Biodiversity Surveys of East Madi Wildlife Reserve

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EXECUTIVE SUMMARY

The East Madi Wildlife Reserve in northern Uganda has existed for over 50 years in some form of protected area. During this time it has mostly been managed as a controlled hunting area and there has been little focus on the biodiversity of the reserve. Between 1985 and 2005 the reserve was insecure and was used as a base of operations by the Lords Resistance Army at times. This report summarises the first attempt to measure the biodiversity of both savanna and forested parts of the reserve.

The survey teams assessed the species of large and small mammals, birds and plants (ferns and higher plants) in the reserve during a three week inventory in early 2008. A mixture of quantitative and qualitative methods were used to provide species lists for the reserve and also measures of relative abundance and species accumulation curves. A provisional list of 50 mammal species (excluding elephant which are thought to visit the reserve occasionally), 181 bird species and 374 plant species are now known for the reserve. Species accumulation curves for the plants in particular indicate that there are probably many more species to be found.

While not as rich as some of Uganda's National Parks, East Madi Wildlife Reserve is conserving quite a diversity of species. It is likely to be managed in future for wildlife tourism and sport hunting if large mammal populations can be allowed to increase and knowledge about the additional biodiversity of the reserve will be attractive at least for the tourism market. It is clear more survey work would uncover more species for the reserve and we would encourage a longer term collection of bird data for the reserve. It is likely migrant species will pass through the reserve which could greatly increase the bird list.

ACKNOWLEDGEMENTS

We would like to thank many people who helped WCS implement these surveys. The warden of East Madi Reserve, Mr Walter Odokorwot, was very helpful in organizing logistics for the field teams and providing advice on where teams could access safely. We would also like to acknowledge the help of Mr. Muswa Kennedy-Community Conservation Ranger, EMWR; Mr. Openy Edward- LC III Chairman, Amuru Sub County; Mr. Ojera Christopher- LC III Chairman, Pabbo Sub County; Mr. Ajobe Aseraf- Gombolola Internal Security Officer (GISO), Ciforo Sub County; Mr. Sekondo- LC II Chairman, Zoka Parish; Mr. Chadri Micheal-LC I Chairman, Sinyanya Village.

Ellen Bean and the WILD Team in Kampala played an important role in setting up the teams and organising equipment. We want to thank USAID for its financial support for the surveys and also Uganda Wildlife Authority for permission to carry out the surveys.

INTRODUCTION

The East Madi Wildlife Reserve is located north of Murchison Falls National Park in Amuru District in north west Uganda (31.37-31.93^0 E; 2.88-3.33^0 N). Initially gazetted as the Acholi and East Madi elephant sanctuary in 1950 it was known historically to contain some of the largest elephants in Uganda and attracted hunters from around the world who were looking for trophy tusks (Temple Perkins, 1955). The region later became the East Madi Controlled hunting area which was linked to Murchison Falls National Park through the Kilak Controlled Hunting Area. However in 1972 the KIlak Controlled Hunting Area was degazetted to make way for private ranches. Following Uganda's civil wars from the late 1970s to mid 1980s many of the protected areas were invaded and settled by people and in the mid 1990s reassessments of the parks, wildlife reserves, controlled hunting areas and forest reserves were made. Where few large mammals were found in the controlled hunting areas these were degazetted. The East Madi Wildlife Reserve was created from part of the former Kilak and East-Madi Controlled Hunting Areas (Lamprey, Buhanga and Omoding, 2003).

However the insecurity that remained in northern Uganda as a result of the presence of the Lords Resistance Army from 1986 to 2006 meant that few surveys were made of East Madi Wildlife Reserve and the Kilak Controlled Hunting Area during these reassessments. Only the Zoka Forest Reserve was surveyed by the Uganda Forest Department (Davenport and Howard, 1996) and aerial surveys were made of the Kilak Controlled Hunting Area and the East Madi Wildlife Reserve (Fig 1. Lamprey, Buhanga and Omoding, 2003). While large and medium sized mammal lists exist for the parks in Uganda together with bird lists the wildlife reserves have historically been very poorly surveyed for their biodiversity.

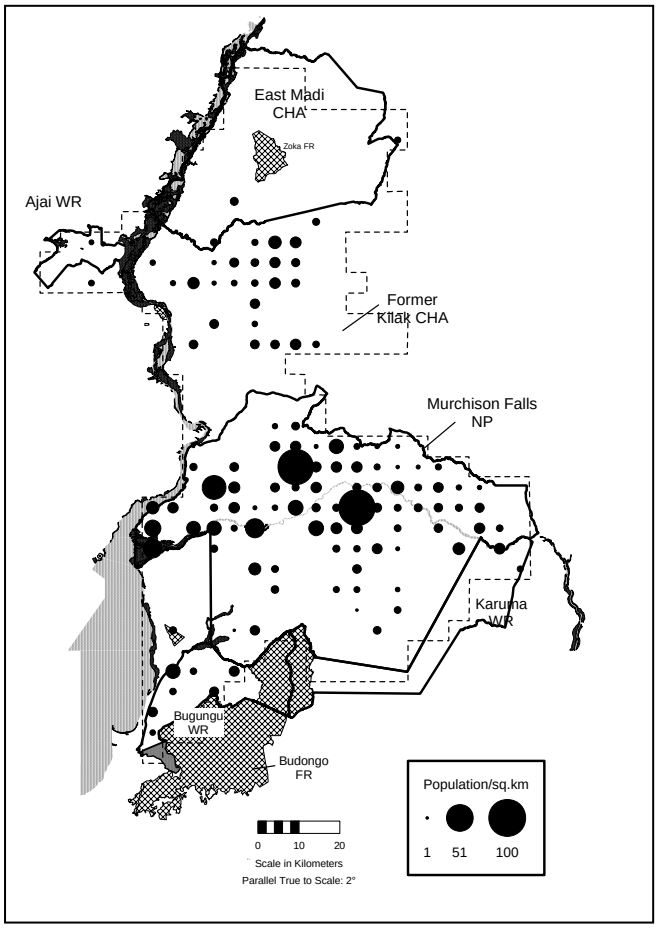


Figure 1. Relative large mammal abundance in the 1995 surveys of the region.

As part of the WILD (Wildlife, Landscapes and Development for conservation) project of the Wildlife Conservation Society a biodiversity survey was made of the East Madi Wildlife Reserve to assess its

contribution to the conservation of biodiversity in Uganda as well as its large mammals. The region was still relatively insecure and teams needed to visit quickly and then remove themselves for their own safety. Surveys focused on the following taxa: large and small mammals, birds and plants as surrogates for overall biodiversity. This report summarises the results of this survey.

East Madi Wildlife Reserve

East Madi Wildlife Reserve is an area of 831 km2 of savanna which ranges from about 1,100 metres altitude a.s.l. in the south east of the Reserve down to about 600 metres along the river Nile to the west of the reserve (figure 2a). The vegetation is primarily savanna grassland and woodland/bush apart from papyrus swamp along the river Nile and the tropical high forest of Zoka Forest Reserve (figure 2b).

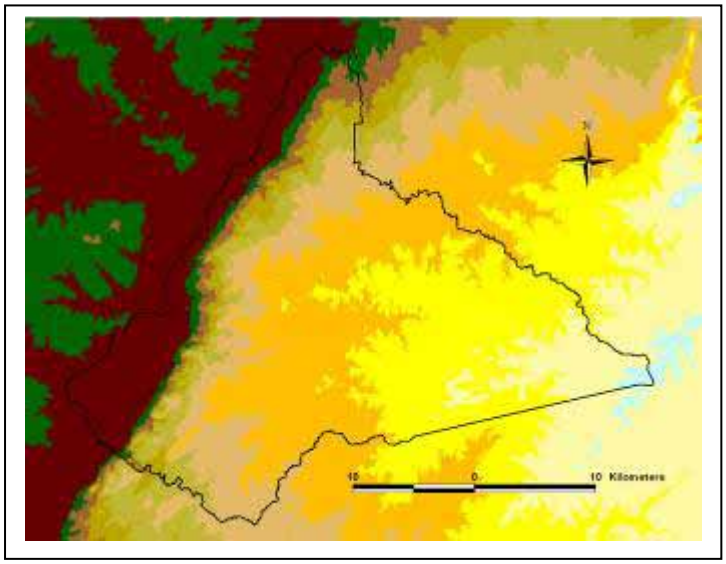


Figure 2a. Altitude variation ranging from around 600 metres (brown) up to 1,100 metres (cream).

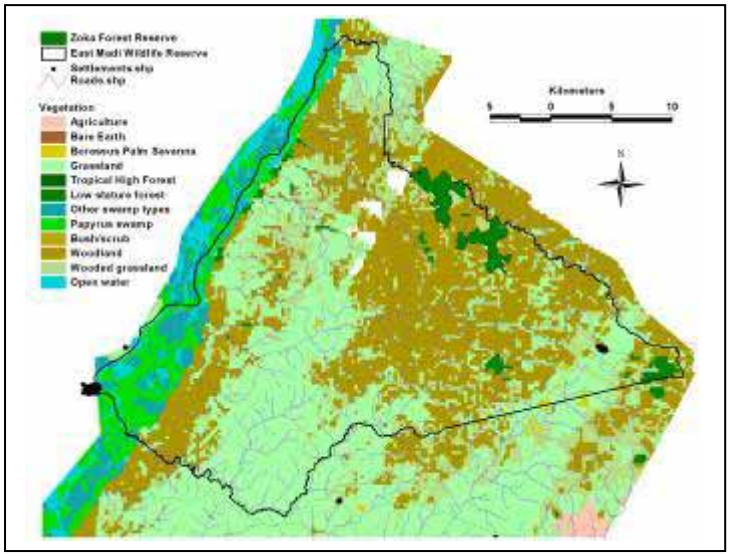


Figure 2b. Vegetation types as classified from aerial photography collected in 2008 (WCS GIS Lab). The white areas in the centre were covered by cloud in the photos and are unclassified as a result.

