The biodiversity of Mont Mbilan

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The biodiversity of Mont Mbilan

Preliminary results and observations

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Missouri Botanical Garden
Gabon 2005

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 in the Monts de Cristal landscape assessing the plant biodiversity of the Mont Mbilan range. The first results and observations are presented here (task 1).

The conclusions drawn from this biodiversity assessment in combination with a GIS-analysis looking for areas with a similar geographical position as Mt Mbilan helped to identified Biodiversity Sanctuaries outside the park system. The recommendations are also presented here (task 2).

The author has contacted climate-vegetation modelers, Dr Pietsch from the University of Agricultural Sciences and Dr Lovett from the University of York to meet at the International Botanical Congress (IBC) in Vienna to explore the possibility of developing a model to simulate Pleistocene forest dynamics (task 3).

The results and conclusions here presented are preliminary in the sense that the full identification of the plants is still pending. Also the scientific rigor of the conclusions drawn is constrained by the limited number of transects, but general trends are clear and useful for conservation management.

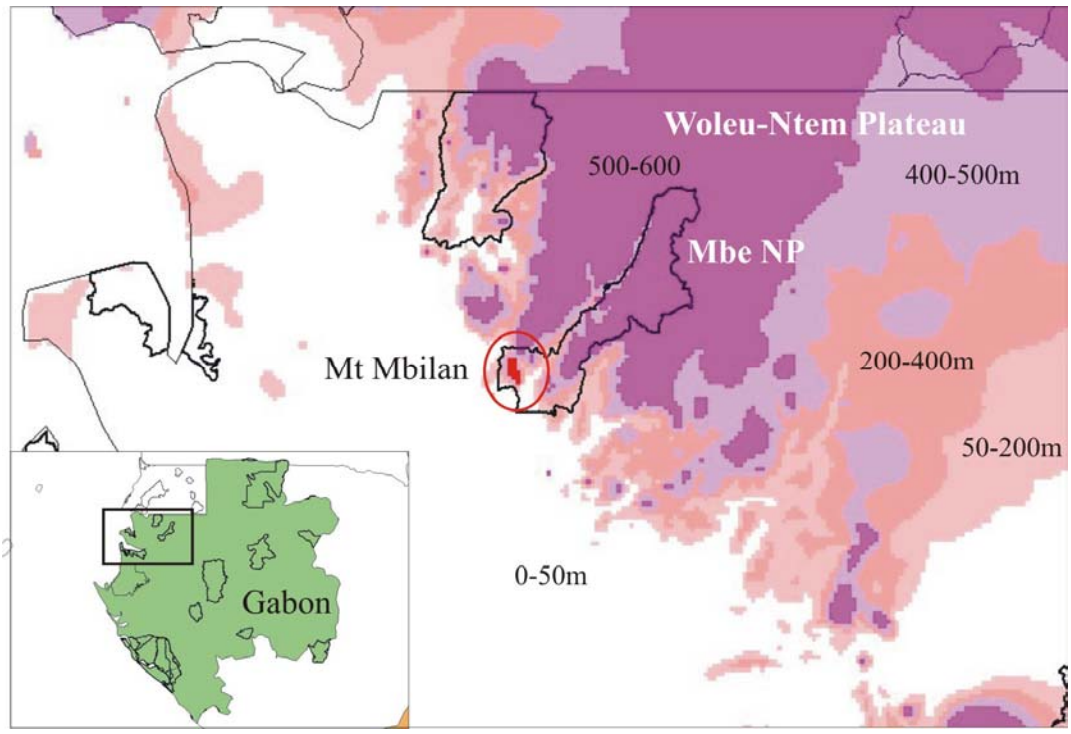
The author is a specialist in the Pleistocene Refuge Forest theory, a connoisseur in vegetation-climate dynamics and expert in the plant biodiversity of Gabon and central Africa.

Miguel E. Leal

July 2005

The biodiversity of **Mont Mbilan**

Mbe National Park

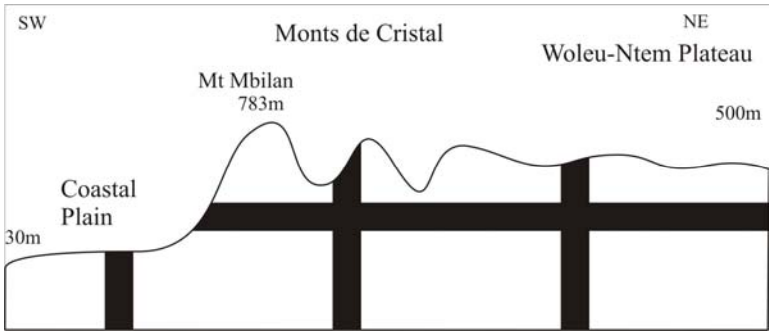


The geographical position of the Mt Mbilan range (red and encircled) at the edge of the Woleu-Ntem Plateau.

