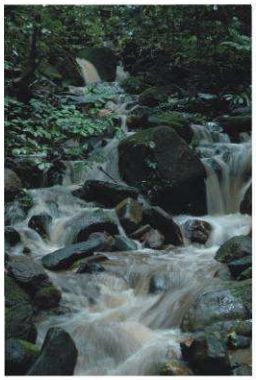
The Biodiversity West of Waka



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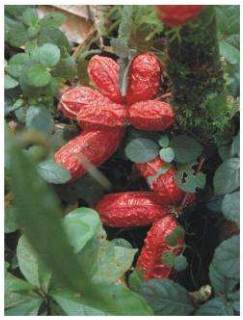


Missouri Botanical Garden

The biodiversity of West of Waka

Preliminary results and observations

Prepared by Dr M.E. Leal

Missouri Botanical Garden
Gabon 2006

Prologue

Missouri Botanical Garden was awarded a Central African Regional Program for the Environment (CARPE) subcontract from the Wildlife Conservation Society (WCS) to perform a series of tasks.

These tasks were defined accordingly:

1. Map biodiversity with special focus on certain taxonomical groups, i.e. Caesalpinioideae and Begonias.

2. Identify Biodiversity Sanctuaries that complement the existing park system.

3. Improve the understanding of the Pleistocene forest refuge history to be able to make recommendations for landscape management

During this fiscal year Missouri Botanical Garden (MBG) has executed botanical activities assessing the plant biodiversity West of Waka national park. The first results and observations are presented here (task 2).

The site west of Waka was chosen after a GIS-analysis which showed that it may have been a forest refuge area. The conformation of a high plant biodiversity for the site would support the model which was used to identify postulated forest refugia (task 3).

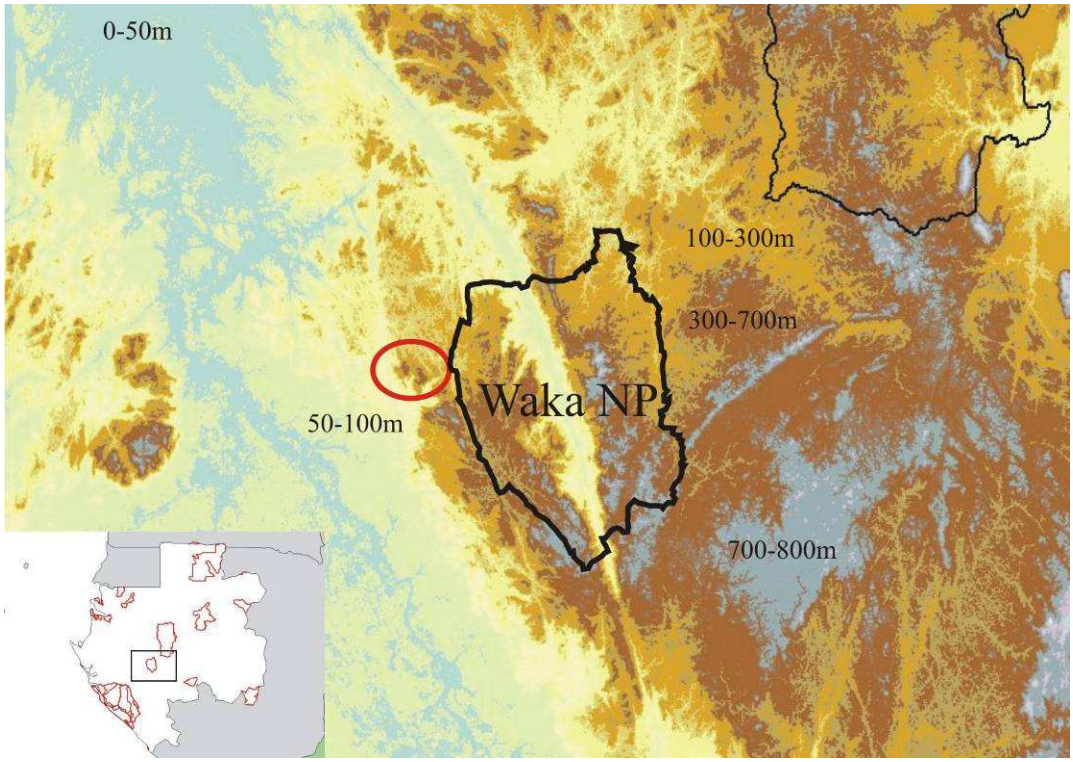
The results and conclusions here presented are preliminary in the sense that the full identification of the plants is still pending. The number of transects (6) are enough to observe general trends which are useful for conservation management.