The vegetation map (figure 2b) was digitized from aerial photos that were taken in 2007 of the East Madi Wildlife Reserve and former Kilak CHA by the WCS flight program. These images were captured and joined using the ENSO Mosaic hardware/software package to produce a digital photographic map of the region. A grid of 250 metre cells was overlaid on the photo imagery and all cells classified into the various habitat types based on the most abundant habitat type in each cell. When selecting survey sites the vegetation map was selected to identify different habitat types for surveying.

METHODS

Four sites were selected for surveys that were relatively evenly spaced around the reserve but accessible by road or river. Only three of the sites were eventually surveyed however, because the fourth (in the south east) was near a region that is currently being contested by the local community and the government who do not want it to be within the reserve. The surveys were made between 20th February and 9th March 2008.

Site 1. was accessed by taking canoes up the Nile from the north west corner of the reserve. A camp was established by the river and teams hiked up into the reserve from the river.

Site 2. was within the Zoka Forest Reserve and surveyed the forest and woodland that surrounds the forest.

Site 4. was in the south of the reserve on the escarpment above the river and was located in more open savanna woodland and grassland.

The Zoka forest represents a medium altitude moist semi-deciduos formation that Langdale-Brown, Osmaston and Wilson (1964) described as a *Cynometra-Celtis* forest. Sites 1 and 4 were mapped as broadly speaking comprising savanna vegetation formations with dry *Hyparrhenia, Combretum-Acacia-Hyparrhenia* and *Butyrospermum-Hyparrhenia dissoluta* savannas.

Large mammal surveys

Large mammals were surveyed by undertaking reconnaissance and transect walks (figure 3), recording droppings and sightings of all species. Reconnaissance walks were made at all sites and aimed to travel in approximately a straight line where possible but deviated around obstacles or dense vegetation. Transects were cut and walked in Zoka Forest only as there were reports of chimpanzees in this forest and we wanted to obtain a better estimate of their numbers. Points every 250 metres along the reconnaissance walks were marked with flagging tape and used by the bird and plant teams (see below). A total of 57.37 km were walked at all three sites.

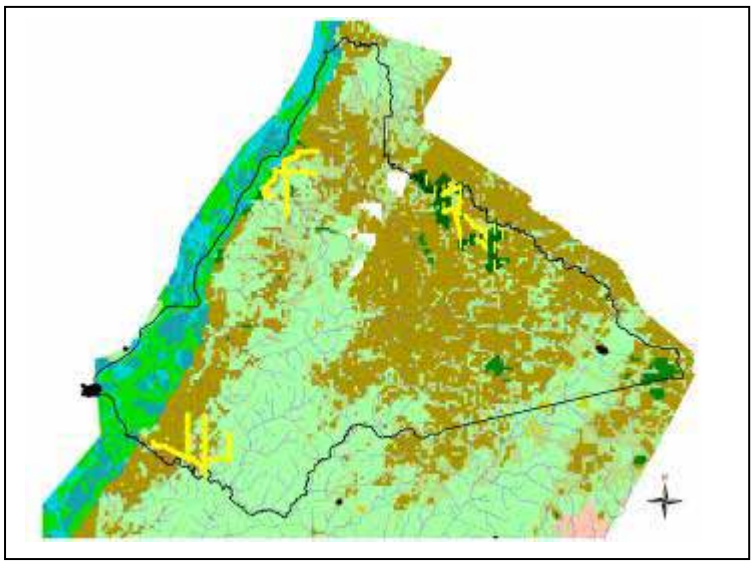


Figure 3. Recce and transect survey coverage (yellow lines) for the surveys.

Small mammal surveys

Small mammals were surveyed at each site using a combination of live traps (Sherman), snap traps, for rodents and shrews and mistnets for bats.

The traps used for capturing the small mammals included a mixture of Sherman traps, museum special rat traps and victor rat traps. Traps were baited with a mixture of peanut butter, maize floor and bananas. A number of traps that could be set before dark, were laid on the first night on arrival at base points. Additional traps or nets and traplines or netlines were then set on subsequent days to sample different varieties of microhabitats that could be easily accessed from base camps. Table 1 summarises location details of the areas where trapping was done in sites 1,2 and 4.

Table 1. GPS locations around which netting and trapping were done

Sampling locations	Latitudes			DDLAT	n/s	Longitudes			DDLONG	e/w
	DEG	MIN	SEC			DEG	MIN	SEC		
Site 2. Zoka camp	3	7	15.6	3.121	N	31	39	35.4	31.65983	E
Trap station 1	3	7	18	3.121667	N	31	39	32.8	31.65911	E
Trap station 2	3	7	10.7	3.119639	N	31	39	30	31.65833	E
Trap station 3	3	7	27.1	3.124194	N	31	39	43.3	31.66203	E
Net line 1	3	7	22.7	3.122972	N	31	39	35.1	31.65975	E
Net line 2	3	7	27.1	3.124194	N	31	39	43.3	31.66203	E
Site 1. Station 1	3	8	8.7	3.13575	N	31	31	52.5	31.53125	E
Site 1. Station 2	3	8	5.0	3.134722	N	31	31	58.8	31.533	E
Site 4. Station 1	2	54	38.3	2.910639	N	31	28	45.6	31.47933	E
Site 4. Station 2	2	54	35.9	2.909972	N	31	28	44.7	31.47908	E

In all situations, the traps and nets were set in areas within at most 1 km radius from base camp. Given that the vegetation types were generally the same in the non-forested sampling areas it might be safe to assume that areas that were sampled might be representative of the wider scale ecosystems in the East Madi area. In all cases the surveys lasted only four sampling days, which is not long enough for sampling small mammals if more complete checklists are to be accumulated.

Bird Surveys

Every 250 metres along the reconnaissance walk trails birds were recorded during 5 minute point counts by experienced ornithologists who know most bird calls in Uganda. A total list of birds was also recorded at each site by recording any observations or calls identified during the team's time at the site. In this way nocturnal species were recorded as being present even if no quantitative data were obtained. Mist netting was carried out on one day at each site to try to capture species that might not be easily observed because they do not call very frequently.

A total of 37, 25 and 43 point counts were made at sites 1,2 and 4 respectively and a total of 105 point counts for the whole reserve.

Plant surveys

Every 250 metres along the reconnaissance walk trails a nested circular plot was measured with all herbs identified within a radius of two metres, all lianas, woody shrubs and trees less than 10cm DBH but greater than 2.5 cm DBH within a radius of 10 metres and all trees greater than 10 cm DBH within a radius of 20 metres. Plant specimens were collected and dried for all species identified to confirm IDs and also to make identifications of unknown species. These identifications were made at the Makerere University Herbarium by Ben Kirunda.

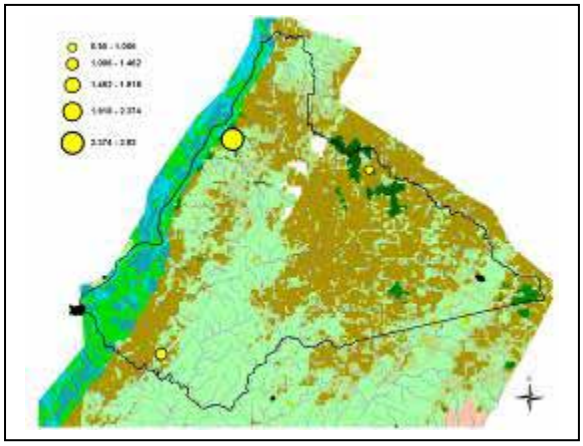
A total of 35, 15 and 37 plots were measured for sites 1, 2 and 4 respectively, and a total of 87 plots for East Madi Wildlife Reserve.

RESULTS

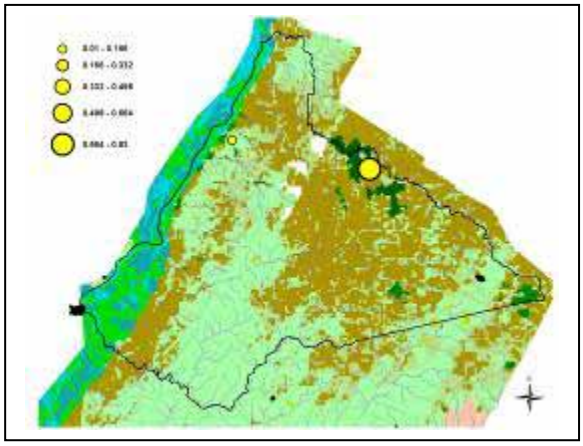
Large mammals

Sightings of large mammals or their sign was limited from these ground surveys and there were not enough sightings to attempt to calculate any densities of the large mammals. We were able to calculate relative abundances from encounter rates (no per km walked) for each site and these are mapped in figure 4.