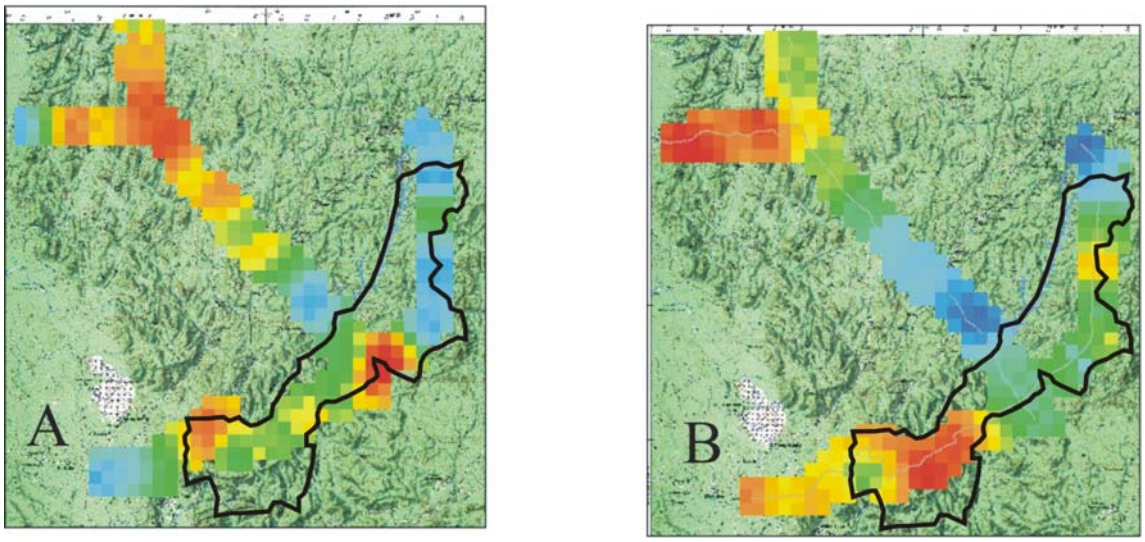
Monts de Cristal

Mont Mbilan is situated at the edge of the Monts de Cristal or Cristal Mountains (see above). These so-called mountains are actually the dissected edge of the Woleu-Ntem Plateau (400-600m) and with an altitude below 1000m they are by definition hills. The mountainous topography at the edge gradually disappears further on the Woleu-Ntem Plateau and becomes more undulating.

Mt Mbilan is the last range of hills before this rugged landscape changes into the flat coastal lowland (see next page above). The transition between plateau and lowland is like an escarpment, due to the sharp difference in altitude. The altitude of the ridges of Mt Mbilan is around 700 m whereas the coastal lowland does not exceed the 50 m. Therefore, when coming from the coastal plain the Monts de Cristal appear as mountains.



Cross-section showing the transition between coastal lowland and the Woleu-Ntem plateau. The rugged landscape at the edge are the Monts de Cristal.



The density of Begonias (A) and Caesalpinioideae- Leguminosae (B). Red means a high concentration and blue low (park evaluation transects, Chris Wilks).

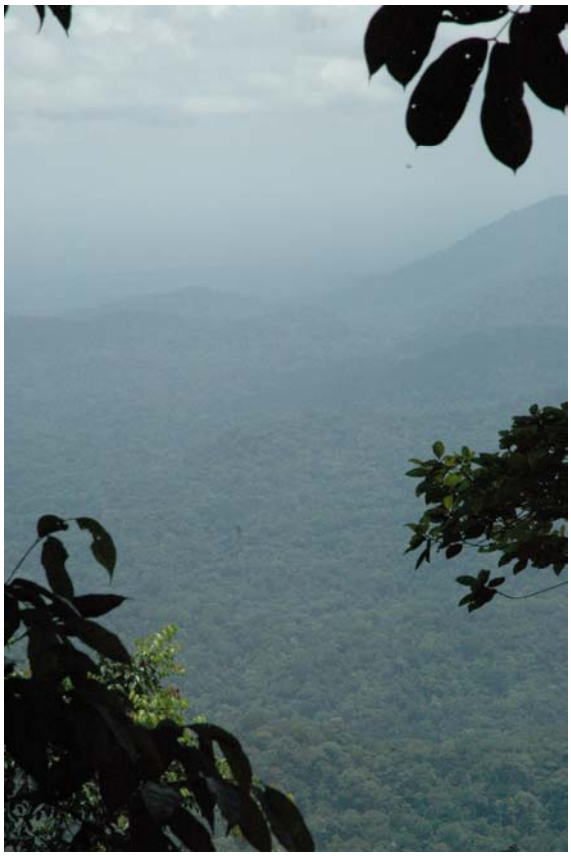
Biological significance

The Monts de Cristal are famous for their botanical richness. It is the richest area in Gabon and almost certainly also in tropical Africa. Two sections of the Monts de Cristal are now protected as national parks, Mt Sene and Mbe.