The author is a specialist in the Pleistocene Refuge Forest theory, in vegetation-climate dynamics and expert in the plant biodiversity of Gabon and central Africa.

Miguel E. Leal

June 2006

The biodiversity of **West** of **Waka**



The geographical position of the study site (red and encircled) West of Waka NP.

The western hills of Waka

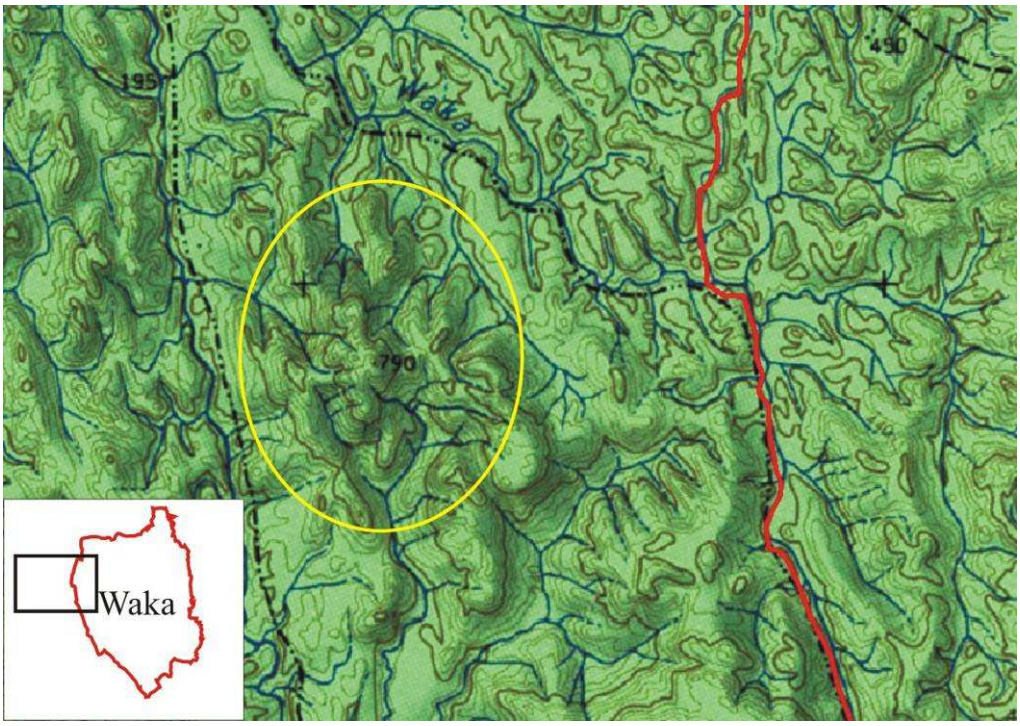
The Waka National Park is split by the Ikobé Rift valley in two elevated areas, the western and eastern hills. The eastern hills are part of the "mountain range" which separates the coastal lowland plain from the interior elevated plateau.

The western hills lay more isolated and as the first range of hills they mark the transition from the coastal lowland plain to the more "mountainous" massif du Chaillu.

Rainfall in the western hills is relatively high as the rain drifts in from the ocean which makes it less dependent on internal recycling like further east into the park or in the mountains where rain fall is lower.

The forest in the western hills has been in concession and logged before the declaration of the park system. But after the initial exploitation, the logging company SBL has decided to refrain from further logging in this part of their concession as it is now part of the buffer zone around the park.

The western hills were inventoried to locate botanically valuable forest which could serve as compensation after the NE part of the park was severely logged by the logging company Bordamur during the process of declaration of the park (see the Biodiversity of NE Waka rapport).



Section of the hills west of Waka NP (borderline red) and the hill system which was investigated (encircled yellow).

Biodiversity sanctuaries

Biodiversity sanctuaries are a tool for conservation to protect botanically valuable forests outside the park system of Gabon. Establishing such protected areas should in principle be fairly straightforward as logging companies are legally obligated to set aside 5% of their concession.