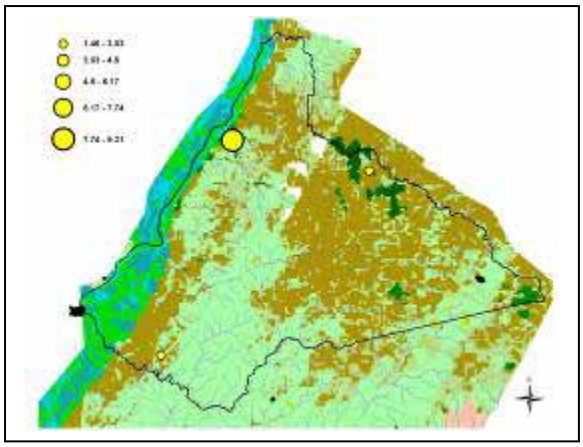
Primates



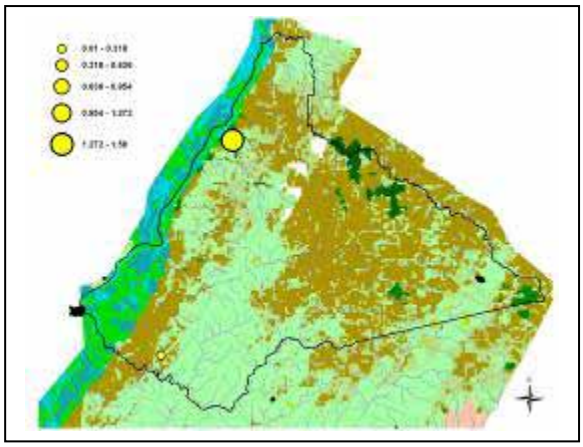
Baboon sighting



Blue monkey sighting

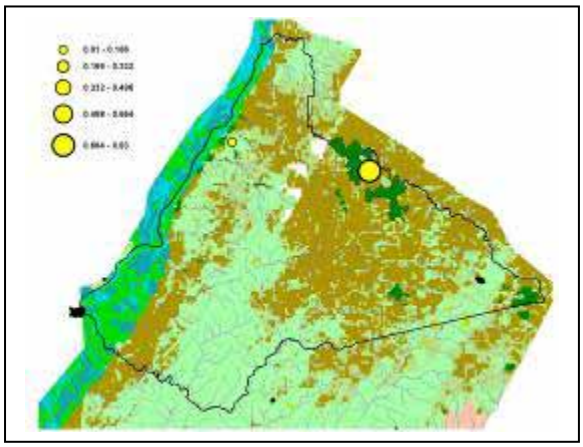


Black and white colobus sighting

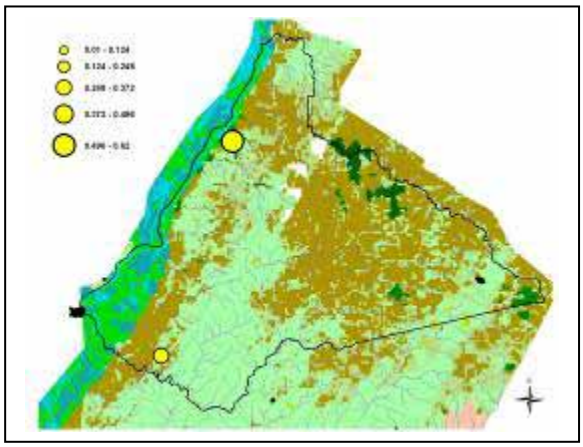


Vervet monkey sighting

Ungulate sightings

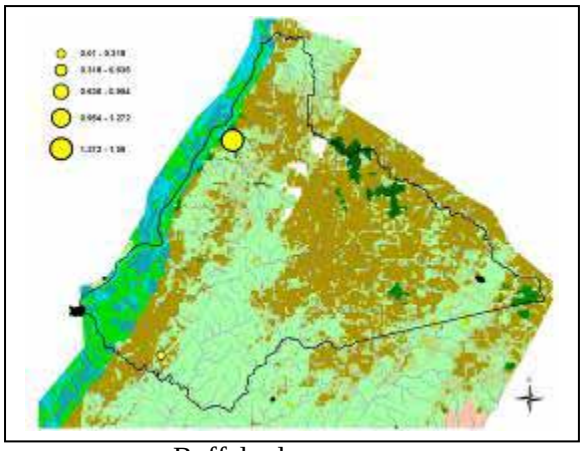


Redtail monkeys

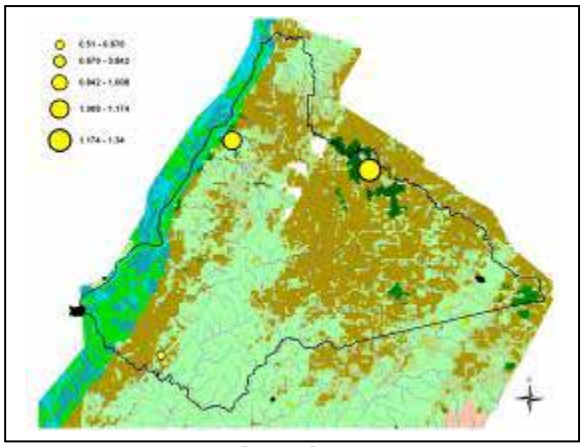


Warthogs

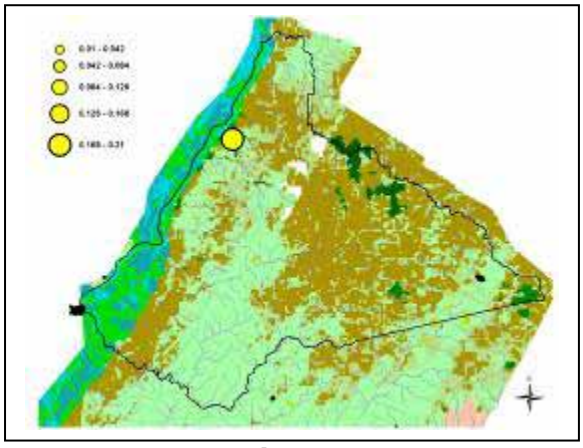
Ungulate dung encounter rate



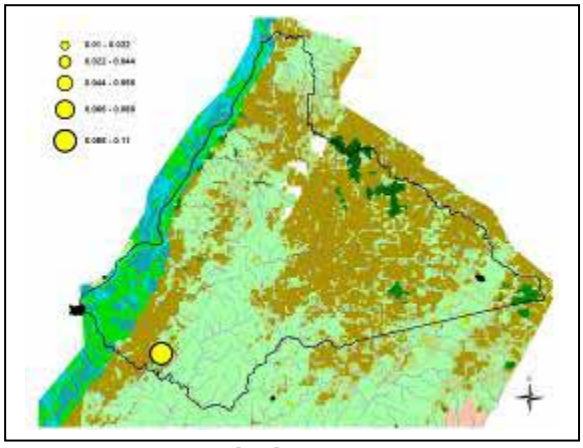
Buffalo dung



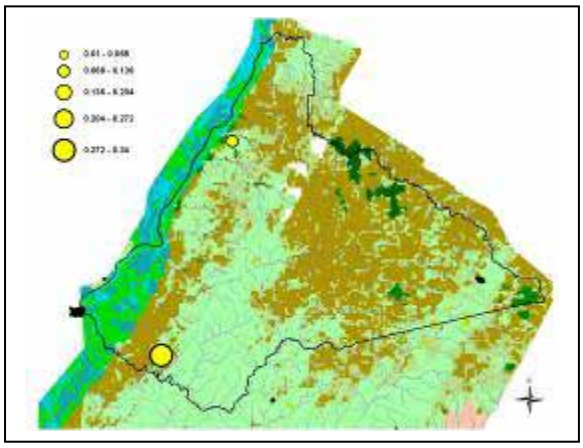
Bushpig dung



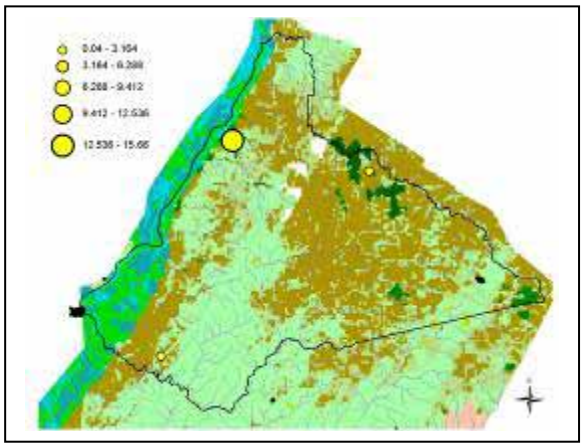
Hippo dung



Oribi dung



Uganda Kob dung



Waterbuck dung

Figure 4. Relative abundance (encounter rate per km walked) for large mammals that were observed several times in East Madi.

Additional mammal species for which sign was encountered rarely included: Aardvark, bushbuck, and a red duiker (species unknown).

Small mammals

The surveys for this report were conducted in a northern dry season where resources that would be responsible for small mammal population build up would ordinarilly be scarce. Such scarcity would translate into a low relative abundance of the small mammals. Overall all speciecs of terrestrial small mammals were captured in very low abundances, with only 7 individuals captured for the commonest species *Lemniscomys striatus* from all the sampling areas. Among the bats the fruit bat *Epomophorus labiatus* a usually abundant bat in open habitats was the commonest in all sampling habitats. In total 20 species of small mammals were recorded for the East Madi wildlife Reserve. These comprised of 9 species of bats, 4 of insectivores and 7 of rodents. Table 2 details the record of species captured in each of the locations at which sampling was based. Overall the richer species record was that of Site 4 and lowest for Site 1.

Table 2. List bats, insectivores and rodents recorded in the the sampling areas.

Order	Species	Site 4	Site 1	Site 2
Megachiroptera	*Epomorphorus labiatus*	√	√	√
	Micropteropus pusilus	√	√	√
Microchiroptera	*Hipposideros ruber*	√		
	Mimetillus moloneyi			√
	Mops major			√
	Myotis bocagei			√
	Nycteris hispida	√		
	Pipistrelus capensis		√	
	Pipistrelus rusticus		√	
Insectivora	*Crocidura olivieri*			√
	Crocidura gracilipes		√	
	Crocidura luna	√		
	Crocidura jacksoni	√		
Rodentia	*Aethomys hindei*	√		
	Grammomys dolichurus	√		
	Lemniscomys striatus	√	√	√
	Lophuromys sikapusi	√		
	Mastomys hildebrandtii	√		
	Mus minutoides		√	√
	Myomys fumatus	√		
Total bat species		**4**	**4**	**5**
Total Insectivore sp.		**2**	**1**	**1**
Total Rodent sp.		**6**	**2**	**2**
Overall total species		**12**	**7**	**8**

The list of species recorded (Table 2) comprises of open and savannah country species, with a clear abscence of forest environment species. Previous surveys (Table 3) however recorded three species (*Graphiurus murinus*, *Praomys jacksoni* and *Grammomys dolichurus*) that are commonly associated with forested environments. Of these three though, only *P. Jacksoni* seems to be more tightly associated with forest environments since the other two get commonly recorded away from forests.

