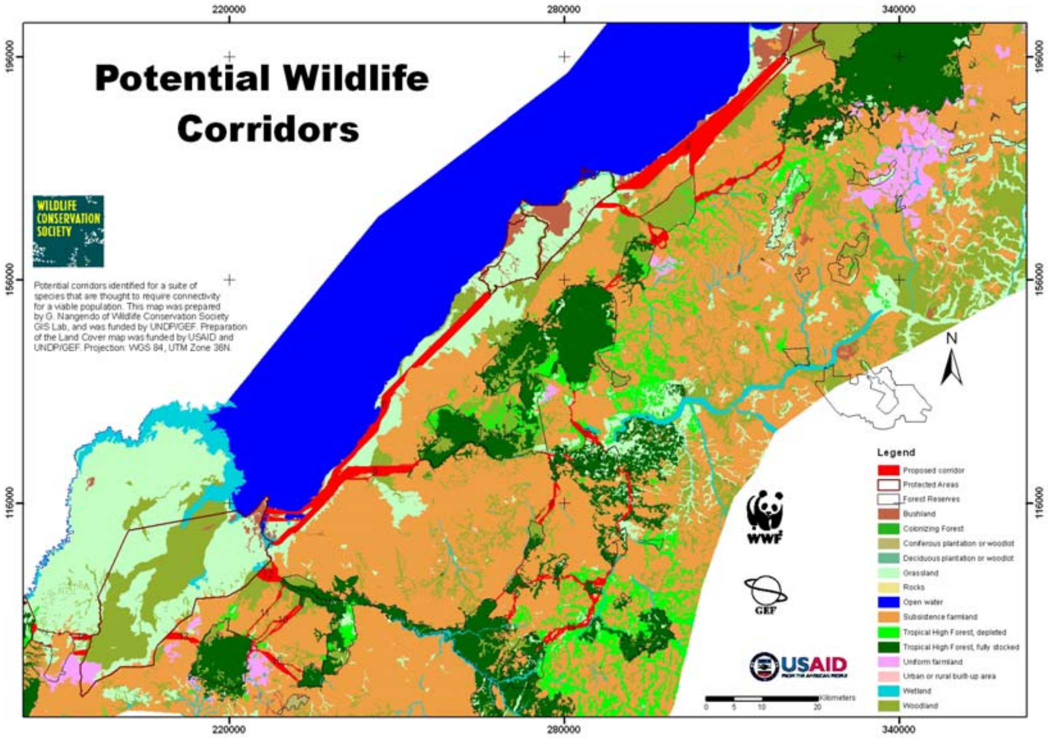

Figure 6: Potential wildlife corridors for a suite of species that are thought to require connectivity to ensure long term maintenance a viable population. The corridors given here are each of the 1% of landscape areas for each of the eight species/species groups.

3. BIODIVERSITY AND SOCIO-ECONOMIC SURVEYS IN AND AROUND KASATO CENTRAL FOREST RESERVE

The methods that will be used in 2010 to assess whether the species identified under the modeling are using the corridors at present were tested in the Kasator Forest Reserve and surrounding forest on private lands. We also tested a socioeconomic survey that was designed to assess whether local people would be willing to conserve forest as corridor land and also to quantify what they currently get from the forest and how it contributes to their annual income. Thirdly we tested a method to measure the standing crop of carbon to assess whether carbon funding could offset costs local people would have from conserving the corridor forests.

a) Survey of Mammals

Objectives:

- To identify whether any of the identified species groups are using the corridors
- To identify anthropogenic threats facing forest conservation in the corridors

Line transect surveys

We used line transect/recce survey techniques to collect quantitative data on mammals that inhabit Kasato Forest reserve and the adjacent communal/private forest patches. During the surveys, we also relied on animal signs such as dung and nests. Use of animal signs was specifically applicable to counting chimpanzees due to the fact that they live at low densities (0.2-2.0 per km^2) wherever they occur in comparison with monkeys and hence are rarely seen. Therefore indirect signs (nest and dung counting techniques) were used to census them. Four transects/recces of 1.653 km, 4km, 3.8km and 4.7km in separate forest locations were established and surveyed for mammals. All large mammals and their sign were recorded if seen (Table 1).