Forest history

Botanically valuable forests for biodiversity sanctuaries are located by applying the fundamentals of the Pleistocene forest history theory. These same fundamentals were used to establish the present park system.

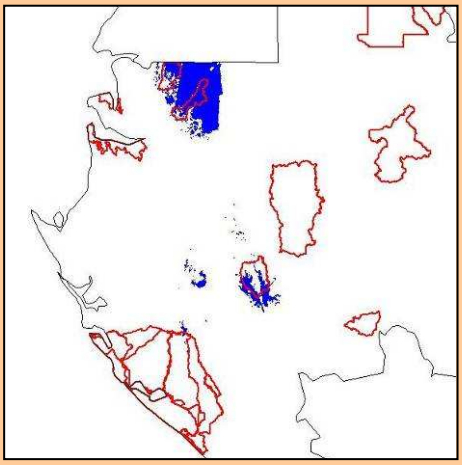
The Pleistocene forest history theory describes how the African rain forest was much smaller and fragmented some 18,000 years ago by global cooling. Also during the Holocene (10,000 yrs- present) the forest has been smaller. Most recently, 2500 years ago the central African forest had become reduced and fragmented due to regional or global warming.

Both global cooling and warming have left a mark on the pattern of biodiversity, which is still visible in the present-day rain forest. But global cooling and warming have had a different effect on how the forest became disturbed and reduced.

Climate change due to global cooling mostly affected the forest in the lowland reducing it to gallery forest. Forest in elevated areas (above 500 m) was able to persist because of the frequent occurrence of low clouds which created misty conditions.

Climate change related to global warming caused the opposite effect. Whereas before forests on hill tops were sheltered, they now became exposed and disappeared. Drought sensitive plant species were only able to persist in nearby narrow valleys where exposure to the desiccating heat was reduced.

Therefore, in order to locate botanically valuable forests the effects of both global cooling and warming should be considered.



Pleistocene landscape core areas (blue) in Gabon

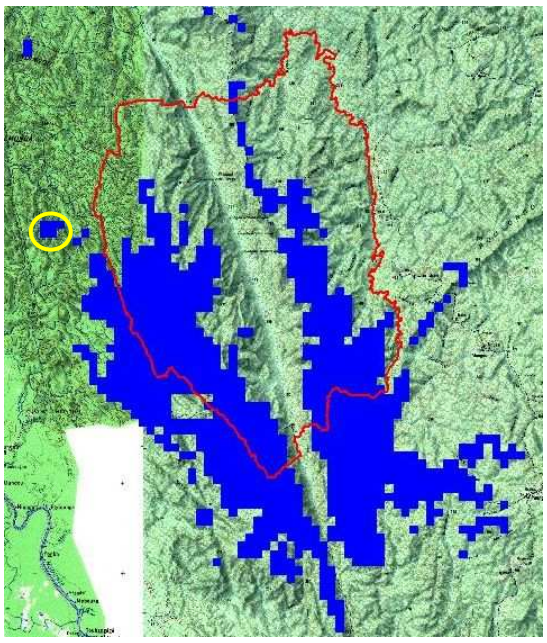
Maniellia gustavii a rare orchid ►

A refuge Begonia present in hills studied

The model

In order to find the refuge forest core areas, a GIS analysis (Arcview) is performed by overlapping rainfall and elevation data. Procedure is to build a query to find areas where mean annual rainfall is higher than 2000 mm and elevation higher than 500 m. This combination of environmental characteristics separates dry hilly areas from wet hilly areas.

The resulting map shows (on the left above) that by these parameters the Massif du Chaillu is considered a dry hilly area and close to Fougamou wet hilly area.



This first analysis shows where the African rain forest most likely persisted during climate change related to global cooling. This is a postulation which needs to be verified by the presence of forest refuge indicators. These are species-group like refuge Begonias (see above) which migrate poorly. Therefore when the forest disappears in a locality these species become extinct and remain so even when the forest reappears.

The next step in the procedure is to check whether the area identified in the GIS analysis is also rugged in topography. In this step the postulated refuge forest is superimposed on a national map which is the only source for geomorphology (see left). In this way flat and wet plateaus are distinguished from rugged and wet hill complexes. Wet plateaus most probably became deforested during the latest period of global warming 2,500 years ago.

This two-step procedure is a model by which the effects of both global cooling and warming are estimated which helps to reconstruct the forest history of Gabon.