Table 3. List of rodents and shrews known from before for Zoka forest (Davenport and Howard 1996)

Species	**Record**
Insectivores	
Crocidura gracilipes	*
Crocidura hildegardeae	*
Crocidura jacksoni	**
Crocidura olivieri	**
Crocidura pasha	*
Crocidura turba	**
Rodents	
Aethomys hindei	*
Grammomys dolichurus	*
Graphiurus murinus	*
Lemniscomys striatus	**
Mastomys hildebrandtii	**
Praomys jacksoni	*

*Notes: Species marked with ** were recorded in surveys conducted by the Forest Department inventory team in 1993 while those with * were from earlier surveys*

In Table 2, species in bold print are those recorded for the area for the first time. All are however species that are quite wide spread in Uganda and often quite common where they occur. *Myomys fumatus* in Uganda is so far known only from savannah environments of Northern Uganda. Two species (*Graphiurus murinus* and *Praomys. Jacksoni*), recorded previously for Zoka forest, were not encountered during the present surveys.

Table 4 lists the species of bats now known for the East Madi Wildlife Reserve area from previous records (* in table) and the 2008 surveys (** in table).

Six species (*Nycteris hispida, Hipposideros ruber, Pipistrelus rusticus, Mimetillus moloneyi, Myotis bocagei and Mops major)* are recorded in the area for the first time. In addition several species known from earlier records were not captured in the present surveys.

Figures 5 – 7 plot the cummulative number of species for each of small mammals (insectivores and rodents) of the 3 sampling areas. In two of the cases, the cummulative curves leveled off at 3 species which is by no means the true species richness for these areas. As will be observed from Table 3, Zoka forest alone has yielded a total of 12 species from previous surveys. In Amuru on the other hand the cummulative number of species was still on the rise after recording 8 species.

Table 4. Species list of bats currently known for the East Madi Wildlife Reserve

Family Pteropodidae (Fruit bats)		
Epomophorus labiatus	*	**
Micropteropus pusilus	*	**
Family Nycteridae (Slit faced bats)		
Nycteris hispida		**
Nycteris macrotis	*	
Family Hipposideridae (Horseshoe bats)		
Hipposideros ruber		**
Family Vespertilionidae (Vesper bats)		
Pipistrelus (Eptesicus) capensis	*	**
Pipistrelus rusticus		**
Pipistrellus somalicus	*	
Pipistrelus (Eptesicus) tenuipinnis	*	
Pipistrelus (Eptesicus) zuluensis	*	
Mimetillus moloneyi		**
Miniopteris schreibersi	*	
Myotis bocagei		**
Nycticeinops schlieffeni	*	
Scotophilus leucogaster	*	
Scotoecus albofuscus	*	
Family Molossidae (Free tailed bats)		
Mops major		**

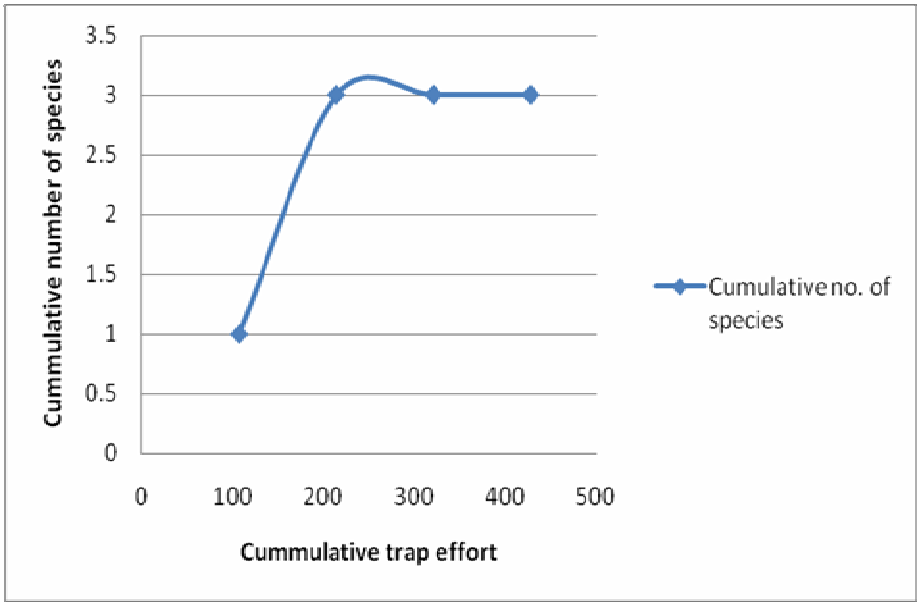


Figure 5. Cummulative number of speceis in the Zoka Forest area – site 2

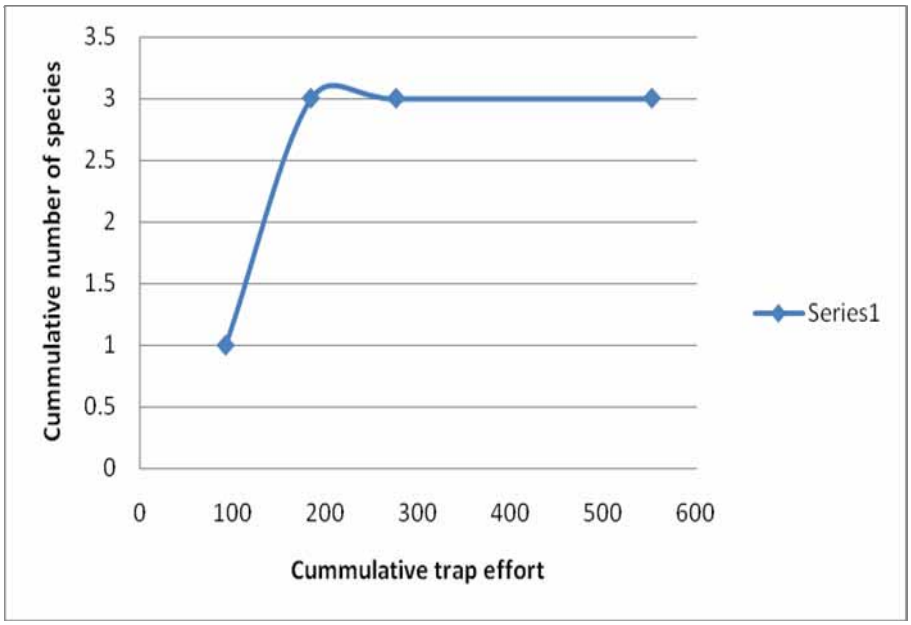


Figure 6. Cummulative number of species in Site 1.

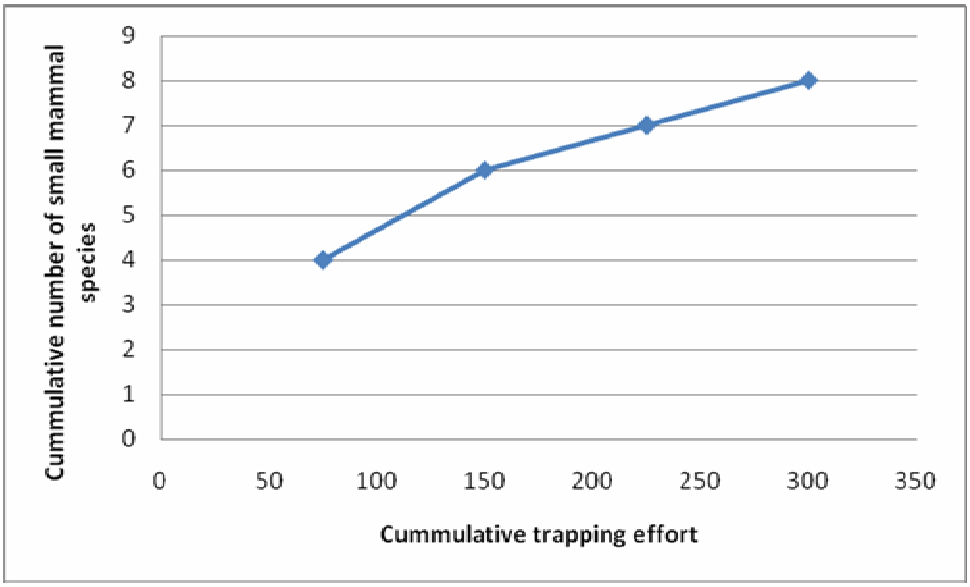


Figure 7. Cummulative number of species in Site 4.

Five species (*Crocidura hildegardeae, Crocidura pasha, Crocidura turba, Graphiurus murinus* and *Praomys jacksoni*) previously recorded for the Zoka Forest area were for example not recorded by the 2008 surveys. In addition several other species have been recorded for the East Madi wildlife Reserve for the first time (compare tables 2 & 3).