Table 1: Mammal species sighted along 4 transect/recce length in Kasato Forest reserve and private forests

Number	Mammal species sighted		Number of animals/signs seen	Comments/habitat type
	Common name	**Scientific name**		
1.	Black-and-white colobus monkey	*Colobus guereza*	16	THFC ,THFO, cultivated forest patch (shamba)
2.	Chimpanzee	*Pan troglodytes*	1	THFC, chimp nest sighted at GPS W: 0284700 and GPS N: 0123929
3.	Red tailed monkeys	*Cercopithecus ascanius*	9	THFO, THFC

Key: THFC = Closed Tropical High Forest, THFO = Open Tropical High Forest

Qualitative data was gathered by talking to people living next to the forest and asking them about what animals they see in the forest patches. With the help of interviewees and mammal guide book, a list of animals for Kasato Forest reserve and nearby privately/communally owned forest patches was created. Five informants (2 females and 3 males) were drawn from Kiryanga, Kyakatebe, Nyisamba and Segu Villages (Local Council I). From the surveys, it emerged that the mammals in table 2 inhabit the forests:

Table 2: Mammals reported by local residents to reside in Kasato Forest Reserve and nearby private forest patches as revealed in a qualitative survey

Number	Mammal species	
	Common name	**Scientific name**
1.	Black-and-white colobus monkey	*Colobus guereza*
2.	Blue duikers	*Philantomba monticola*
3.	Bushbuck	*Tragelaphus scriptus*
4.	Bush pigs	*Potamochoerus larvatus*
5.	Chimpanzee	*Pan troglodytes*
6.	Jackal	
7.	Mongooses	*Herpestidae spp*
8.	Olive baboon	*Papio anubis*
9.	Red tailed monkeys	*Cercopithecus ascanius*
10.	Vervet monkey	*Cercopithecus aethiops*

Camera-trap surveys

Camera-trap surveys were conducted in Kasato Central Forest Reserve to identify additional species that would not be observed along the transects/recces. Specifically, the main interest was to photo capture low density species that may need the biological corridor for genetic connectivity and establishing viable populations. Camera-trap surveys were conducted between 16th December 2009 and 20th January 2010 within the forest. Three areas within the forest were chosen for deploying camera traps. Cameras were set to take pictures 24 h day^{-1} on colour print film. The date and time of each exposure were shown on the film. Cameras were kept in the field for 33 - 35 days. Specific locations being selected depended upon presence of animal trails, dung piles and other animal signs and avoidance of areas used by people. Cameras were set at a height of 10 – 30 cm in 3 different habitat types i.e. closed tropical high forest, open young/secondary forest and closed young /secondary forest. A total of 17 camera-traps were set in 3 transects. Between January 19 and 21, 2010, all camera traps were collected from the forest and taken to a photo studio in Kampala city for development of print films.

We subsequently identified most wildlife photos to species as indicated in table 3 and the accompanying wildlife photographs on the next two pages.

Table 3: Wildlife species photo-capture by the camera-trap survey

No.	Wildlife		No. of photos
	Common name	**Scientific name**	
1.	Blue duiker	*Philantomba monticola*	1
2.	Bush pig	*Potamochoerus larvatus*	1
3.	Servaline genet	*Viverridae spp*	4
4.	Crested guineafowl	*Numida meleagris*	13
5.	Olive baboon	*Papio anubis*	3
6.	Side-striped jackal	*Canis adustus*	3
Total			25

b) Survey of birds

Objectives: Identify species of birds at low density specifically and generally avifauna diversity

Methods
The surveys were carried out using the following techniques:

- Quantitative data was collected by making 5 minute point counts at points spaced 250 metres along the transects/recces used by the mammal teams. At each point, all bird species within specified distance intervals were recorded. A total of 17 point counts were made in 4 different forest habitat types i.e. Closed Tropical High Forest, Open Tropical High Forest, Open Tropical High Forest-degraded and Shamba (Tropical forest degraded for cultivation). The data obtained was recorded on quantitative data sheets.
- Qualitative data was gathered by the bird survey team moving around the forests (private and communal forests as well as Kasato Forest Reserve) and recording any sightings of birds specifically looking for those that appear on our focal species list for species that may require the corridors. The obtained data was recorded on qualitative data sheets.
- Mistnetting involved setting 8 mistnets in forest areas where species of understorey birds were expected to be. Mistnet data sheets were used to record the data

Table 4: Birds sighted in a qualitative survey

No.	Bird species	Number seen	Forest habitat type
1.	Greater Blue Turaco	2	THFO-D
2.	Black and White Casqued Hornbill	6	THFO-D
3.	White-thighed Hornbill	3	THFC
4.	Black-billed Turaco	3	THFO
5.	African Goshawk	1	Shamba