◄The postulated refuge forest (blue) superimposed on a topographical national map. In circled in yellow is area studied.

Patterns of Biodiversity

Evaluation

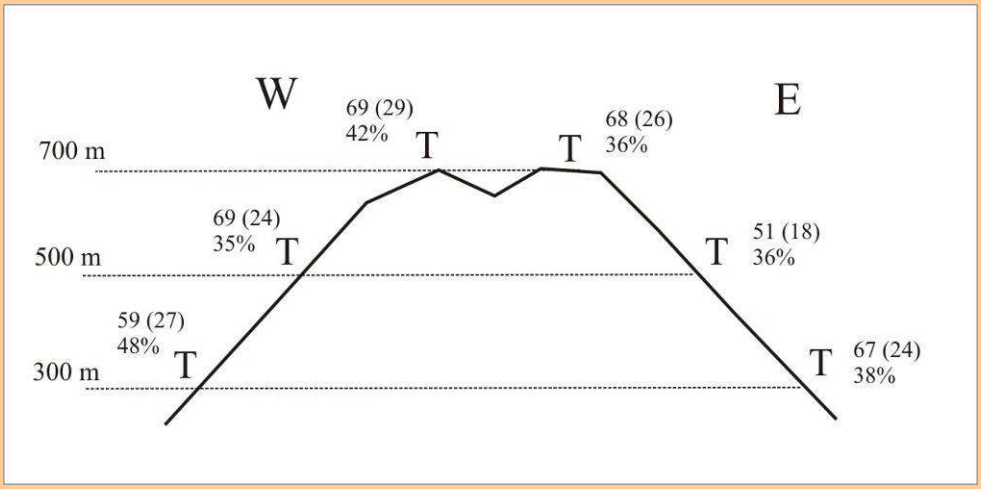
The objective of this mission was to locate botanically interesting forest outside the Waka NP. The GIS analysis showed that a large block of forest was identified west and south of the park. For evaluation an isolated hill complex north of the main area was chosen to be assessed.

The biodiversity assessment was done by putting in transects (200 m x 5 m) on which every individual with a diameter at breast height (dbh) of 5 cm and greater was recorded and identified. For each species which remained unidentified a voucher specimen was taken for further examination in the herbarium of Libreville or Wageningen.

To be able to evaluate that the forest of the western hills is more botanically interesting, this site, West Waka was compared with the site of NE Waka on species richness (gamma-), species turnover (beta-) and local diversity (alpha-diversity).

In total 6 transects were put in along the west and east facing slopes of the hill complex at 300m and 500m, and 700m. General collecting complemented the ecological data collected and gathers information on herbaceous and rare plant species.

Transects were put in after the altitudinal zone was prospected to estimate the heterogeneity of the environment, and habitat diversity. This procedure ensures to record maximum species diversity present within a certain altitudinal zone and avoids replication, i.e. transects with a similar species composition.



Profile of the hill complex range showing the distribution of the transects (T) from bottom to summit and aspect, the figures at each transect are the total number of species, between brackets the number of species restricted to that transect (endemic) and the percentage.

General characteristics

In total species 233 (morpho-) species were recorded on the 6 transects, 155 species on the western slope (3 transects) and 150 species on the eastern slope (3 transects). On average 66 species were recorded per transect. The lowest number was 51 species at 500 m at the eastern slope and the highest number was 69 species on 500 m at the western slope and at 700 m at the summit. 85 species were recorded on both sides. The majority of the species (148) were restricted to a single transect.

NE	total	263						
aspect	W	W	W	E	E	E	E(p)	
altitude	100m	300mw	500mw	700m	500me	350m	360mp	average
alpha	51.8	67.2	67.4	35.6	48.7	38.7	40.1	49.9
species	55	64	66	44	55	44	56	55
n	98	107	112	87	102	82	122	101
endemic	34	39	38	25	32	15	29	30
end%	61.8	60.9	57.6	56.8	58.2	34.1	51.8	54.5

W	total	234					
aspect	W	W	W	E	E	E	
altitude	300	500	700	300	500	700	average
alpha	36.08	48.38	57.14	98.4	48.77	110.38	66.5
species	59	69	69	67	51	68	64
n	149	153	134	96	90	94	119
endemic	28	24	29	24	18	26	25
end%	47.5	34.8	42.0	35.8	35.3	38.2	38.9

Biodiversity characteristics between the two study sites NE: North East Waka and W: hills west of Waka; W: west-facing slope, E: east-facing slope.

