Vegetation data analysis Sali Forest Reserve

REPORT SUBMITTED TO THE FRONTIER TANZANIA BREAM PROJECT

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1 Summary

One of the most striking characteristics of the vegetation of the Eastern Arc Mountains in Tanzania is the immense variation in both species composition and vegetation structure that to date has eluded a systematic classification. Furthermore, the species' ecologies, their dispersal abilities and the evolutionary history of the area are poorly known. Attempts to tackle these questions - fundamental to developing sound conservation and management plans - are further constrained by large parts of the Eastern Arc Mountains being under-researched. This report has been produced for the Frontier Tanzania Biodiversity Research and Awareness in the Lesser-Known Eastern Arc Mountains project (BREAM), which will significantly contribute to filling gaps in the Eastern Arc Mountain biodiversity research through targeted field assessments. It classifies vegetation associations, the vegetation-shaping environmental gradients, regeneration properties and broad-scale floristic affinities of Mselezi Forest Reserve, Mahenge Mountains (Fig. 1).

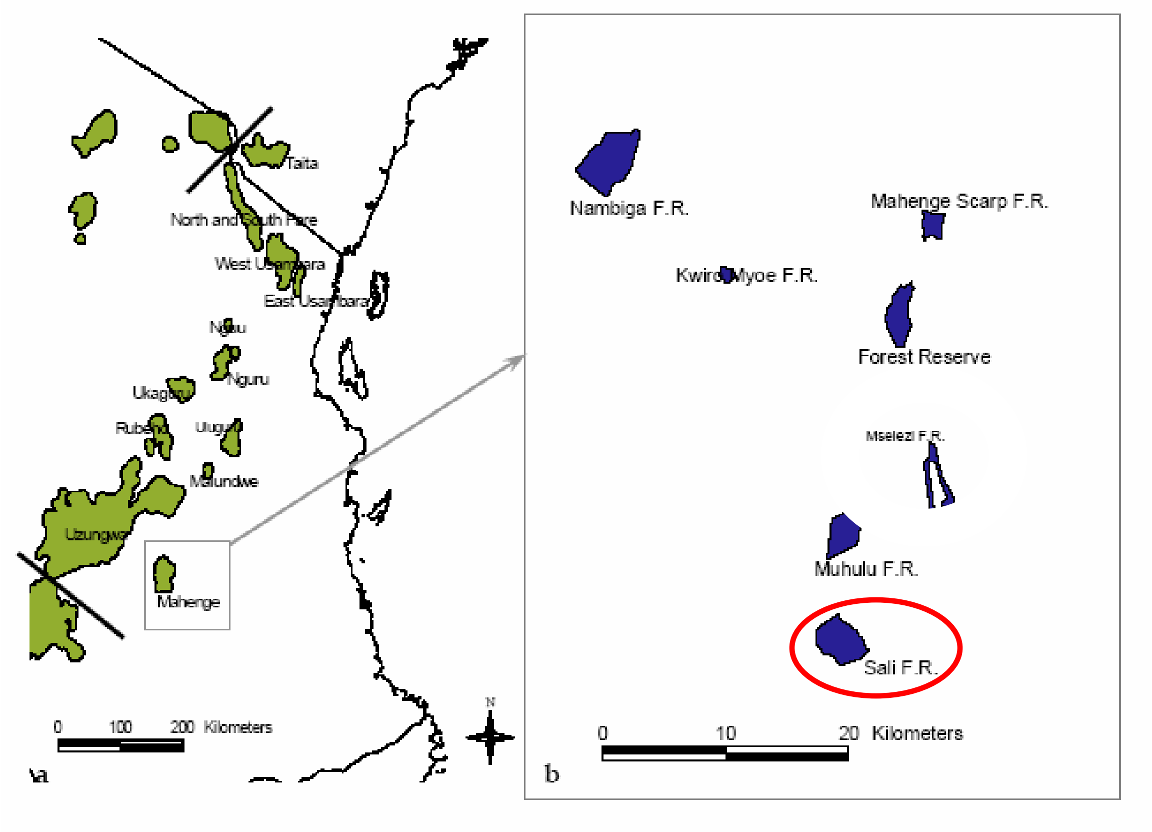

Fig. 1: Eastern Arc Mountains (a) and the Mahenge Mountains region (b)