N.B. A preliminary list of 103 species of birds (Please see appendix 3) was compiled

Blue duiker

Crested guineafowl


Servaline genet

Olive baboon

Bush pig

Side-Striped Jackal

c) Monitoring and estimation of carbon stocks in Kasato Forest Reserve and adjacent privately owned forest patches

REDD is one of the funding options that has been proposed to provide financial incentives to communal and private forest owners in the corridor forests to help voluntary reduce deforestation rates and associated carbon emissions. Forest owners that demonstrate emission reductions may be able to sell those carbon credits on the international carbon market or else where. These emissions reductions could simultaneously combat climate change, conserve biodiversity and protect other ecosystem goods and services. One of the steps towards realization of REDD incentive schemes is an assessment of carbon stock available. To quantify carbon stocks in and around Kasato forest reserve, the following activities were implemented:

- 20 circular nested plots of different radii were established in Kasato forest reserve and adjacent private forests to sample trees of different sizes as follows:
    - 0-2m radius: Trees of 5-9.9cm DBH,
    - 0-10m radius: Trees of 10-29.9cm DBH
    - 0-20m radius: Trees of 30+ DBH
- In each nested plot, the name of the tree, DBH in cm, the height of the first branch and the height of the canopy in metres and the habitat types were recorded.

The outcome of this activity was a preliminary list of 40 species of trees as can be found in the appendix 4).

d) Socio-economic survey

Objectives of the socio-economic survey:

- To identify environmental goods and services utilized by households from Kasato forest reserve and the adjacent private forests
- To determine the Total Economic Value of environmental goods and services gained by households from the use of the forests
- To estimate the proportion of household income derived from forests through assessing gross household income.
- To determine the attitudes of local populations towards the conservation of the forests and their willingness to be compensated for not cutting down the corridor.
- To assess whether forest/savanna corridor conservation can be a profitable form of land use as opposed to other forms of land use.

50 questionnaires were administered to heads of households in Kiryanga and Kisegu Villages (Local Council 1) in Kiryanga Sub-county, Kibaale District. The data are in the process of being entered in a computer for analysis.

4. NEXT STEPS

In 2010 WCS will build upon the start of this corridor assessment to undertake the following:

1. Undertake a sensitivity analysis of the model outputs and finalise the model write up
2. Modify the ground survey methods in the light of lessons learned in the pilot survey and survey the nine major forest corridors identified in figure 6
3. Assess the potential for carbon funding of these corridors based on the standing crop of carbon

4. **REFERENCES**

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Tucker, C, Grant, D, & Dykstra, J. (2003) *Photogrammetric Engineering and Remote Sensing* 55B: 378-390.

Woodcock, C. E & Harward, V. J. (1992) *International Journal of Remote Sensing* 13(16): 3167-3187.

Woodcock, C, Macomber, S, Pax-Lenney, M, & Cohen, W. (2001) *Remote Sensing of Environment* 78: 194-203.

Appendix 1: Landsat data used in the forest change study

172_58

T1 - 11/29/2005 (Gap filled by USGS with images 12/15/2005, 12/31/2005, 2/20/2007; residual fill 2/6/2002)
T2 - 9/12/2000 (Orthorectified/Geo-Cover product)

172_59

T1 - 11/29/2005 (Gap filled by USGS with images 12/15/2005, 12/31/2005, 2/20/2007; residual fill 2/6/2002)
T2 - 5/23/2000 (Orthorectified/Geo-Cover product)

172_60

T1 - 11/29/2005 (Gap filled by USGS with images 12/15/2005, 12/31/2005, 2/20/2007; residual fill 2/6/2002)
T2 - 01/02/2001 (geometrically corrected to 12/31/1999 Orthorectified/Geo-Cover product)

173_59

T1 - 01/23/2006 (Gap filled by USGS with images 1/10/2007, 2/21/2005, 2/5/2005; residual fill 1/9/2001)
T2 - 01/09/2001 (Orthorectified/Geo-Cover product)

All T1 images (from above) were geometrically corrected using ERDAS Imagine to the orthorectified images from T2.