Evaluation transects through the Mbe NP showed the high concentration of both Caesalpinioideae (large canopy trees) and refuge-Begonias (herbs) in the southern part of the park (see above). Both plant groups are indicators of long-term undisturbed forest and potentially this part, the Mt Mbilan range, could be the richest part of the already botanically rich Monts de Cristal.

Whether this is true is not known as despite decades of botanical activity in the Monts de Cristal no botanist or forest ecologist entered this area. Therefore, because of its great botanical potential the Mt Mbilan range was targeted first.

View from Mt Mbilan over the "broccoli" forest ►



Recently during the delimitation of this part of the park a new and rare variety of *Calvoa hirsuta* was discovered by the author and described as:

Calvoa hirsuta* var. *maculata

the white-spotted Calvoa.

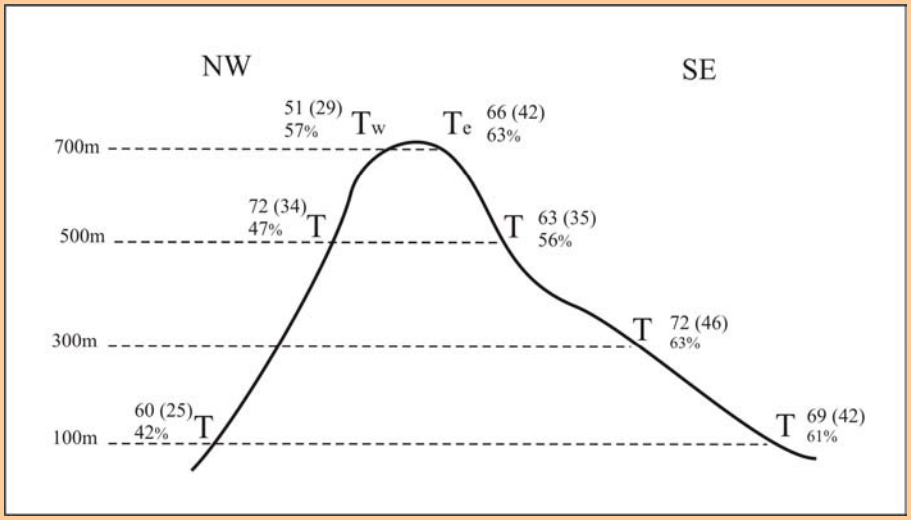
Patterns of biodiversity

Species are not distributed at random within the rain forest and except for common species most other species are restrained to a certain habitat or environment. Within such a geographically bound environment only the most competitive species will be able to co-exist. The repeated co-occurrence of species at a spatial scale is an indication for underlying environmental forces. In hilly areas, two well known environmental influences are altitude and aspect.

In temperate regions the impact of these two forces on the distributions of plant species is clearly visible. With increasing altitude the vegetation changes from oak/beech-dominated forest to pine forest and finally alpine pastures. The impact of aspect is evident when comparing south and north facing slopes. The southern slopes are covered by xeric (drought resistant) shrubby/grassy vegetation and north slopes by forest.

In tropical regions the impact of these arranging forces are less visible and the outer appearance of the rain forest changes little along slopes with altitude and aspect. (From the air it all looks like broccoli, see above). But actually recording plant species along hill slopes or at two opposing sides reveals differences in species composition. How big these differences are is an indication for the biodiversity of an area in general: "the bigger the differences, the greater the biodiversity".

Therefore, by the means of transects, species composition was recorded on both sides of Mt Mbilan, i.e. the west and east facing slope and along these slopes from bottom (100m) to summit (700m).



Profile of the Mt Mbilan range showing the distribution of 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.