Results

Species richness

The total recorded species is higher in NE Waka than in West Waka, 263 and 234 species, respectively (see tables above). But in West Waka species rich on average per transect is higher, 64 versus 55 species. Also the four transects with the highest species richness are from West of Waka.

Species turnover

The level of "endemism" is defined here as the number of species restricted to a single transect. This number depends on the total number of transects in a site. A small number of transects will overestimate the level of endemism. When more transects will be put in the same site more species will turn out to be less restricted to a single transect.

The proportion of species which changes from transect to transect is also known as species turnover. Species turnover can change with environment, like altitude, but also with distance which is a non-environment factor. The latter is not well understood, but it has a strong influence on the turnover rate; the larger the distance the larger the turnover.

Species turnover is on average higher in NE Waka than in West Waka, 54.5% and 38.9%. Distances between the transects were also higher in NE Waka than in West of Waka. In West Waka distances were smaller, because of the scale of the hill complex identified. This may explain why species turnover is lower than in NE Waka.

	NE west	NE east	W west	W east
species	62	50	66	62
endemic	37	25	27	23
end%	60.1	50.2	41.4	36.5

The influence of distance is clear when the slopes of the two sites are compared separately (see above). The slope with the highest level of endemism of species turnover is the western slope in NE Waka. This is also the slope where the distance between the transects was also highest. The other three slopes do not differ much the absolute number of (transect) endemics).

Local diversity
Alpha diversity is a measure of local species diversity. It also takes into account differences in the number of individuals recorded per standard sampled area, because with more individuals there is also a higher change in more species.

Local diversity (alpha) is much higher in West of Waka than in NE Waka, 66.5 and 49.6. Especially, difference for the 700m transects are large. The transect on the eastern ridge of the Ikobey valley (NE Waka) only had a fisher's alpha value of 35.6 and total number of species of only 45. The other two transect from the western hill at 700m had a higher species richness 69 and 68, respectively and also a higher to much higher fisher's alpha diversity, 57.1 and 110.4.

Site	Fisher's alpha	Total species
NE	35.6	45
W	36.1	59
NE	38.7	44

Two of the three transects with the lowest fisher's alpha diversity values were in NE Waka, the one with the intermediate value in West Waka (see above). But the transect West of Waka has the highest species richness of the three transects and even higher than 4 out of the 6 transects of NE Waka.

Site	Total species	Fisher's alpha
NE	44	38.7
W	45	35.6
NE	51	48.8

Two of the three transects with the lowest total species number are in NE Waka and one in West Waka (see above). But the one transect in West Waka has a much higher alpha diversity value than the other two transect in NE Waka and even higher than 6 out of the in total 12 transects.

General collecting
Additional information about the biodiversity of the West Waka in general comes from botanical collecting. First of all the presence of refuge Begionas along the slopes of West Waka was higher than in NE Waka. Another interesting observation was the presence of *Maniellia gustavii*, an orchid which is relatively rare and which has not yet been observed in Waka or even on the wetter slopes of the Mont Mbilan in the Monts de Cristal.

Conclusions

This study had two objectives both related to Biodiversity Sanctuaries. One was to identify botanically interesting forests outside the park as compensation area for the logged part of Waka National Park in the north east. This assessment showed that this small hill complex west of Waka was botanically interesting, especially at a local scale. Species richness recorded in all transects was higher in NE Waka, because the distance between transects was longer and hence a larger area was sampled. Larger distances between the transects also influenced species turnover from transect to transect causing the turnover rate to be higher in NE Waka, but endemism at slope level (east vs. west) differed little. The transects in West Waka showed high to very high levels of local diversity (fisher's alpha). This is the best parameter to evaluate botanically interesting forest. The other objective of this study was to test the model being used to identify botanically interesting forest.