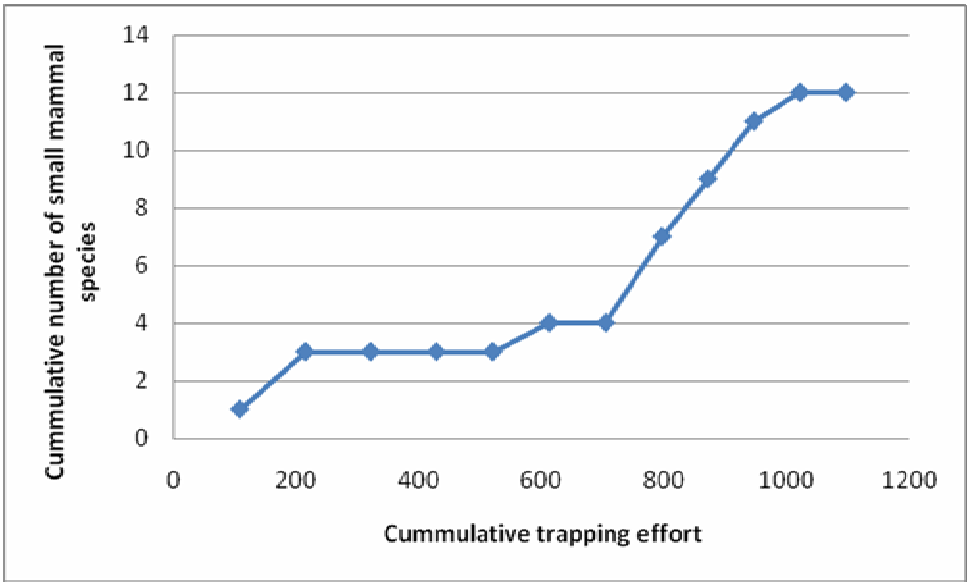


Figure 8. Overall cummulative species number and trap effort

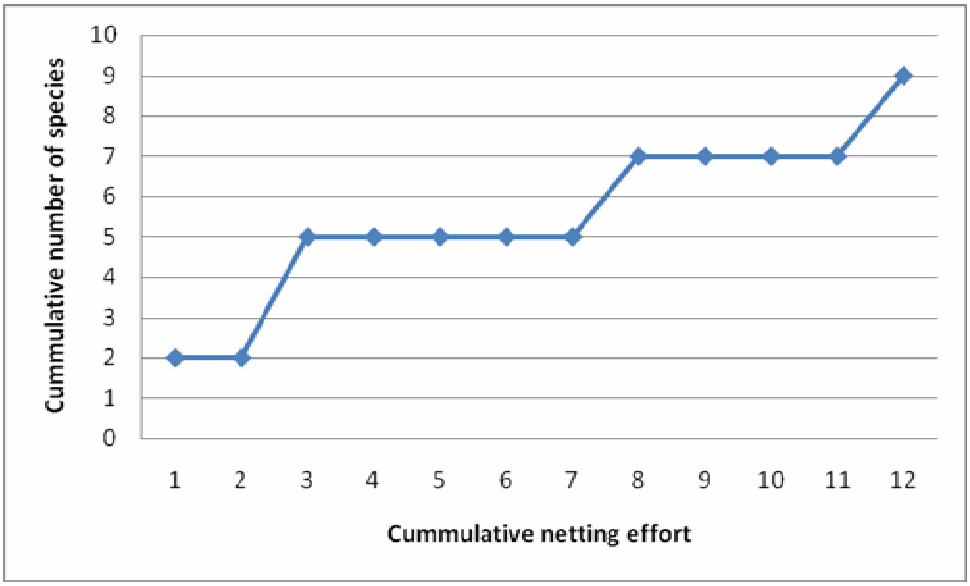


Figure 9. Overall cummulative species number and netting effort

Figures 8 & 9 show the overall total cumulative species records for the terrestrial small mammals (insectivores and rodents) and for bats respectively. In both cases it is possible several more species could have been recorded with investment in longer sampling. Fig 8 shows some sort of asymptote but Fig 9 has several plateuas but ultimately suggests that additional species would be added if more surveys were to be conducted. Indeed a publication by Kityo and Kerbis (1996) recorded as many as 11 species of bats (and more individuals 56 cf 27) from the Zoka reserve area alone in about half the sampling effort used for the present surveys (3456 metre net hours in 1996 compared to7056 meter net hours for present surveys).

In summary the known total list of mammals for the reserve now numbers at least 50 species. This excludes elephants which are known to occasionally visit the reserve from Murchison Falls Park but were not encountered during these surveys. Chimpanzees had been reported from Zoka Forest in the past but these reports were always questionable. We found no sign of this species in any of the forest patches visited and believe that people may have mistaken baboons for this species.

Bird surveys

A total of 122 bird species were recorded in East Madi Wildlife Reserve during these surveys; 84 species in site 1, 30 species in site 2 and 62 species in site 4 (see Appendix 1). Data from point counts were used to calculate rarefaction curves for the three sites (figure 10). These show some leveling off but indicate that with more time and effort more species would be found. Interestingly the forest site has fewer species than the savanna sites (figure 10). Why this should be is unclear. The ornithologists used in these surveys know forest birds well, having surveyed many of the Albertine Rift forests and are unlikely to have missed many birds. It is possible that Zoka forest is so isolated and small that few species have survived here when forest cover retreated in the past, or they never reached this forest in the first place. The bird community composition at site 2 is very different when compared with the other sites (figure 11).

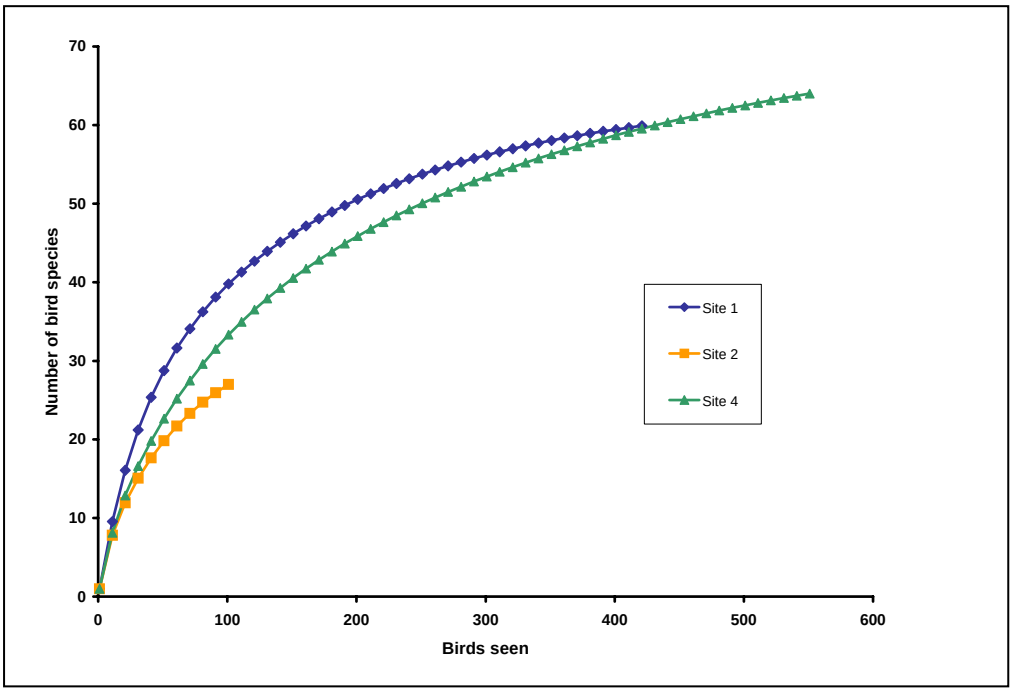


Figure 10. Rarefaction curves for the three sites plotted against the number of birds observed. Data from point counts.

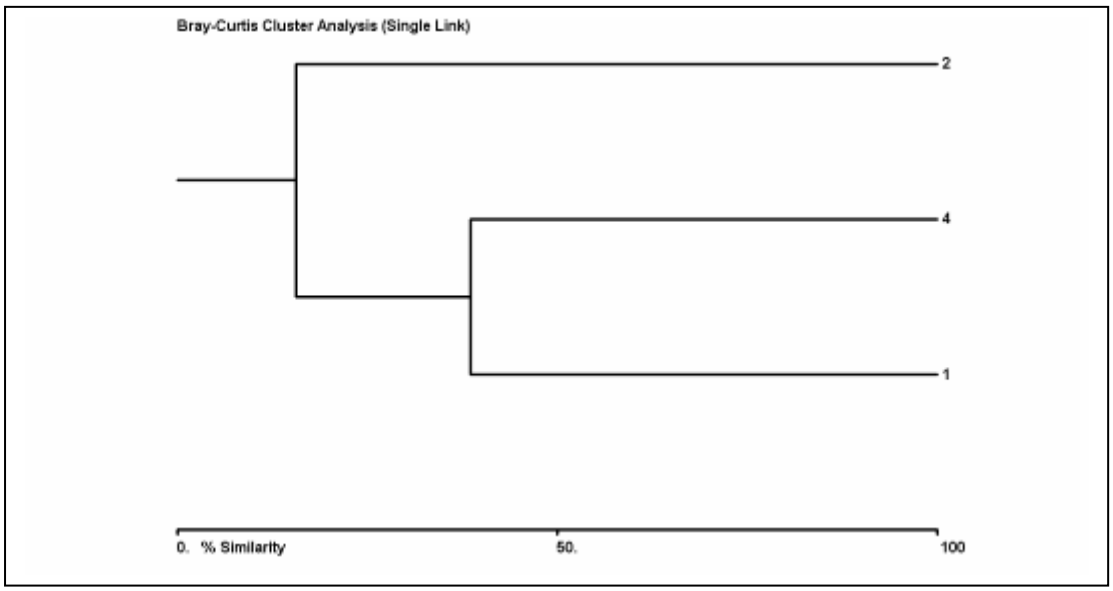


Figure 11. Similarity in bird community composition between the three sites. Data from point counts.

The relative abundance in species richness in birds between the three sites is plotted in figure 12.