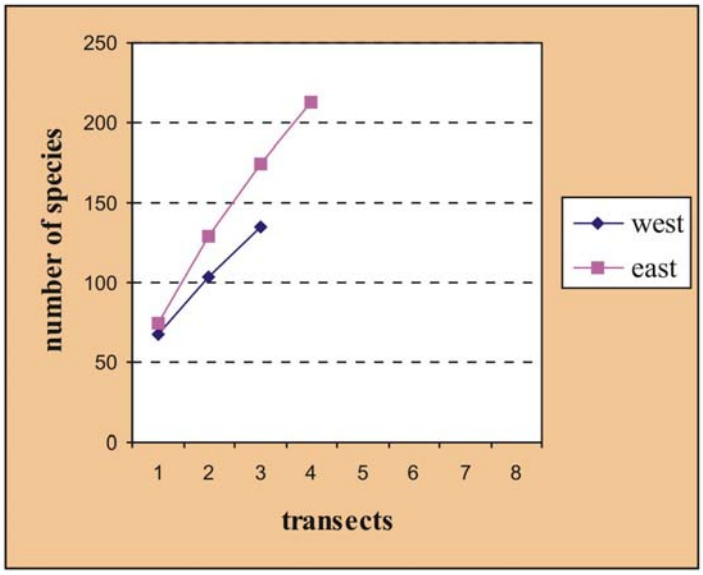
Methods

The transects used to record species composition were 200 m long and 5 m wide. 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 herbaria of Libreville, Wageningen, or Missouri. Often these specimens were without flowers or fruits in which case species were identified only on sterile (e.g. leaf characteristics). Such identifications are less confident and are referred to as morpho-species.

Three transects were placed along the west facing slope of Mt Mbilan at 100m, 500m and 700m and 4 transects along the east facing slope at similar altitudes including an extra transect at 300m (see above). 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.

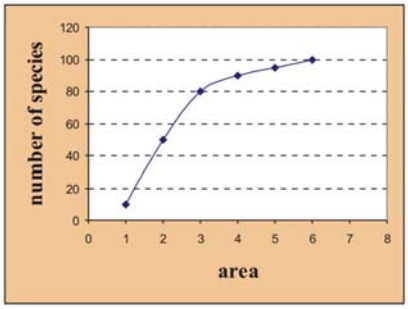
Results

In total species 321 (morpho-) species were recorded on the 7 transects, 135 species on the western slope (3 transects) and 213 species on the eastern slope (4 transects). On average 64 species were recorded per transect. The lowest number was 51 species on western slope at 700m and the highest number was 72 species on the eastern slope at 300m and on the western slope at 500 m. Twenty-eight species were recorded on both sides of Mt Mbilan. On the western side 19 species were recorded at more than one altitude; on the eastern side, 21 species. The majority of the species (253) were restricted to a single transect. The high number of restricted species will most likely decrease when more transects are put in along these slopes.



Species-area curve for the west and east side of Mt Mbilan (left)

Generally, a maximum of total species is reached for an area after a certain area (below)



Species richness

Species richness generally tends to increase with sampled area until after a certain surface area or "ceiling" (maximum) is reached, i.e. the example species-area curve (above right). Such curves are used to estimate the potential maximum number of species within a certain area. To do the same for Mt Mbilan has its limitations, because the total surface area (number of transects) only represents 7,000m^2 (0.7 ha) of the Mt Mbilan area, an area which itself comprises several km^2.

Species richness seems higher on the east-side based on total species recorded on all transects; 213 species at the east-side and 135 species at the west-side. These 87 extra species at eastern side could well be explained by the extra sampled area, i.e. the additional (4^{th}) transect on the eastern side. This is applying the rule of the species-area curve: the more sampled the area, the more species encountered.

Therefore, the comparison should be done on equal sampled area, i.e. 3 transects. The average of the totals of all combinations with 3 transects possible out of 4 transects is 202 species. Now the 67 extra species is a more much plausible indication that the eastern side is species richer.

The steep species-area curves for the west and east side suggests a high maximum number of species for Mt Mbilan (above left). However, the sampling procedure used here was designed to maximize species recording and avoid replication. Additional transects may not necessarily lead to more species. The curve could also start bending with increased sample area without significantly changing the total number of species already recorded.

Which of the two possibilities is most plausible is difficult to say, because the differences between transects is already very large. Even the two ridge transects at 700 m, which are the most similar in habitat and environment, only have 9 species in common. This is only 16 and 14 % of the total number of species recorded on each transect and a very large difference in species composition. It would be unprecedented if this would continue with another transect at 1 km away along on that same ridge. But if it does then Mt Mbilan has an extraordinary high biodiversity.