A **vegetation classification** was attempted using a variety of different techniques including both conventional methods and experimental variations, encompassing (i) the establishment of phyto-sociological groups using TWINSPAN, (ii) a variation of the Braun-Blanquet approach, (iii) the establishment of phyto-ecological groups using species indicator values, and (iv) clustering of structural groups. These were of limited use to produce a convincing classification of the vegetation: they consistently detected the two main groups in the vegetation, but when it came to the identification of sub-groups the applied methods provided erratic results. TWINSPAN, in particular, reacted very sensitive to small changes in the data, meaning that newly available species identifications might generate a different classification. The poor performance of TWINSPAN owed to the fact there was not a single most important environmental gradient. In such a situation, the RA underlying TWINSPAN performs erratically. The assignment of strategy groups (i.e. forest specialist, forest generalist, pioneer) and further indicator properties (i.e. moisture indicator and disturbance resistant) to the individual species s was relatively consistent with the floristic groups. The analysis of structural and regeneration properties diverged slightly, showing that a floristic analysis alone would not have sufficed to classify the vegetation. Thus, conventional methods typically focusing on a single or a few vegetation properties failed to produce a coherent and widely applicable vegetation classification; the fuller picture only emerging when different approaches were combined. In addition, the analysis of vegetation was hampered by the great number of unidentified species. The necessity for combining different approaches and maximising information that the classifications are based upon was further emphasised by the fact that each of the single approaches suffered substantial shortfalls, in particular with respect to the representativity of the data. The species group based analyses (i, ii, and iii) were impacted by poor taxonomic resolution and, to a degree, by the small number of plots. The feasibility of establishing phyto-ecological groups using species indicator values was limited by the majority of the species having poorly known ecologies. Typically, the species specific ecological amplitudes had been established on a very coarse level (e.g. *lowland to submontane*, or *submontane to upper montane*), if at all, and therefore only suitable for broad-scale comparisons. This rendered a phyto-ecological vegetation classification across a small gradient those established in the work units relatively arbitrary.

As the conventional vegetation classification methods thus proved unsuitable due to the high variability of the vegetation and the various shortfalls in data availability, a more appropriate approach combining information on species composition, species' ecological requirements, vegetation structure and site characteristics is proposed. This classification initially is very coarse, but could be subject to further review and refinement once more species identifications (and more data in general through further fieldwork that Frontier Tanzania is conducting) have become available. A grouping that was consistently apparent was that of Sa0104, Sal1l5, Sa0106 and Sa0109. These plots were characterised by a number of shared disturbance resilient species and regeneration of pioneers. However, only Sa0105 exhibited signs of a disturbance and the vegetation structure of the remaining plots indicated undegraded moist forest conditions. Sa0104, Sa0106 and Sa0109 were characterised by the presence of a stream (see below for potential interpretation). The remaining vegetation plots were extremely difficult to classify. There were a great number of species with overlapping distribution between all these plots. From a species composition point of view, the overlap was greatest between Sa0108, Sa0112, Sa0202, Sa0203, Sa0204, Sa0205, Sa0206, Sa0207 and Sa0211. The most dominant species in the identified group were *Parinari excelsa* and *Xymalos monospora*. They appeared mutually exclusive, however, this impression might simply be an artefact of the paucity of the available data, and the division in two sub-groups dominated by these species respectively is therefore unsure. It was however also conspicuous that those plots dominated by *Parinari excelsa* differed from those that were dominated by *Xymalos monospora*.

A noticeable characteristic of the Sali plots was the fact that is was extremely difficult to delineate any vegetation classes as there appeared to be a strong continuum. It is possible that, for the Eastern Arc Mountain vegetation in general, vegetation analyses methodologies that allow for a continuum (gradient analyses) might be more appropriate than classification analyses. Further research is warranted to further elucidate this.

Potential **environmental correlates** (altitude, topography, slope, aspect and water association in addition to past and present disturbance) were explored using different ordination, regression or general linear modelling techniques as appropriate. The major gradients were the same for both mature vegetation and regeneration. The analysis showed that the vegetation was not influenced by a single most important environmental factor, but by a combination of factors with similar weight. These were the presence of roads and clearances (increasing the number of open area and disturbance resilient species, the density of small trees and the regeneration of pioneers), the position on the slope (with plots higher on slope comprising a greater number of forest dependent and montane species, exhibiting a higher basal area and density of larger trees and a more stable regeneration), and water (with plots were steams, dry river beds or wetlands were present containing a greater number of forest independent and disturbance resilient species, exhibiting a higher shrub cover and a greater number of pioneers regenerating). While the impact of roads and clearances is expected, the fact that plots situated higher at the slope seem to exhibit a better forest environment and that plots that have a water association less so, is difficult to explain. It is possible that plots located higher on the slopes have not been subjected to disturbances (e.g. agricultural encroachment) and therefore retain relatively undegraded forest. It was further suggested that streams, in particular when they are large and fast flowing and seasonally vary in the water masses they carry, might constitute a vegetation shaping factor that operates similar to disturbances, e.g. by creating larger tree gaps and introducing an additional species dispersal factor, potentially carrying seeds of widespread and resilient species. This hypothesis warrants further research.