Appendix 2

Appendix 2a: Variables weighted for resistance to movement of the animal species/species group

Layers	Classes	Category	Chimp	Golden cat	Large forest raptors	Small forest raptors	Understorey movers	Lion	Martial eagle	Buffalo
Land cover	Tropical High Forest	10	100	100	100	100	100	25	5	5
	Tropical High Forest	9	75	85	100	95	80	10	5	5
	Colonising forest	2	70	85	100	80	70	25	5	5
	Woodland	14	60	50	80	50	20	100	100	90
	Bushland	1	60	70	90	30	10	90	70	50
	Grassland	5	40	30	50	20	5	100	100	100
	Impediments	6	0	5	50	5	0	5	5	0
	Wetland	13	1	5	50	5	0	0	5	50
	Coniferous plantatio	3	50	60	90	70	50	10	40	5
	Deciduous plantatio	4	50	60	90	70	50	10	40	5
	Subsistence farmlar	8	10	10	25	20	8	5	25	2
	Uniform farmland	11	20	20	30	10	1	10	30	4
	Urban or rural built-u	12	0	0	5	1	0	0	5	0
	Open water	7	0	0	1	0	0	0	1	0
Protected area	NP	4	100	100	100	100	100	100	100	100
	WR	5	90	90	90	90	90	90	90	90
	CWA	2	25	25	25	25	25	50	25	25
	CFR	1	85	85	85	85	85	50	60	85
	LFR	3	35	35	35	35	35	35	35	35
	None	6								
Distance from	0-50		15	10	80	50	5	20	50	10
	50-100		25	20	85	65	15	35	60	25
	100-500		40	35	95	80	30	60	85	50
	500-1000		75	70	98	90	70	80	90	80
	>1000		100	100	100	100	100	100	100	100
Distance from	0-500		20	5	10	5	0	0	20	0
	500-1000		30	10	25	10	5	5	40	10
	1000-5000		60	45	50	40	35	25	65	30
	5000-10000		90	80	90	80	75	75	90	75
	>10000		100	100	100	100	100	100	100	100
Distance from	0-50		100	100	100	100	100	100	100	100
	50-100		100	100	100	100	100	100	100	100
	100-500		100	100	100	100	100	100	100	100
	500-1000		100	100	100	100	80	100	100	80
	>1000		80	80	100	100	60	80	100	60
Population der	0-2500		100	100	100	100	100	100	100	100
	2500-5000		75	75	90	90	95	50	90	60
	5000-10000		40	40	70	80	90	20	75	30
	10000-100000		20	20	50	65	80	1	50	5
Longest distance that will cross (m)			300	500	1000	200	50	600	2000	200
Patch size (ha)	Population		5000	15000	5000	4000	3000	25000	10000	10000
	Breeding		500	2000	2000	1000	500	5000	3000	1000
Search area radius (m)			200	250	220	180	150	280	280	280
Habitant patch threshold			40	40	60	60	50	50	50	50

Appendix 2b: Weighting values of how important each variable is important to the species.

Layers	Chimp	Golden cat	Large forest raptors	Small forest raptors	Understorey movers	Lion	Martial eagle	Buffalo
Land cover	51	42	81	86	86	55	60	55
Protected areas	31	31	9	6	6	20	20	20
Distance from Roads	4	7	3	2	2	3	6	6
Distance from large village or towns	11	16	6	4	4	20	10	10
Distance from rivers	3	4	1	2	2	2	4	9
	100	100	100	100	100	100	100	100

Appendix 3: Preliminary list of Bird species recorded in Kasato Forest Reserve and the adjacent privately owned forests