Acknowledgements
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aspect	W	W	W	E	E	E
altitude	300m	500m	700m	300m	500m	700m
Uapaca heudelotii	1	1				
Cleistanthus 19d	2	2				
Anisophyllea polyneura	1	2	3			
Croton mayoumbensis	2		1			
Pentaclethra eetveldiana	2		1			
Drypetes 19b		1	1			
Trichilia monadelpha		1	1			
Guarea thompsonii				1	1	
Sp 22b				1	1	
Grewia coriacea				2	4	
Tetraberlinia bifoliolata				3	6	
Oubanguia africana				4	5	
Dacryodes edulis				1		1
Klainedoxa gabonensis					1	1
Odyendya gabonensis					1	1
Scaphopetalum blackii					1	2
Beilschmiedia klainei					2	3

Species present on either the western or eastern side

species / altitude / aspect	300m w	300m e	500m w	500m e	700m w	700m e
Pancovia pedicellaris	1	1				
Diospyros bipindensis	2	2				
Strombosia grandifolia	6	2				
Guibourtia ehie	1	1	1			
Octoknema affinis	3	1	1			
Desbordesia glaucescens	4	2	1			
Berlinia confusa		1	3			
Treculia obovoidea		1	1			
Amanoa stobulacea		2	8			
Maesobotrya staudtii		1	4			
Masularia accuminata		1	2			
Daniella klaineana		1	2	1		
Coula edulis		2	1	2		
Pausinystalia macrocera			2	1		
Diospyros cinnabarina			1	1		
Centroplacus glaucinus			3	1	1	
Parkia bicolor			3	1	1	
Sindoropsis letestui				1	1	
Newtonia 21a					1	2
Strombosia pustulata					2	2
Octolobus spectabilis					2	1
Bikinia pellegrinii					1	1
Garcinia epunctata					1	3

Common species which form a narrow altitudinal gradient

species / altitude / aspect	300m w	300m e	500m w	500m e	700m w	700m e
Carapa parviflora	3	1				1
Strombosiopsis tetandra	3	1	2			1
Staudtia stipitata	8		1	1		
Symphonia globulifera	1	1		1		
Microdesmis africana	3	2	2	1		
Beilschmiedia calcitranthera	1	2	5	1	4	1
Heisteria parvifolia	1	3	1	2	3	1
Santiria trimera	2	3	11	3	13	1
Plagiostyles africana	2	1		2	1	1
Coelocaryon preussi	7	2		6	1	1
Scytopetalum klaineanum	1	2	2		1	1
Synsepalum longecuneatum		1		1	1	1
Greenwayodendron suaveolens		1	2	1	1	2
Dichostemma glauscens		3	17	14	4	2
Dacryodes klaineana		3	5		7	1
Dacryodes heterotricha		1	5		10	3
Dacryodes buettneri		1	2	1	1	
Aucoumea klaineana		3	1	3	1	
Dacryodes letestui			5	1	3	2
Hymenostegia pellegrinii				1	1	3

Common species forming a broad altitudinal gradient

altitude	**300m**	**300m**	**500m**	**500m**	**700m**	**700m**
species aspect	w	e	w	e	w	e
Diogoa zenkeri	3			1	1	
Cola lissachensis	5					1
Oncoba glauca	4				3	2
Phyllanthus diandrus	2					1
Uapaca 21a	1					1
Rinorea verrucosa	16			7		
Pycnanthus angolensis	1			3		
Scyphocephalium ochocoa	1			1		
Irvingia gabonensis	1			1		
Bikinia le testui		1				2
Pogonophora letouzeyi		3		1	2	
Dacryodes macrophylla		1			2	1
Picralima nitida		1			1	1
Afrostyrax kamerunensis		1			3	2
Scorodophioeus zenkeri		1			3	3
Dacryodes igaganga		1			2	
Memecylon lateriflorum		1			1	
Baphia laurifolia			1		2	3
Sorindeia juglandifolia			1		1	3
Cleistanthus polystachyus			1		1	1
Garcinia smeathmannii			1			1
Rinorea batesii			1			1
Calpocalyx dinklagei			1			1
Cola pachycarpa			1			2
Aphanocalyx cynometroides			1			1