With six threatened species (A*llanblackia stuhlmanii, Alsodeiopsis schumannii, Baphia semseiana, Dasylepsis integra, Morinda asteroscepa, Vitex amaniensis*), of which five (A*llanblackia stuhlmanii, Alsodeiopsis schumannii, Baphia semseiana, Dasylepsis integra* and *Vitex amaniensis* are also (near) endemic to the region, being identified despite the yet poor taxonomic resolution, Sali appears of great importance to species conservation.

In general, the analysis proved once again how (i) poorly Eastern Arc vegetation-environment relations are understood to date, (ii) how little information there is available on the species-specific ecological tolerances, (iii) how varied the vegetation is across the different Eastern Arc Mountain blocks and (iv) how many more vegetation samples will be needed to establish a robust and refined vegetation classification system that is applicable throughout the Eastern Arc Mountains. Furthermore, the analysis was complicated by the low number of workable plots and the as yet low taxonomic resolution. Nonetheless, the intensive fieldwork that Frontier Tanzania had undertaken - in particular with regard to the meticulous recording of site, vegetation structure and regeneration variables – allowed for a good preliminary analysis, and will certainly pay dividends as more plot data become available. The report concludes with recommendations on the sampling design and protocol that are aimed to add further value to Frontier Tanzania field data collections and our understanding of the Eastern Arc Mountain ecosystem.

2 Research questions

As in Mselezi Report

3 Methods

As in Mselezi Report

4 Results

4.1 Exploration of the most feasible and suitable vegetation classification(s):

Establishing a floristic classification proved difficult, there being little overlap in the distribution of species with low and medium frequency, and a fair number of species appearing in six or more plots, thus not serving as differential species. Only two groups could be delineated that showed acceptably low variation in various sensitivity analyses, and that were robust across the different methodologies applied. The following paragraphs illustrate the findings in further detail:

4.1.1 Two-Way Species Indicator Analysis (TWINSPAN)

Numeric classification using species abundance values alone

TWINSPAN performed erratically in the analyses on the original dataset and modifications of this (Methods). The only stable division was the isolation of Sa0104 and Sa0105 from the rest of all plots (Tab. 2). These were distinguished by the presence of three species mainly confined to these two plots (*Rauvolfia volkensii, Rauvolfia caffra* and *Rothmannia urcelliformis*). In the majority of the TWINSPAN variations, Sa0106 was also associated with this group, sharing two species (*Alangium chinense* and *Maesa lanceolata*) with Sa0105. Sa0109 was also repeatedly categorised in this group due to the presence of *Rauvolfia caffra* and *Pittosporum viridiflorum* (shared with Sa0104).

4.1.2 Phyto-sociological classification (Braun-Blanquet approach)

Subjective classification using combined species dominance-abundance values

Equally to the TWINSPAN classification, the Braun-Blanquet phyto-sociological classification established only two groups with certainty: the above division of Sa0104, Sa0105, Sa0106 and Sa0109 from the rest of the vegetation plots (Tab. 3). While this association was characterised by high abundance/dominance of *Maesa lanceolata, Rauvolfia volkensii* and *Rauvolfia caffra*, none of these species was sufficiently dominant enough to qualify as an association character species. A further group that stood out was that of Sa0102, Sa0103, Sa0107 and Sa0208, and three of these plots (Sa0102, Sa0103 and Sa0208) had also repeatedly been identified by TWINSPAN. However, there only being one differential species (*Cola microcarpa* and the widespread *Strombosia scheffleri*), this grouping was less convincing. Another group with only one differential species (*Morinda asteroscepa*) was that of Sa0210 and Sa0212. The remaining plots constituted an undifferentiated block with a near to continuous floristic overlap. While plots Sa0108, Sa0109, Sa0204 and Sa0206 were distinguished by the dominance of *Parinari excelsa*, and Sa0112, Sa0202, Sa0203, Sa0205 and Sa0207 by *Xymalos monospora*, they also shared a fair amount of species. A species that dominated across both these sub-groups was *Turraea holstii* in addition to *Ochna holstii* and *Lasianthus aff. L. pedunculatus*.