Number	Bird species	No. seen	Forest habitat type
1	Afep Pigeon	2	THFO
2	African Emerald Cuckoo	5	THFO-D
3	African Firefinch	2	Shamba
4	African Green Pigeon	1	THFO-D
5	African Goshawk	1	Shamba
6	African Open Billed Stork	1	THFO-D
7	African Thrush	1	Shamba
8	Angola Swallow	2	Shamba
9	April Dusky Flycatcher	1	THFO-D
10	Ashy Flycatcher	1	THFO-D
11	Baglafecht Weaver	8	THFO-D, Shamba
12	Black and White Casqued Hornbill	7	THFC, THFO-D
13	Black and White Shrike Flycatcher	2	Shamba
14	Black Bee-eater	2	THFC, THFO
15	Black-billed Turaco	3	THFC
16	Black-crowned Waxbill	21	Shamba, THFO-D
17	Black-headed Weaver	2	Shamba
18	Black-necked Weaver	3	Shamba
19	Black-throated Apalis	3	THFO-D, Shamba
20	Black-faced Rufous Warbler	4	THFO-D, Shamba
21	Black-necked weaver	2	THFO, THFO-D
22	Blue-shouldered Robin Chat	1	Shamba
23	Bronze Mannikin	13	Shamba
24	Brown-throated Wattle-eye	20	THFO, THFC, Shamba
25	Buff-throated Apalis	2	Shamba
26	Cardinal Wood Pecker	1	THFO-D
27	Chestnut Wattle-eye	7	THFO, THFC
28	Chocolate-backed Kingfisher	2	THFC
29	Collared Sunbird	4	THFO-D, Shamba
30	Common Bulbul	20	THFO, THFO-D, Shamba
31	Crested Guineafowl	9	THFC
32	Crowned Hornbill	9	THFC, Shamba
33	Double -Toothed Barbet	2	THFO-D
34	Dusky Long-tailed Cuckoo	8	THFC, THFO, THFO-D
35	Dusky Tit	6	THFC
36	Great Blue Turaco	19	THFO, THFO-D
37	Green Crombec	1	THFO
38	Green Hylia	8	THFC, THFO, THFO-D, Shamba
39	Grey-backed Camaroptera	8	THFO, THFO-D, Shamba
40	Grey-throated Barbet	8	THFO-D, Shamba
41	Grey-headed Negrofinch	1	THFO-D
42	Grey-headed Sparrow	2	Shamba
43	Grey-throated Flycatcher	1	Shamba
44	Hairy-breasted Barbet	5	THFO, THFO-D, Shamba
45	Honey Guide Greenbul	7	THFC, THFO, Shamba

46	Icterine Greenbul	4	THFC
47	Klaas's Cuckoo	2	THFO-D, Shamba
48	Little Bee-eater	4	Shamba
49	Little Greenbul	6	THFC, THFO, THFO-D, Shamba
50	Little Grey Greenbul	6	THFC
51	Lizard Buzzard	3	THFO, Shamba
52	Narina's Trogon	2	THFC, Shamba
53	Narrow-tailed Starling	12	THFO, Shamba
54	Northern Puffback	3	Shamba
55	Olive Green Camaroptera	2	THFC, THFO
56	Olive Sunbird	3	THFC, THFO
57	Red-bellied Paradise Flycatcher	9	THFC, THFO, THFO-D, Shamba
58	Red-Chested Cuckoo	6	THFO, THFO-D, Shamba
59	Red-eyed Dove	2	THFO, Shamba
60	Red-faced Cisticola	2	Shamba
61	Red-headed Bluebill	2	Shamba
62	Red-headed Malimbe	3	THFO-D, Shamba
63	Red-tailed Ant-Thrush	3	THFC
64	Red-tailed Bristlebill	2	THFC, THFO-D
65	Red-tailed Greenbul	2	THFO
66	Ross's Turaco	6	THFO
67	Rufous Thrush	1	THFO
68	Scaly-breasted Illadopsis	3	THFC, THFO-D, Shamba
69	Slender Billed Greenbul	11	THFC, THFO, THFO-D, Shamba
70	Snowy-headed Robbin Chat	1	THFO
71	Speckled Mousebird	5	THFO-D, Shamba
72	Speckled Tinkerbird	9	THFC, THFO, THFO-D, Shamba
73	Splendid Starling	17	THFO, THFO-D
74	Spotted Greenbul	10	THFC, THFO-D, Shamba
75	Striped Kingfisher	7	Shamba
76	Tambourine Dove	24	THFC, THFO, THFO-D, Shamba
77	Toro Olive Greenbul	5	THFC, THFO-D
78	Valvet Mantled Drongo	2	THFO
79	Vieillot's Black Weaver	24	THFO-D
80	Western-black-headed Oriole	8	THFC, THFO, Shamba
81	Western Nicator	14	THFC, THFO, THFO-D, Shamba
82	White-browed Coucal	2	Shamba
83	White-spotted Flufftail	11	THFO-D, Shamba
84	White-thighed Hornbill	3	THFC
85	White-throated Bee-eater	4	THFO-D
86	White-breasted Negrofinch	1	THFC
87	Whistling Cisticola	2	THFO-D, Shamba
88	Yellow-backed Weaver	2	Shamba
89	Yellow-billed Barbet	7	THFC, THFO-D, Shamba
90	Yellow-browed Camaroptera	3	THFC, THFO-D, Shamba
91	Yellow-crested Woodpecker	2	Shamba
92	Yellow Longbill	1	THFC
93	Yellow-spotted Barbet	4	THFC, Shamba
94	Yellow-spotted Greenbul	3	THFC
95	Yellow-throated Tinkerbird	1	THFO-D