Species	aspect altitude	W **100m**	E **100m**	E **300m**	W **500m**	E **500m**	W **700m**	E **700m**
Strombosia pustulata		5	1					
Hymenostegia klainei		2	1					
Xylopia hypolampra		1		1				
Aucoumea klaineana		2	1	2				
Greenwayodendron suaveolens		3	4	1				
Cola acuminata		3			4			
Scaphopetalum blackii		5	1	3	2	1		
Dichostemma glaucescens		3	4	12		12		
Erismadelphus exsul		1				1		
Desbordesia glaucescens		1	1	3		1		
Diospyros crassiflora		1	2			1	2	
Strombosia grandifolia		3	1	2	2	4		
Heisteria parvifolia		3	2	1	2	1	1	
Carapa procera		1	3	2				2
Santeria trimera		4	6	5	5			4
Tetraberlinia bifoliolata		1	1	3	7	5	2	7
Anisophyllea purpurea		2		3	2	4	9	7
Dacryodes spp 1		1		1	4	2	14	6
Garcinia smeathmannii		3			3	6	7	5
spp 6 [Euphorbiaceae]		2			1		2	5
Strombosiopsis tetandra			1		7	6	11	6
Anisophyllea polyneura			2	2	1	7	8	13
Garcinia mannii				1	5	1	2	3
Amanoa strobilacea					3			3
Aphanocalyx microphyllus					2	1		
Drypetes gossweileri					2	7		
Bikinia letestui							3	1
Mammea africana							3	1

Common species present at both sides of Mt Mbilan
The figures in the row after the species name are the number of individuals

Aspect and altitude

In hilly or mountainous areas, altitude and aspect are strong environmental forces determining species distributions. On the Mt Mbilan Range their force is also apparent. Each species is differently affected by these forces, however three species groups can be distinguished. The first group consists of common species (9 %) which are unaffected by the difference in aspect being present on both sides of Mt Mbilan. Altitude here is the principle force causing a gradient in species composition from bottom to summit (see table above). At one end of the gradient are species like *Strombosia pustulata,* restricted to the bottom, and at the other end species like *Bikinia letestui,* restricted to the summit with intermediate species in between like *Tetraberlinia bifoliolata*.

species	aspect altitude	W 100m	W 500m	W 700m	E 100m	E 300m	E 500m	E 700m
Cola 3		1	1					
sp 7		1	1					
Warneckea 1		1	1					
Zanthoxylum 1		1	1					
Diogoa zenkeri		1	3					
Plagiosyphon 1		1	3					
Cola 1		1	4					
Diospyros 5		3	1					
Oubanguia africana		3	1					
Vitex doniana		3	2					
Annonac 4		4	2					
Plagiosyphon 2		2	2					
Drypetes 1		6	1	1				
Beilschmiedia 1		3	5	4				
Duguetia 1			1	1				
Syzygium 1			1	1				
Annonac rood			3	1				
Trichilia 1			2	1				
Memocylon 1		1		2				
Dialium pachyphyllium					1	1		
Grewia coriacea					1	1		
Marquesia excelsa					1	1		
Odyendyea gabonensis					2	1		
Garcinia lucida					3	2		
Bikinia durandii					1	2		
Coula edulis					1	1	1	
Dacryodes buetneri					3	1	1	
Warneckea 4a						1	1	
Guibourtia ehei						2	3	
Irvingia gabonensis						3	1	
Diogoa zenkeri						4	4	
Garcinia conraunana							1	1
Maesobotrya 5a							1	2
Sterculia 5a							1	2
Xylopia staudtii							1	1
Maryopsis 4c							2	8
Dacryodes macrophylla					1	4		1
Caes 6a					1		3	
Symphonia globulifera					2			3
Berlinia 4a						1		1

Species present on either the western of eastern side of Mt Mbilan

The second group of species (12 %) is more strongly affected by aspect and less by altitude (see table on page before). 19 species were absent on the eastern side, but formed a gradient with altitude along the western side. Similarly, 21 species showed the inverse being absent on the western side, but forming a gradient with altitude on the eastern side.

The third and biggest species group is affected by both aspect and altitude (79 %). These species were only recorded on a single transect on only one side of the Mt Mbilan Range and they are referred to as the group of endemics (see appendix 1 and appendix 2).

Endemism

The level of endemism is unusually high and partially overestimated due to the small number of transects. More species may turn out to be less restricted as concluded from this data when more transects are put in along these slopes. This would also change the size of the other two groups as they will become larger at the expense of the group of endemics.

Whether more transects will level out the differences observed is doubtful since these recorded differences in species composition are already so large. The differences in species composition between west and east facing slopes will remain and with similarly with altitude, they would only be less pronounced.