4.1.3 Phyto-ecological classification (vegetation form approach)

Subjective classification using combined species-dominance abundance values and species indicator functions

As detailed in the Methods section, four indicator properties were established: the degree of forest dependence, the resistance to disturbances, the moisture indicating function and the altitudinal amplitude. The majority of the species, and in particular those that were widespread, were species occurring in both lowland and montane areas (Appendix C). While there was also was a good number of exclusively (sub/upper) montane species and a few lowland species, these showed no particular distributional patterns across the plots, meaning that it was not possible to classify the species based on their altitudinal amplitude. The degree of forest dependence showed a slight pattern across the plots, however, on its own did not suffice for a vegetation classification. The same was true for the resilience to disturbances, this being the indicator function that showed greatest overlap with the identified species associations (the moisture dependence only exhibited a slight overlap). Hence, a classification based on the species' ecological requirements alone was not feasible. However, the species associations were largely coherent with the species' ecologies (Tab. 3): The group comprising Sa0104, Sa0105, Sa0106 and Sa0109 harboured the greatest number of disturbance resilient species (*Alangium chinense, Bersama abyssinica, Cordia africana, Crassocephalum mannii* and *Maesa lanceolata*), which mostly also are open-area species or forest generalists. However, there also were a fair number of moisture indicating species. Henceforth, this group shall therefore be referred to as *disturbance resilient/moist forest group*. The two smaller groupings (Sa0102, Sa0103, Sa0107 and Sa0208, and Sa0210 and Sa0212) comprised forest dependent species only. However, in order to reflect the fact that their identification was not unequivocal, they shall be termed the two *forest groups with uncertain delineation*. The undifferentiated remainder mostly contained forest dependent species (along with a few forest generalists). This group also comprised the greatest number of moisture indicating species (although the *disturbance resilient/moist forest group* also had a few moisture dependent species). This group shall be called the *undifferentiated moist forest group.*

4.1.4 Classification based on the vegetation structure

Numeric classification using vegetation structural variables alone

Cluster analyses based on vegetation structural variables showed moderate overlap with the floristic associations (Fig. 2). The *disturbance resilient/moist forest group* was split: while Sa0104, Sa0106 and Sa0109 (in addition to Sa0103) exhibited a relatively similar vegetation structure with a high average dbh, conspicuous variation in this (Fig. 3) and a low density of trees (> 10 cm dbh), Sa0105 was characterised by the opposite - a very low average dbh and a high density of small trees. Sa0102, Sa0103, Sa0107 and Sa0208 (*forest group with uncertain delineation*) differed greatly with respect to vegetation structure. The Sa0210-Sa0212 group formed a big cluster with a number of plots from the *undifferentiated moist forest group* (Sa0112, Sa0203, Sa0205 and Sa0211), characterised by medium values for average dbh and tree density and a mostly tall canopy. The remainder of the latter group (Sa0108, Sa0206, Sa0207 and Sa0208 in addition to Sa0201 and Sa0209) formed a separate cluster, exhibiting high tree density, maximum dbh, basal area and canopy cover.