96	Yellow-whiskered Greenbul	14	THFC, THFO, THFO-D, Shamba
97	Yellow-billed Barbet	2	THFC, THFO
98	Yellow-browed Camaroptera	1	Shamba
99	Yellow-crested Woodpecker	1	Shamba
100	Yellow-rumped Tinkerbird	6	THFC, THFO, Shamba
101	Yellow-spotted Barbet	3	THFO-D
102	Brown-chested Alethe	1	
	Total number of birds counted	**538**	

Abbreviations and Acronymes
THFC: Closed Tropical High
Forest
THFO: Open Tropical High
Forest
THFO-D: Open Tropical High Forest - Degraded
Shamba (Tropical forest degraded for cultivation

Appendix 4: Preliminary list of tree species recorded in Kasato Central Forest Reserve and the adjacent private/communal forests

No.	Tree species	Average DBH in cm	Average branch height (m)	Average canopy height (m)	Habitat type
1	*Acanthus pubescens*	6.4	1	4.5	SFO, Shrub
2	*Albizzia coriara*	51.7	4	19	THFO, Shamba
3	*Albizzia grandibracteata*	72	14.5	31	THFO/degraded, Shamba
4	*Albizzia spp*	50.8		11	THFO
5	*Alchornea laxiflora*	12.6	3	13	THFC
6	*Antiaris toxicaria*	13.3	9.9	12	SFO, SFC, THFO
7	*Argomuellera macrophylla*	6.2	1	5	THFO
8	*Blighia unijugata*	26.9	7.7	15.2	Shamba, THFO/degraded, THFC, SFO, THFO
9	*Blighia welwitschii*	69.9		9	THFC
10	*Cassia spectabilis*	43	6.7	33.3	THFC
11	*Cassipourea ruwenzorensis*	12.3	9	12	THFC, THFO
12	*Celtis Africana*	7.3	4	10	SFC
13	*Celtis durandii*	39.43	11.72	19.8	Shamba, THFO/degraded, THFC, SFC
14	*Celtis mildbraedii*	15.9	9.4	14.5	THFO, THFC, Shamba
15	*Celtis zenkeri*	49.2	10.3	15.3	THFC, Shamba, SFC
16	*Clausena anisata*	11.3	1	7	THFO
17	*Diospyros abyssinica*	28.5	12.4	19.4	THFO-Degraded, SFO, THFC, Shamba
18	*Dombeya mukole*	11.2	3	11	Shamba
19	*Ehretia cymosa*	40.4	3.5	11	THFO
20	*Entandrophragma angolense*	14.2	7	10	THFO, SFC
21	*Fagaraposis angolensis*	27.23	6.6	13.22	THFC, THFO, Shamba
22	*Ficus exasperata*	51.3	17.5	24.5	THFO
23	*Ficus sur*	30.1	10	14	THFO
24	*Funtumia elastica*	15.6	10	14	THFO, Shamba, SFC, THFC, THFO-degraded
25	*Haloptelea grandis*	20.1	15.3	19.5	THFO, Shamba, SFC
26	*Lasiodiscus mildbraedii*	11.2			THFC

27	*Margaritaria discoideus*	37.2	3.8	19	THFC, Shamba, THFO
28	*Markhamia lutea*	25.9	19	25	THFC
29	*Markhamia platycalyx*	11.2	1	4	Shrub
30	*Morus lactea*	41	29	37	THFC
31	*Muphonis dumerii*	17.2	2	12	THFC
32	*Newtonia buchananii*	26.3	13.5	21	Shamba
33	*Olea welwitschii*	52.5	11.64	25.5	THFO, SFO, Shamba, THFC, THFO-Degraded
34	*Oxyanthus specious*	5	2	4	SFO
35	*Phoenix reclinata*	12.1	8.5	11.5	Shamba
36	*Premna angolensis*	31.2	5	13.5	THFO, THFO/degraded
37	*Prunus africana*	86.3	19	30	THFC
38	*Sapium ellipticum*	48.5	5.8	13.5	SFO, THFO, Shamba
39	*Spathodea campanulata*	22.2	1	11	SFO
40	*Teclea nobilis*	20.52	5	13.7	THFO, SFO, Shamba, THFC, THFO-Degraded
41	Unknown	32.5	6	12	THFO
42	Unknown	35.9	10	21	Shamba

Abbreviations and acronyms

THFC : Closed Tropical High Forest
THFO : Open Tropical High Forest
SFC : Closed young/secondary forest
SFO : Open young/secondary forest