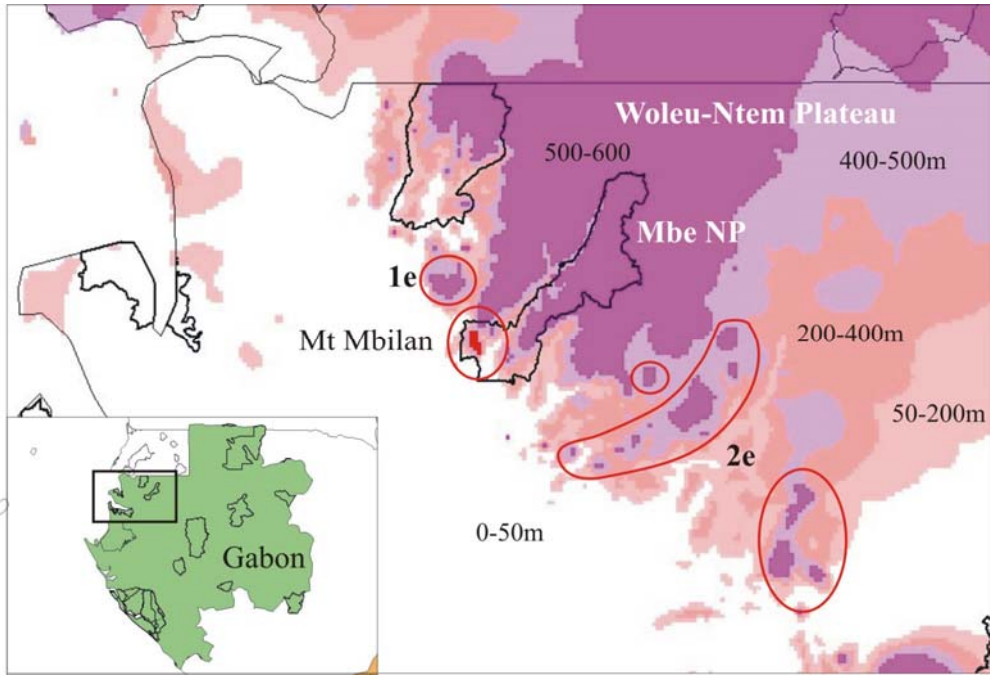
The group of endemics will remain relatively large compared to other forested areas. Presently, they represent the large majority of the biodiversity observed on Mt Mbilan Range. Unfortunately, this group of species is also the most vulnerable for disturbance.

Any pressure from outside leading to the partial destruction of this rain forest on will potentially cause the permanent extinction of these endemics. As these endemics are not restricted to only a single altitude or slope the destruction of any part of this forest will harmful for species survival.

Conclusions

Prior to this biodiversity assessment, Mt Mbilan was identified as potentially the richest or one of the richest parts of the already species rich Monts de Cristal. This assessment has shown that biodiversity is high to potentially very high. It was also shown that most of the biodiversity recorded is represented by endemic species. Endemism ranged from 42 to 63% and was evenly distributed over the Mt Mbilan Range. This high figure is most likely inflated, due to the small number of transects. But the analysis has indisputably shown that altitude and aspect are important arranging forces in this hilly to mountainous area. Therefore, it would be interesting and imperative to see whether biodiversity and endemism continues along nearby slopes and whether is continues outside the park system. This is especially important for conservation since endemic species are susceptible to permanent extinction by any form of human disturbance. Such areas outside the park system should be identified and protected as Biodiversity Sanctuaries against future forest destruction.

Identification of Biodiversity Sanctuaries



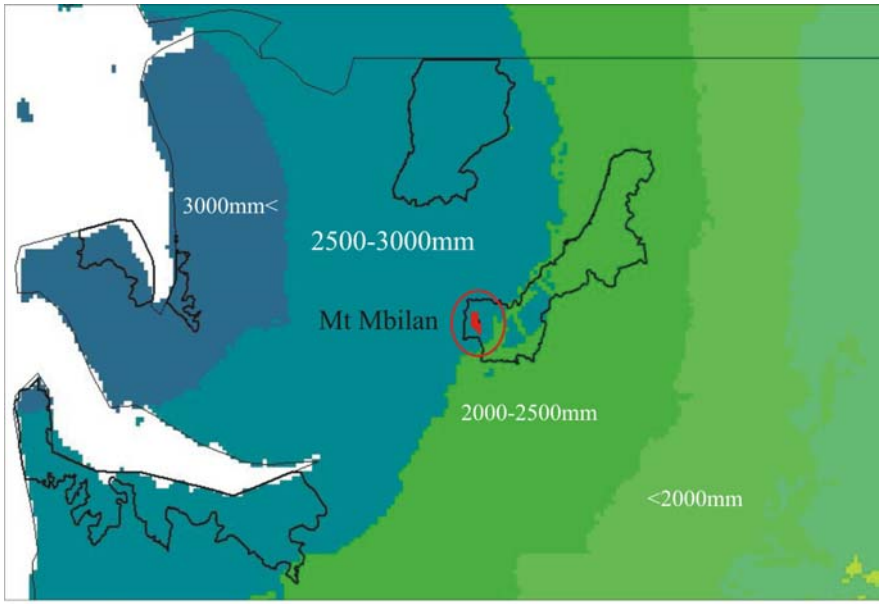
The geographical location of potential areas to put Biodiversity Sanctuaries in

Biodiversity Sanctuaries

Biodiversity sanctuaries are a tool for conservation to protect valuable areas outside the park system of Gabon. Gabon is famous for its botanical richness and the Monts de Cristal are the crown jewels of this richness. Presently, only a part of this region is protected as two relatively small parks (small compared to the other parks in Gabon, see inset above), whereas the Monts de Cristal as a whole should be worth protecting. This situation puts pressure on installing Biodiversity Sanctuaries in the region to protect the most valuable areas against future exploitation.