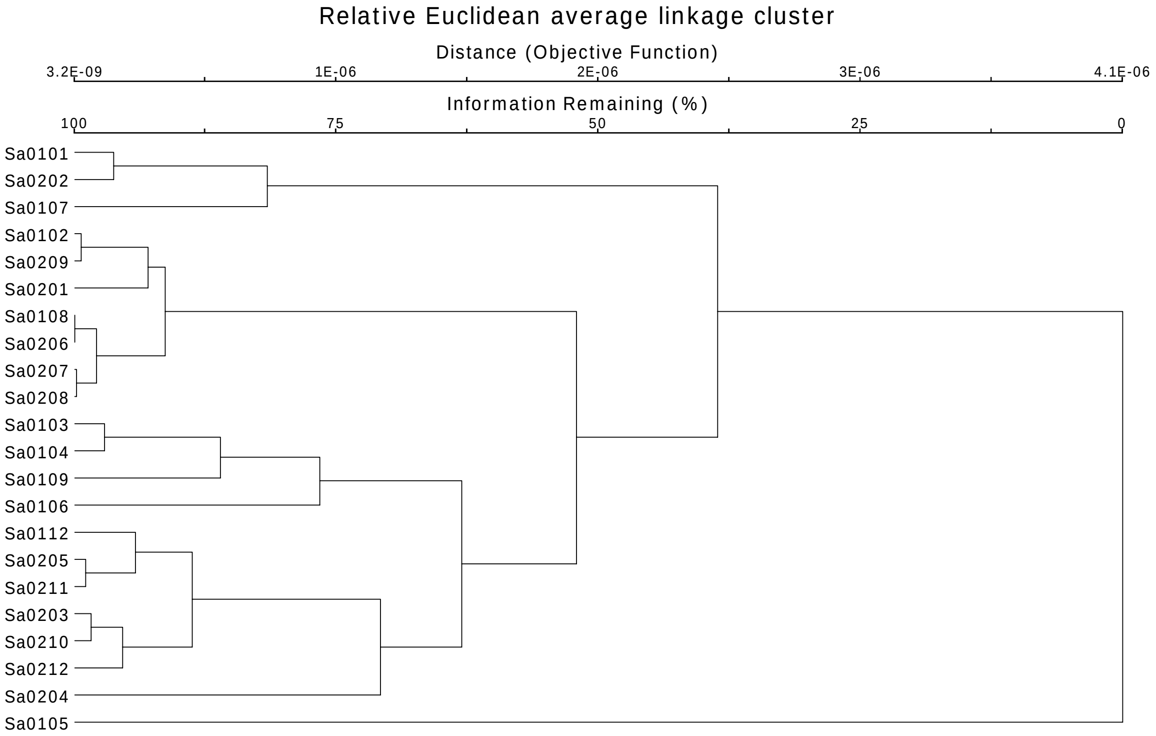

Fig. 2: Vegetation structure average-linkage cluster. The same result was produced when using single-linage and complete-linkage methods.

	Sa 0206	**Sa 0207**	**Sa 0211**	**Sa 0102**	**Sa 0103**	**Sa 0208**	**Sa 0209**	**Sa 0108**	**Sa 0112**	**Sa 0202**	**Sa 0203**	**Sa 0205**	**Sa 0101**	**Sa 0107**	**Sa 0210**	**Sa 0212**	**Sa 0106**	**Sa 0109**	**Sa 0201**	**Sa 0204**	**Sa 0104**	Sa 0105						
Crabre	-	1	2	3	1	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1	**0**	**0**				
Newbuc	-	-	-	1	2	2	2	2	2	-	1	1	-	-	-	-	2	-	1	-	1	1	**0**	**0**				
Allstu	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**0**	**0**
Colmic	-	-	-	1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**0**	**0**
Crylie	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**0**	**0**
Garhui	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**0**	**0**
Memsch	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**0**	**0**
Tripal	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**0**	**0**
Harmad	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**0**	**1**
Dasint	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**1**	**0**
Ocousa	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**1**	**0**
Rinsub	-	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**1**	**0**
Tarpav	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**1**	**0**
Turhol	4	4	2	-	-	1	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**1**	**0**
Drynat	3	4	-	2	3	4	2	3	1	2	-	-	1	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**1**	**1**
Strsch	3	-	-	-	2	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**0**	**1**	**1**
Dralax	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**1**	**0**	**0**
Lasaff	3	2	-	-	-	-	-	3	3	-	-	1	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**1**	**0**	**0**
Zanlep	-	3	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**1**	**0**	**0**
Casmal	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**1**	**0**	**1**
Ficlau	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**1**	**0**	**1**
Xymmon	-	1	-	-	-	-	-	-	4	3	3	3	-	-	-	-	-	-	-	-	-	-	**0**	**1**	**0**	**1**	**0**	**1**
Ochhol	-	-	2	-	-	-	-	1	1	-	2	-	-	-	-	-	-	1	-	-	-	-	**0**	**1**	**0**	**1**	**1**	
Bapsem	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	**0**	**1**	**1**	**0**		
Oxyspe	-	1	1	-	-	4	-	-	3	2	2	-	1	2	-	-	-	-	1	-	-	-	**0**	**1**	**1**	**0**		
Parexc	3	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1	-	2	-	-	**0**	**1**	**1**	**0**		
Vepsto	1	-	-	2	-	2	2	2	-	-	-	2	-	-	-	-	-	1	1	1	-	-	**0**	**1**	**1**	**0**		
Chapar	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	**0**	**1**	**1**	**1**	**0**	
Tabpac	-	-	-	3	-	-	3	-	2	2	1	-	2	5	4	1	2	-	-	-	-	-	**0**	**1**	**1**	**1**	**0**	
Morast	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	**0**	**1**	**1**	**1**	**1**	**0**