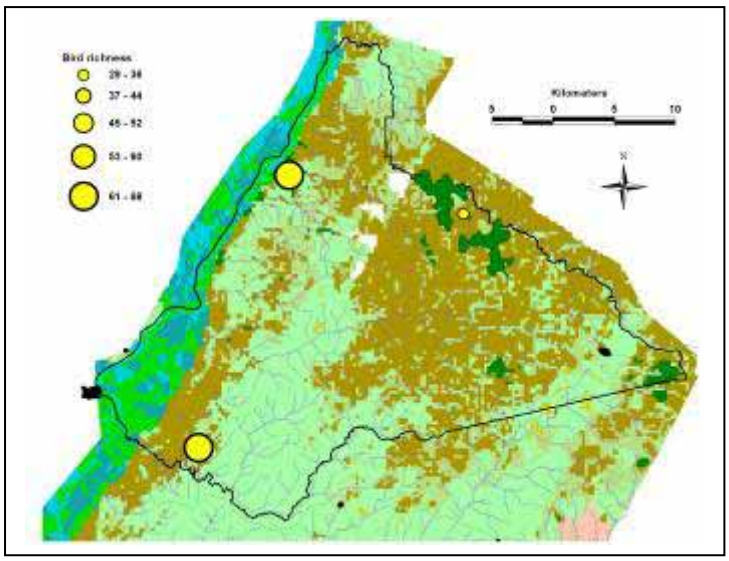


Figure 12. Relative abundance in species richness at the three sites.

Bird diversity was calculated using the Shannon-Wiener Index and the alpha index and shows that site 1 is the most diverse of the sites for birds (table 5).

Table 5. Shannon Wiener diversity and evenness and the Alpha diversity index calculated for the three sites.

Index	Site 1	Site 2	Site 4
Shannon H' Log Base 10.	1.604	1.206	1.398
Shannon Hmax Log Base 10.	1.778	1.431	1.806
Shannon J'	0.902	0.843	0.774
Alpha	19.063	12.064	18.753

The total number of birds recorded for Zoka/East Madi now numbers 181 species including the list in Davenport and Howard (1996). This study added 74 species to the total list. Davenport and Howard's list includes many savanna species although it is theoretically for Zoka Forest and we therefore are happier combining the Zoka and East Madi lists when comparing with theirs. This study also added an additional 14 species to the list specifically for Zoka forest (Appendix 1).

Plant species

A total of 329 plant species were identified as separate species for all sites combined (some specimens remain to be identified and may prove to be separate species so this number should be considered a minimum count). Site 1 had 97 species, site 2 had 206 species, and site 4 had 117 species. A total of 189 tree and shrub species were identified which compares with the 188 species identified from Zoka by Davenport and Howard (1996). Comparisons of the species lists indicates that 143 trees and shrubs were common to both lists and therefore 46 trees and shrubs were new for these surveys and an additional 45 species can be added to the total list from the 1990 surveys (appendix 2). Therefore 224 tree and shrub species, and a total species list of 374 plant species are known for the reserve. Rarefaction curves were also calculated for the plant species or specimen codes (figure 13).

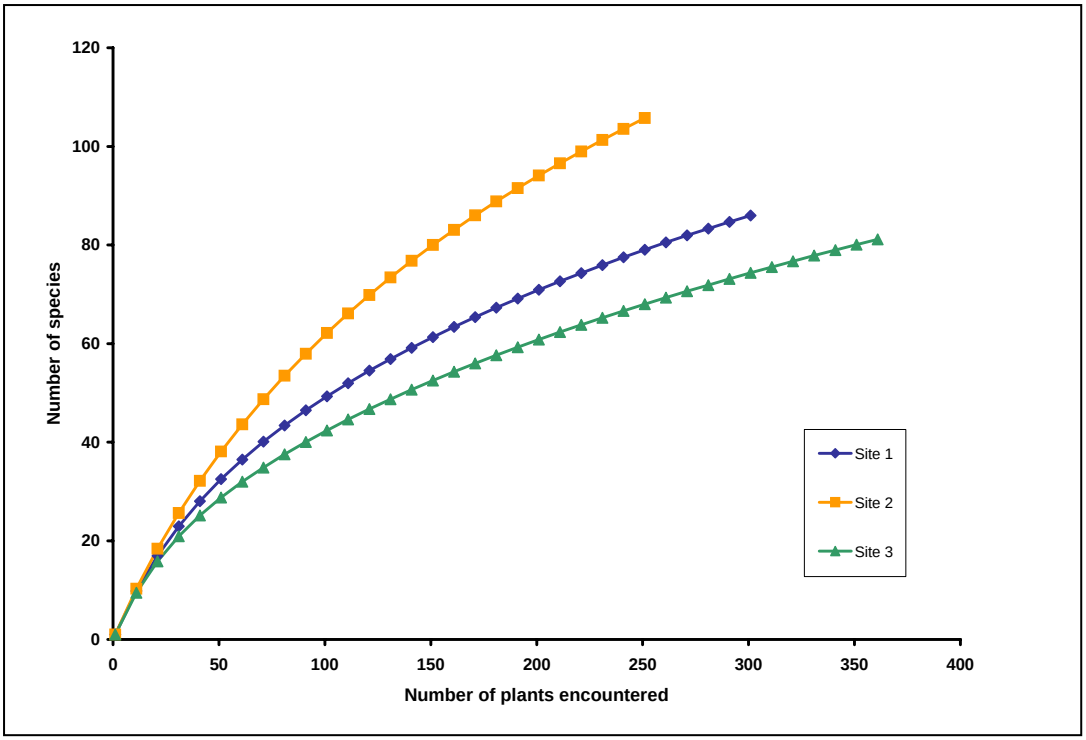


Figure 13. Rarefaction curves for plant species. Data from plots.

The rarefaction curves in figure 13 are not leveling off yet and it is very likely that more work would discover many more species for the reserve. We may have less than half the total species for the reserve according to these curves. This would make East Madi relatively rich for plant species.

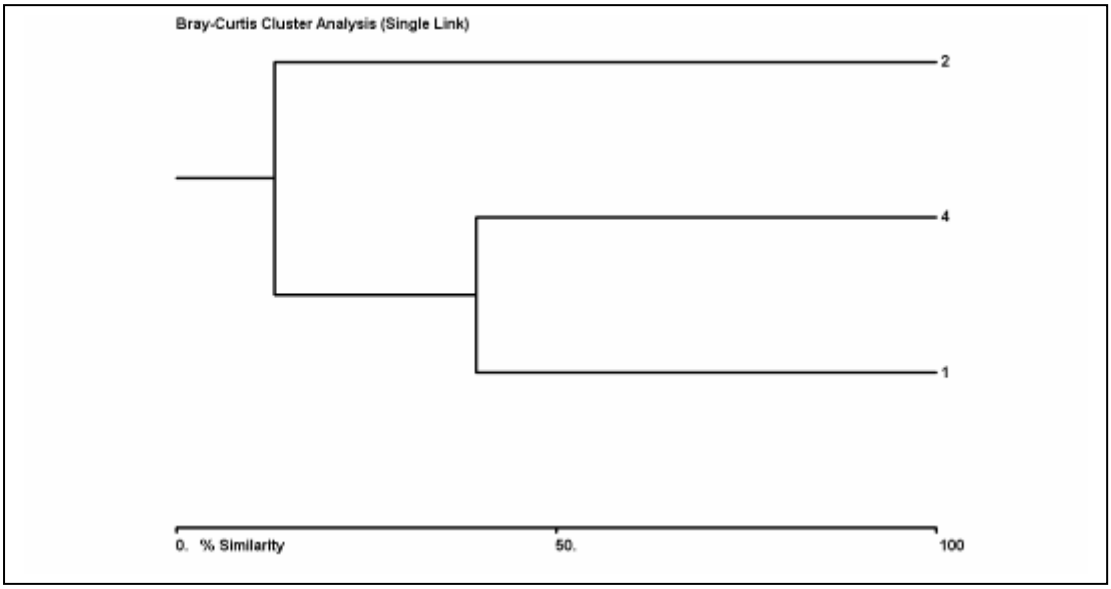


Figure 14. Similarity in plant communities between sites. Data from plots.

The degree of similarity between sites is low, site 2 being very different in plant composition (figure 14). Site 2 is by far the richer site which is not surprising given that it is a tropical forest and woodland compared with the other two savanna sites (figure 15).

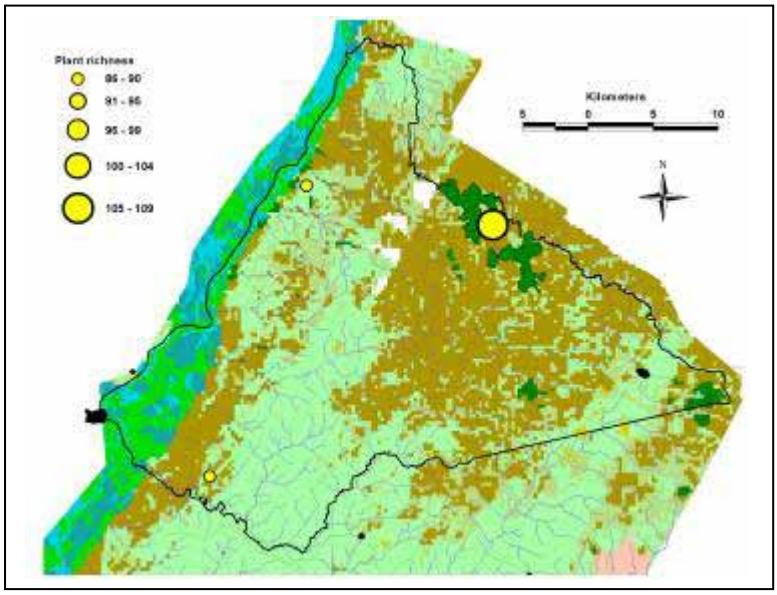


Figure 15. Plant species richness. Data from total plant lists for each site.

Plant species diversity indexes were also calculated as for the bird community: Shannon-Wiener and Alpha diversity (table 6). These also show that site 2 is the most diverse of the three sites.

Table 6. Diversity of the plant community at each site.