A first appraisal where these most valuable areas are can be obtained by overlapping regional environmental characteristics like mean annual rainfall and topography. But very important in this procedure is verification on the ground of the areas identified by the geographical analysis.

Fortunately, vegetation data is already available for part the Monts de Cristal, in the form of transects. The evaluation transects showed that biodiversity is highest along the dissected edge of the plateau. This is also confirmed by the smaller transects put in along the slopes of the Mt Mbilan range.



Mean annual rain fall over north-west Gabon

A second important force arranging species richness at a regional scale is climate, i.e. mean annual rainfall and length and severity of the dry season. In general species richness is high where rainfall is high or the dry season short. Over the Monts de Cristal three rainfall zones can be distinguished. Rainfall is highest in the western zone and gradually decreases towards the east. Mt Mbilan is situated in the middle zone (above).

Overlapping topography with rainfall shows that an area similar in the characteristics of Mt Mbilan is situated to the east (previous page, encircled in red and marked with 1e). The similarity in environment suggests a similarity in biodiversity. This area is considered as a primary target area for Biodiversity Sanctuaries, compared to several secondary target areas situated further south (previous page encircled in red and marked 2e). These secondary target areas are similar in topography with Mt Mbilan, but rainfall is lower. Since species richness is related with rainfall, species richness may be not as high. On the other hand these secondary areas are geographically isolated and such areas are known to be rich in endemics.

Acknowledgements

This project was funded by USAID's Central African Regional Program for the Environment in collaboration with the Wildlife Conservation Society. Additional funded was secured from the National Geographic Society. The project thanks for their support: Dr. Ludovic Ngok Banak, Herve Allogho, Chris Wilks, Dr. Lee White, Bryan Curran, and Dr. Han Overman. Photos were taken by Chris Wilks and Miguel Leal.

Appendix 1

West slope Altitude endemics

species	100m
Diospyros 1	2
Diospyros 2	2
Diospyros 3	2
Microdesmis 1	2
Myrianthus 1	2
Strombosiopsis tetrandra	2
Annonac 1	1
Annonac 2	1
Annonac 3	1
Caes 1	1
Cleistanthus 1	1
Calpocalyx heitzii	1
Drypetes 2	1
Euphorb 1	1
Euphorb 2	1
Euphorb 3	1
Hymenostegia 1	1
Microdesmis	1
Rub 1	1
sp 2	1
sp 3	1
sp 4	1
Sterc 1	1
Thomandersia spp 5	1
Trichoscypha 1	1

species	500m
Mareyopsis 1	5
sp 8	5
Anisophyllea ?	3
Maesobotrya	3
Grewia 1	2
Manilkara 1	2
Manilkara 2	2
Rhabdophyllum 1	2
sp 9	2
Caes 2	2
Synsepalum 1	2
Trichoscypha 2	2
Annickia chlorantha	1
Baphia spp 1	1
Cola 2c	1
Dichostemma 1	1
Diospyros mannii	1
Drypetes 3	1
Eriocoelum 1	1
Euphorb 5	1
Ochtocosmus 1	1
Oncoba glauca	1
Picralina 1	1
Polyalthia 1	1
Rub 2c	1
Scytopetalum 1	1
sp 10	1
sp 11	1
sp 12	1
Spathodea campanulata	1
spp A	1
spp B	1
Strephonema 1	1
Xylopia 1	1

species	700m
Uapaca mont	7
Anthonotha	5
Psychotria 1	4
Trichoscypha	4
Uapaca 3a	4
Annonac 3a	3
Psychotria	3
Rub 3c	3
Calpocalyx outre	2
Garcinia 3d	2
Maesobotrya 1	2
Ouratea 1	2
Beilschmiedia 2	1
Beilschmiedia 3d	1
Chrysob 3a	1
Dactyladenia	1
Drypetes 3a	1
Lecomtedoxa 1	1
Maranthes 3c	1
Olac 3c	1
Protomegabaria mac	1
sp 3a	1
sp 3b	1
sp 3c	1
sp 3d	1
sp 3d2	1
Sterc 3d	1
Taebernamontana 1	1
Trichilia 2	1