Common species with a disjunct altitudinal distribution

Appendix 1

Eastern slope altitude endemics

species	300m
Brazzeia soyauxii	1
Cleistanthus 20b	1
Cleistanthus 20c	1
Cleistanthus 20d	2
Cleistanthus camerounensis	1
Dalium tesmannii	1
Dialium corbisieri	1
Drypetes sp (Euph 20b2)	1
Euphorbiaceae 20a	1
Homalium le testui	1
Hymenostegia felicis	1
Lophira alata	1
Mareya micrantha	3
Mariopsis longifolia	2
Myrianthus serratus	1
Rabdopetalum sindarense	1
Rinorea cerasifolia	2
Rubiacea 20b	1
Sorindea 20a	1
Sorindea 20d	1
Synsepalum 20b	1
Synsepalum 20c	1
Warneckea 20c	1
Xylopia milbraedii	1

species	500m
Barteria fistulosa	1
Funtumia africana	1
Garcinia 19d	1
Maesobotrya barteri	1
Mammea africana	2
Maranthes chrysophylla	1
Pentacletra macrophylla	1
Petersianthus macrocarpa	2
Phylliopsis discophora	1
Plagiosiphon gabonensis	1
Ptychopetalum petiolatum	2
Sp 19b	1
Uapaca guineensis	2
Warneckea membranifolia	1
Xylopia phloiodora	1
Zanthoxylum heitzii	1

species	700m
Anisophyllea myriosticta	1
Baikiaea insignis	1
Cleistanthus 21b	1
Cola digitata	1
Dactyladenia 21c	1
Diospyros hoyleana	1
Drypetes 21c2	1
Drypetes 21d	1
Drypetes arborescens	1
Drypetes inaequalis	1
Eriocoelum macrocarpum	1
Euphorb spp 6	1
Maranthes glabra	1
Paraphyadanthe flagelifera	1
Parinari hypochrysea	1
Placodicus sp (Sapinda 21a)	1
Psychotria gabonica Hiern	1
Sapotacea 21d	1
Strephonema 21a	1
Strephonema 21c	1
Syzygium 21d	1
Warneckea 21c	1
Warneckea 21d	1
Zeyherella mayumbensis	1
Thomandersia hensii	2
Trichoscypha acuminata	3

Appendix 2

Western slope altitude endemics

Species	300m
Blighia welwitschii	9
Calpocalyx klainei	2
Chrysophyllum 22d	1
Chrysophyllum africana	1
Chytranthus macrophyllus	1
Diospyros canaliculata	1
Discoglyprenna caleneura	1
Drypetes 22a	2
Elaeis guineensis	3
Enantia chlorantha	1
Entandophragma angolens	2
Euphorbiacea 22a	2
Euphorbiacea 22d	1
Euphorbiacea sp (spp 22a)	5
Ficus vogeliana	1
Hylodendron gabunens	2
Leonardoxa africana	2
Lovoa trichillioides	1
Panda oleosa	3
Papilionaceae 22d	1
Piptostigma fasciculata	1
Plagiosiphon emarginatus	2
Pseudospondia microcarpa	1
Spathodea campanulata	1
Spp	1
Strephonema sericeum	4
Vitex 22c	2

Species	500m
Afzelia bipindensis	1
Anthonotha 23a	1
Aphanocalyx microphyllus	1
Aulacocalyx jasminiflora	2
Bersama paullinioides	4
Bombax buenoposense	1
Cleistanthus 23a	1
Cleistanthus 23a2	1
Cleistanthus 23b	1
Cleistanthus 23c	1
Cleistanthus sp (Drypetes 23a)	1
Dialium polyanthum	1
Drypetes 23a	1
Drypetes 23d	1
Newtonia leucocarpa	1
Protomegabaria stapfiana	1
Rauvolfia letouzeyi	2
Rhicinodendron heudolotii	1
Sorindeia	1
Strombosia schefleri	2
Swarzia fistuloides	1
Synsepalum 23b	1
Xylopia staudtii	1
Zanthoxylium macrophylla	1

Species	700m
Afrostyrax lepidophyllus	1
Anisophyllea purpurascens	3
Berlinia 24b	2
Carapa procera	1
Cleistanthus 24a	6
Cleistanthus 24a2	2
Cola lateritia	1
Corynanthe pachyceras	1
Dactyladenia bellayana	1
Dactyladenia pallescens	1
Dialium guineense	1
Diospyros iturensis	1
Drypetes 24c	1
Euphb 22a	1
Garcinia gnetoides	1
Garcinia mannii	1
Klaineanthus gabonense	3
Meliaceae sp	1
Memecylon aequidianum	1
Mononthoxis letouzeyi	1
Newtonia glandulifera	2
Sibangea arborescens	1
Sorindeia gabonensis	1
Syzygium guineense	1
Tabernamonteana crassa	2
Tessmania anomala	1
Uapaca staudtii	1
Warneckea floribunda	1
Warneckea reygaerti	1