Index	Site 1	Site 2	Site 4
Shannon H' Log Base 10.	1.724	1.883	1.631
Shannon Hmax Log Base 10.	1.934	2.029	1.914
Shannon J'	0.891	0.928	0.852
Alpha	40.213	68.8	32.678

Human Impacts

Signs of human activity were recorded along transects and reconnaissance walks by the team looking for large mammal signs. These included sightings of pitsaw sites, sawn timber, collection of poles and stakes for building and beans respectively and pitfall traps to capture large mammals. In general signs of human activity were limited (figure 16).

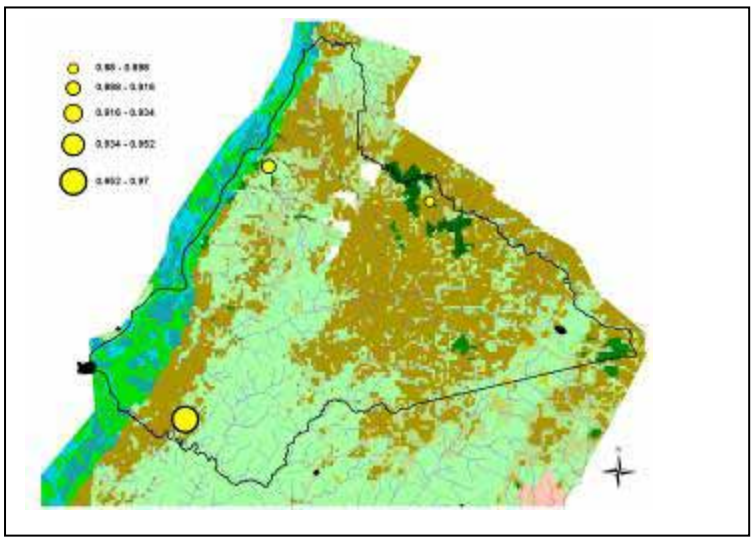


Figure 16. Relative abundance of signs of human impact along reconnaissance walks and transects.

CONSERVATION IMPLICATIONS

These surveys show that East Madi Wildlife Reserve is relatively diverse with at least 50 mammal species, 181 bird species and 374 plant species known for the reserve. Table 7 compares East Madi's species diversity with other savanna-woodland sites in the Albertine Rift region of western Uganda. This shows that East Madi ranks closely with other Wildlife Reserves for mammals but has fewer birds but possibly a good representation of plant species. Unfortunately few plant surveys have been made in Uganda in the savanna protected areas and those that have been carried out such as in Murchison Falls Park are mainly of tree/shrub species rather than all plants. However Esat Madi tree and shrub species compare well in number with Queen Elizabeth Park which also includes Maramagambo Forest Reserve.

Table 7. Comparison of species numbers for the three taxa surveyed here in other protected areas in western Uganda. Data from Plumptre et al. 2003.

Site	Mammals	Birds	Plants
Murchison Falls Park	109	476	149 (145 trees)
Queen Elizabeth Park	97	610	950 (288 trees)
Kyambura Wildlife Reserve	37	450	n/a
Toro-Semuliki Wildlife Reserve	69	435	n/a
Karuma Wildlife Reserve	57	n/a	n/a
East Madi Wildlife Reserve	50	181	374 (224 trees)

While not one of the most important sites for biodiversity conservation East Madi is important and is probably one of the more diverse savanna areas in northern Uganda.

At present human impacts are relatively few in comparison with forest reserves WCS field teams have surveyed. However we were prevented from surveying areas in the south east of the reserve which is closest to human habitation and it is possible we would have found more activity in this region.

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Appendix 1. Bird species sighted or heard at each site. *= new record for Zoka forest

Name	Site 1	Site 2	Site 4
Abdim's Stork*	1		
African Black-headed Oriole	1		
African Emerald Cuckoo		1	
African Fish-eagle*	1	1*	
African Green Pigeon		1	
African Grey Hornbill	1	1	1
African Harrier-Hawk*			1
African Hoopoe	1		
African Moustached Warbler	1		
African Palm Swift	1		1
African Paradise-flycatcher	1	1	1
African Pygmy Kingfisher	1	1	1
African Scops-Owl	1		
African Thrush*			1
Bateleur	1		1
Beautiful Sunbird*	1		
Black Cuckoo-shrike*	1		
Black Kite	1		
Black-&-white Casqued Hornbill	1	1	
Black-and-white Cuckoo*	1		
Black-bellied Firefinch			1
Black-billed Barbet	1		1
Black-billed Wood-Dove*	1		1
Black-chested Snake-eagle*			1
Black-crowned Tchagra*	1		1
Black-headed Batis*	1		
Black-lored Babbler*	1		1
Black-throated Apalis*		1*	
Blue-breasted Kingfisher	1	1	1
Blue-cheeked Bee-eater*			1
Blue-headed Coucal*	1		
Blue-naped Mousebird*	1		
Blue-spotted Wood-Dove	1		1
Broad-billed Roller	1	1	1
Bronze Mannikin	1		1
Brown Parrot*	1		
Brown-throated Wattle-eye*	1		
Collared Sunbird	1	1	1
Common Bulbul	1	1	1
Common Buzzard*	1	1*	1
Common Quail*			1
Common Sand Martin *	1		1
Common Squacco Heron*	1		
Common Waxbill*	1		
Compact Weaver	1		
Croaking Cisticola	1		
Diederik Cuckoo	1		
Eastern Grey Plantain-eater	1		1
Eurasian Bee-eater*	1		1
Fork-tailed Drongo*	1		
Giant Kingfisher*			1
Great Cormorant*	1		
Great Sparrowhawk*	1		
Greater Blue-eared Starling*	1	1*	

Greater Honeyguide*	1		1
Green Wood-hoopoe	1		
Green-backed Eremomela*	1		
Green-backed Twinspot*		1*	
Grey-backed Camaroptera	1		1
Grey-capped Warbler*	1		
Grey-headed Bush-shrike	1		1
Grey-headed Kingfisher*	1		
Hadada Ibis	1	1	1
Hamerkop*		1*	
Helmeted Guineafowl*	1	1	
Lesser-striped Swallow			1
Levant Sparrowhawk*	1		
Little Greenbul*		1*	
Little Swift*			1
Lizard Buzzard	1		
Malachite Kingfisher	1		
Montagu's Harrier*			1
Namaqua Dove	1		
Northern Carmine Bee-eater			1
Northern Puffback	1		1
Nubian Woodpecker*	1		
Olive Sunbird		1	
Pale Flycatcher			1
Papyrus Gonolek*	1		
Plain Martin*	1		
Plain-backed Eremomela*			1
Purple-banded Sunbird*			1
Rattling Cisticola*	1		1
Red-bellied Paradise-flycatcher*		1*	
Red-cheeked Cordon-bleu	1		
Red-chested Cuckoo*			1
Red-eyed Dove	1		1
Red-faced Cisticola	1		1
Red-faced Crombec*		1*	
Red-throated Bee-eater			1
Ring-necked Francolin*	1		1
Ross's Turaco*	1		
Scaly-throated Honeyguide*		1*	
Senegal Coucal	1		
Siffling Cisticola*			1
Silverbird*	1		
Singing Cisticola*			1
Slender-billed Greenbul*		1*	
Snowy-headed Robin-Chat*	1		1
Speckled Mousebird			1
Speckle-fronted Weaver*	1		
Spot-flanked Barbet*	1		
Striped Kingfisher	1		1
Swallow-tailed Bee-eater	1		
Tambourine Dove	1	1	
Tawny-flanked Prinia	1		1
Tree Pipit			1
Vinaceous Dove*	1		1
Violet-backed Starling			1
Whinchat	1		1
White-browed Coucal*			1

White-crested Turaco	1		
White-headed Barbet*			1
White-headed Saw-wing			1
White-throated greenbul		1	
White-winged Warbler*	1		
Woodland Kingfisher	1	1	1
Yellow-bellied Hyliota*	1		1
Yellowbill*	1	1*	
Yellow-breasted Apalis*			1
Yellow-fronted Tinkerbird*	1	1*	1
Yellow-throated Greenbul *		1*	1
Total species	84	30	62

Appendix 2. Plant list for East Madi Reserve with presence/absence data for each sector surveyed. Those species recorded in previous surveys (Davenport and Howard, 1996) are also marked (*).

Species	Site 1	Site 2	Site 4
Abrus fruticulosus	1		
Abrus precatorius	1	1	
Acacia gerrardii*	1		
Acacia hockii*		1	
Acacia macrothyrsa	1		
Acacia pentagona		1	
Acacia seyal	1		
Acacia sieberiana*	1		
Acalypha neptunica*		1	
Acalypha racemosa		1	
Acalypha villicaulis		1	1
Acanthus pubescens		1	
Achyranthes aspera	1	1	1
Adenia bequeartii			1
Adenia cissampeloides	1		
Agelaea pentaphylla		1	
Albizia ferruginea	1		1
Albizia glaberrima		1	
Albizia grandibacteata*		1	
Albizia gummifera*		1	
Albizia zygia*	1	1	1
Alchornea laxiflora*		1	
Allophylus africana*	1		
Ampelocissus africana			1
Anchomanis giganteus		1	
Annona senegalensis*	1	1	1
Antiaris toxicaria*	1	1	1
Antidesma membranaceum	1		
Aphania senegalensis*		1	1
Argomuellera macrophylla*		1	
Argomuellera sp		1	
Artabotrys likimensis		1	1
Artabotrys velitinus		1	
Asparagus africanus	1		
Asplenium emargnatum		1	
Astripomoea malvaceae			1
Baissea caudiloba		1	
Balsamocitrus dawei*		1	
Baphia wollastonii*		1	
Barleria submollis	1		
Bersama abyssinica*		1	
Blepharis maderaspatensis	1		
Blighia unijugata*		1	1
Borassus aethiopicum*	1		1
Bracharia documbens			1
Bridelia micrantha*		1	1
Bridelia ndellensis	1		
Brillantaisia cicantricosa		1	
Butyrospermum paradoxum*		1	
Calamus deerratus*		1	
Caloncoba schweinfurthii		1	
Calycosiphonia spathicalyx*		1	
Capparis tomentosa*	1	1	1