species	100m
Rub 7C	8
sp 7C	4
Dialium 7a	2
Drypetes 7d	2
Eriocoelum 7a	2
Erismadelphus 7c	2
Klaineanthus gabonii	2
Maprounea membranacea	2
Trichoscypha acuminata	2
Anacard 7d	1
Beilschmiedia 7a	1
Beilschmiedia 7b	1
Cleistanthus 7b	1
Cola 7a	1
Dacryodes igaganga	1
Dialium 7a2	1
Dialium 7c	1
Dialium 7c2	1
Diospyros	1
Diospyros 7a	1
Diospyros 7b	1
Drypetes 7a	1
Euphorb 7c	1
Euphorb 7d	1
Gambeya africana	1
Macaranga 7d	1
Manilkara 7a	1

species	100m
Microdesmis spp 2	1
Myrianthus serratus	1
Napoleonaea 7a	1
Plagiosyphon emarginatus	1
Psychotria 7a	1
Rub 7C2	1
Sorindeia 7c	1
sp 7b	1
spp ?	1
Sterculia 7b	1
Swartzia fistuloides	1
Uapaca 7a	1
Warneckea 7c	1
Xylopia 7d	1
Xylopia aethiopica	1

species	300m
Strombosia 4d	3
Dacryodes klaineana	2
Diospyros 4b	2
Euphorb 4d	2
Microdesmis 4b	2
Microdesmis 4c	2
Rinorea 4c	2
sp 4a	2
Warneckea 4d	2
Anisophyllea 4c	1
Anthonotha 4d	1
Beilschmiedia 4d	1
Beilschmiedia 4d2	1
Berlinia 4d	1
Caes 4a	1
Caes 4b	1
Cola 4a	1
Cola 4c	1
Cola ssp	1
Diospyros 4c	1
Diospyros 4c2	1
Diospyros 4d	1
Diospyros 4d2	1
Drypetes 4d	1
Duguetia 4b	1
Euphorb 4b	1
Heinsia crinita	1

species	300m
Korupodendron songweanum	1
Mareyopsis 4c	1
Nauclea 4b	1
Plagiosiphon 4b	1
Prioria goveri	1
Rub 4b	1
Rub 4c	1
Rub 4c2	1
Rub 4d	1
Scyphocephallum ochocoa	1
Sorindeia 4c	1
sp 4b	1
sp 4c	1
sp 4d	1
spp	1
Uapaca 4b	1
Warneckea 2	1
Warneckea 4a 2	1
Xylopia 4a	1

Appendix 2 East slope altitude endemics

species	500m
Beilchmiedia 6a	5
Monanthotaxis 6c	4
Scytopetalum klaineanum	4
Warneckea 6c	3
Dacryodes 6a	2
Diospyros 6b 2	2
Diospyros melocarpa	2
Drypetes 6b	2
Drypetes 6b 2	2
Euphorb 6a	2
Plagiosyphon 6c	2
Rinorea 6c	2
Sindoropsis le-testui	2
sp 6a	2
Xylopia 6c	2
Anacard 6b	1
Anopyxis klaineana	1
Anthonotha 6b	1
Beilschmiedia 5c	1
Berlinia 6b	1
Calpocalyx 6b	1
Cleistanthus 6a	1
Cola ficilifolia	1
Dialium 6a	1
Dialium 6b	1
Diospyros 6b	1
Diospyros 6b 3	1

species	500m
Euphorb 6c	1
Hymenostegia 6a	1
Lovoa trichilioides	1
Maesobotrya 6a	1
Memecylon 6c	1
Monanthotaxis 6a	1
Vitex 6b	1
Zeyherella 6c	1

species	700m
Uapaca 5b	8
Syzygium 5a	5
Anthonotha 5d	4
Baphia 5b	4
Lecomtedoxa 5a	3
Cola digtata	2
Duguetia 5b	2
Garcinia 5b	2
Memocylon 5a	2
sp 5d	2
Warneckea 5b	2
Anisophyllea 5a	1
Baphia 5c	1
Baphia 5c2	1
Beilschmiedia 5a	1
Beilschmiedia 5b	1
Beilschmiedia 5c	1
Chrysob 5c	1
Cleistanthus 5b	1
Dactyladenia 5b	1
Dactyladenia 5c	1
Diospyros 5a	1
Euphorb 5a	1
Flacourt 5a	1
Maesobotrya 5b	1
Manilkara 5b	1
Melasto 5c	1

species	700m
Memecylon 5b	1
Pap 5c	1
Protomegabaria 5b	1
Rub 5c	1
Rub 5d	1
Sapinda 5c	1
sp 5a	1
sp 5c	1
Taebernamontana crassa	1
Trichilia 5a	1
Trichilia 5b	1
Trichoscypha 5c	1
Trichoscypha 5d	1
Vitex 5c	1
Warneckea 5a	1

Appendix 2 continued