Capscum annuum		1	
Cardiospermum helicacabum			1
Carissa edulis*			1
Cassia bicapsularis	1		
Cassia mannii*		1	
Cassia petersiana*			1
Cassipourea congoensis		1	
Celosia golubosa		1	
Celtis zenkeri*		1	
Chaetecma aristata*		1	
Chrysophyllum albidum*		1	
Chrysophyllum muerense*		1	
Cissamploss mucronata		1	
Cissus quadrangularis		1	1
Citropsis articulata*		1	
Clausena anisata*		1	
Cleistopholis patens*		1	
Clerodendrum pogei		1	
Coffea canephora*		1	
Cola gigantea*		1	1
Combretum capituliflorum*		1	
Combretum collinum*	1	1	1
Combretum fragrans			1
Combretum fuscum	1	1	1
Combretum molle*	1		1
Commelina diffusa	1		1
Cordia millenii*		1	
Costus dubius		1	
Craibia brownii*		1	
Crateva adansonii*	1		
Croton salviticus		1	
Culcasia falcifolia		1	
Custus dubius			1
Custus lucanusianus			1
Cyperus laspan			1
Cyperus sp			1
Cyphostemma adenocaule		1	
Dalbergia lactea		1	
Dalbergia melanoxylon*	1		
Daniellia oliveri*			1
Desmodium setigerum			1
Dichapetalum ugandense		1	
Dicliptera maculata	1		
Dicrostachyus cinerea*		1	
Digitaria diagonalis			1
Diospyros abyssinica*	1	1	1
Diospyros mespiliformis*			1
Dissotis decumbens			1
Dombeya bagshawei*		1	
Dombeya kirkii		1	
Dovyalis macrocalyx*		1	
Dracaena fragrans*		1	1
Dryopteris manniana			1
Drypetes gerrardii*		1	
Drypetes ugandensis*		1	
Dyschoriste nagchana		1	
Ekebergia capensis		1	1
Elaeodendron buchananii			1

Englerophytum oblancoelatum		1	
Entada abyssinica*	1		
Entada rheedei		1	
Entandrophragma cylindricum		1	
Entandrophragma utile*		1	
Erythrina abyssinica*	1		1
Erythrococca atrovirens		1	
Erythrophleum suaveolens*		1	
Erythroxylum fischeri*	1	1	1
Ficus glumosa*			1
Ficus ingens*			1
Ficus mucuso*			1
Ficus ovata*		1	1
Ficus platyphylla*			1
Ficus pseudomangifera*		1	
Ficus saussureana*		1	
Ficus sur*			1
Ficus sycomorus*	1		
Ficus trichopoda*	1		
Ficus vallis-choudea*			1
Flacourtia indica*	1		1
Flueggea virosa*	1	1	
Garcinia buchananii*		1	1
Gardenia vogelii		1	
Gardenia volkensii	1	1	
Geophila repens			1
Glenniea africana		1	
Glyphiea brevis*		1	
Gongronema angolense		1	1
Grewia mollis*	1		1
Grewia similis		1	
Harrisonia abyssinica*	1		
Hexalobus monopetalus*	1		1
Hilleria latifolia	1	1	
Holoptelea grandis*	1	1	
Hoslundia opposita*			1
Hygrophila uliginosa			1
Hymenocardia acida*			1
Hymenodictyon floribundum	1		
Hyperrhania cymbaria			1
Hyperrhania filipendula			1
Hyperrhania poecilotricha		1	1
Hyperrhania rufa	1		
Hypertheria dissoluta			1
Hypoestes forskaolii		1	
Imperata cylindrica	1		
Indigofera emarginella*			1
Indigofera garckeana		1	
Ipomoea involucrata	1	1	1
Irvingia gabonensis		1	
Isolana congolana		1	
Jasminum pauciflorum		1	
Justicia flava	1		
Justicia ladanoides			1
Justicia nyassana		1	
Keetia gueinzii		1	
Keetia venosa		1	1
Keetia zanzibaricum		1	

Khaya anthotheca		1	1
Kigelia africana*	1	1	1
Lagenaria rufa	1		
Landolphia buchananii		1	
Lankasteria elegans		1	
Lannea barteri*	1	1	1
Lannea schweinfurthii	1		
Lasiodiscus mildbraedii*		1	
Lecaniodiscus cupanioides*		1	
Leea guineense		1	
Leptaspis zeylanica		1	
Lindackeria bukobensis		1	
Loeseneriella africana	1	1	
Lonchocarpus laxiflorus*	1		1
Loudetia arundinecea	1		
Loudetia phragmitoides			1
Maerua duchesnei*		1	
Maerua triphylla	1		
Mallotus oppositifolia*			1
Manilkara obovata			1
Margaritaria discoidea*		1	1
Maytenus heterophylla*			1
Maytenus senegalensis*	1		1
Maytenus undata*		1	
Microglossa pyrifoilia		1	
Mildbraediodendron excelsum*		1	
Millettia lacus		1	
Mimusopsis bagshawei*	1	1	
Momordica foetida		1	
Momordica pterocarpa		1	
Monanthotaxis buchananii	1		1
Monanthotaxis ferruginea			1
Monanthotaxis lucidula		1	
Monanthotaxis orophila		1	
Monodora angolense		1	
Morus mesozygia*		1	
Motandra guineense		1	
Myrianthus holstii		1	
Nelsonia smithii		1	
Neoboutonia macrocalyx	1	1	
Ochna afzelii		1	
Ochna bracteosa*		1	
Ochna holstii*		1	
Olax gambicola*		1	
Olyra latifolia		1	
Oncoba spinosa*	1	1	1
Oplismenus hirsuta	1	1	1
Orthosiphon australis			1
Oxyanthus unilocularis*		1	1
Pandanus chiliocarpus		1	
Panicum breviflorum		1	
Panicum deustum	1		
Panicum heterostachyum	1		
Panicum maximum	1		1
Panicum robynsii		1	
Parkia filicoidea*		1	
Paropsia guineensis		1	
Paspalum glumacuem			1

Paullinia pinnata		1	
Pavonia urens	1		
Pennisetum purpureum			1
Periploca linearifolia	1		
Periploca nigrescens	1		1
Phonex reclinata*		1	
Phyllanthus muellerianus	1		
Piliostigma thonningii*		1	1
Piptadiniastrum africanus		1	
Pisonia aculeata		1	
Polyspatha paniculata		1	
Pothorphe umbellata		1	1
Pouteria altissima		1	1
Premna angolensis*	1		
Pseuderanthemum ludovicianum		1	
Pseudocedrella kotschii*			1
Pseudomussaenda flava	1		1
Pseudospondias microcarpa*		1	
Psorospermum febrifugum*			1
Pterocarpus lucens*	1		
Pycnanthus angolensis*		1	
Pycnostacys meyeri			1
Psydrax parviflora			1
Rauvolfia vomitoria		1	
Rawsonia lucida*		1	
Rhaphiostylis beniniensis	1		
Rhinacanthus virens		1	
Rhus natalensis*	1		
Rhynchosia micrantha	1		
Rhynchostigma racemosum	1	1	
Ricinus comminis	1		
Rinorea angustifolia		1	
Rinorea brachypetala*		1	
Rinorea ilicifolia*		1	
Rinorea oblongifolia*		1	
Rothmania urcelliformis*		1	
Rourea coccinea		1	
Rutidea smithii		1	
Rytigynia bugoyensis		1	
Saba comorensis	1	1	1
Salacia chlorantha		1	
Sapium ellipticum*		1	
Sateria megaphylla	1		
Sateria sphacelata			1
Schrebera arborea*		1	
Sclerocarya birrea	1		
Secamone africana	1		
Secamone stuhlmannii		1	1
Securidaca longipenduculata	1		1
Solanum incanum*			1
Sporobolus pyramidalis			1
Steganotaenia araliacea*	1		
Stephania abyssinica		1	
Sterculia dawei		1	
Sterculia setigera*	1		1
Stereospermum kunthianum*	1	1	1
Streptogyna crinita		1	
Strychnos innocua*			1

Strychnos mitis*		1	1
Suregada procera*		1	
Tabernaemontana pachysiphon		1	
Tamarindus indica*	1		
Tapura fischeri*		1	
Tarenna pavettoides*		1	
Terminalia brownii*	1		
Terminalia glaucescens*	1	1	1
Tetracera potatoria		1	
Tetrapleura tetraptera*		1	
Thecocaris lucida		1	
Thelypteris fadenii			1
Thelypteris striata			1
Thunbergia alata	1	1	1
Tiliacora funifera		1	
Tinospora caffra		1	
Toona ciliata			1
Trachyphrynium braunianum		1	
Tragia brevipes	1	1	
Treculia africana*		1	
Trema orientalis*		1	
Trichilia dregeana*	1	1	1
Trichilia emitica	1		
Trichilia martineaui*		1	
Trichilia prieureana*	1	1	1
Turraea vogelii*		1	
Uncaria africana		1	
Uraria picta			1
Urochloa panicoides			1
Urtica massaica		1	
Uvaria angolensis*		1	
Uvariopsis congensis*		1	
Vangueria apiculata*		1	
Ventilago diffusa		1	
Vepris nobilis	1	1	1
Vernonia amygdalina*	1		1
Vernonia smithiana			1
Vitex doniana*			1
Whitfieldia elongata		1	
Ximenia americana*	1		
Xylophia parviflora*	1		
Zahna golungensis*		1	
Ziziphus abyssinica*	1		
Ziziphus mucronata*		1	
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