	Sa 0206	Sa 0207	Sa 0211	Sa 0102	Sa 0103	Sa 0208	Sa 0209	Sa 0108	Sa 0112	Sa 0202	Sa 0203	Sa 0205	Sa 0101	Sa 0107	Sa 0210	Sa 0212	Sa 0106	Sa 0109	Sa 0201	Sa 0204	Sa 0104	Sa 0105						
Phorec	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	**0**	**1**	**1**	**1**	**1**	**0**
Vitama	-	1	-	1	-	-	1	-	-	1	-	-	-	2	-	-	-	-	-	2	-	-	**0**	**1**	**1**	**1**	**1**	**0**
Alssch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	**0**	**1**	**1**	**1**	**1**	**1**
Corafr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	**0**	**1**	**1**	**1**	**1**	**1**
Lepusa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	**0**	**1**	**1**	**1**	**1**	**1**
Myrhol	-	-	-	1	-	-	-	-	2	-	-	-	-	-	-	1	2	2	2	-	-	-	**0**	**1**	**1**	**1**	**1**	**1**
Pitvir	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	2	-	**1**	**0**				
Alachi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	**1**	**1**	**0**			
Maelan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3	**1**	**1**	**0**			
Raucaf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	**1**	**1**	**0**			
Beraby	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	**1**	**1**	**1**			
Craman	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	**1**	**1**	**1**			
Rauvol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	**1**	**1**	**1**			
Roturc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	**1**	**1**	**1**			
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**						
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**								
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**								
	0	**0**	**0**	**1**	**1**	**1**	**1**	**1**																				
				0	**0**	**0**	**0**	**1**																				

Tab. 2: Two-way ordered site by species matrix for the dataset containing the fully identified taxa only (TWINSPAN). A key for the species codes is given in Appendix B. (The code operates with the first three letters of the genus and the first three letter of the species name.) The patterns of zeros and ones in the last columns respectively columns indicate the established group dichotomy in a dendrogram style. The matrix displays the pseudo-species values (Methods). The colour coding represents the groups established using the plant sociological approach and shows how remarkably coherent the associations have been identified by these two methods.

	Sa 0101	Sa 0209	Sa 0104	Sa 0105	Sa 0106	Sa 0109	Sa 0204	Sa 0211	Sa 0108	Sa 0206	Sa 0205	Sa 0207	Sa 0203	Sa 0112	Sa 0202	Sa 0208	Sa 0102	Sa 0103	Sa 0107	Sa 0201	Sa 0210	Sa 0212	Sa 0110	Sa 0111	f	dfid	dis	moi	alt
Colmic																3	2	3							**3**	**1**	**0**	**0**	**1.5**
Strsch										3						3		3	2						**4**				
Rauvol			4	2																					**2**	**1.6**	**0.625**	**0.25**	**1.38**
Roturc			2	2																					**2**				
Pitvir			3			2													1						**3**				
Raucaf			3	3		4																			**3**				
Alachi				2	3																				**2**				
Maelan				3	3																				**2**				
Beraby				2																					**1**				
Corafr					3																				**1**				
Craman				1																					**1**				
Ochhol						1		4	1				3	2			11								**5**	**1.1**	**0.18**	**0.35**	**1.35**
Parexc						5	4	1	5	5							20								**5**				
Harmad								1								2	3								**2**				
Dasint								1				1					2								**2**				
Ocousa								3				5					8								**2**				
Rinsub												2				2	4								**2**				
Zanlep											3	3			3		9								**3**				
Lasaff									3	2	1	2		2			10								**5**				
Dralax									2		1						3								**2**				
Ficlau												3	2				5								**2**				
Xymmon											3	2	3	3	3		14								**5**				
Turhol		3						3		4	3	4				3	17								**6**				
Tarpav								2									2								**1**				
Tripal									1								1								**1**				
Bapsem							1										1								**1**				
Casmal														1			1								**1**				
Crylie																2	2								**1**				

	Sa 0101	Sa 0209	Sa 0104	Sa 0105	Sa 0106	Sa 0109	Sa 0204	Sa 0211	Sa 0108	Sa 0206	Sa 0205	Sa 0207	Sa 0203	Sa 0112	Sa 0202	Sa 0208	Sa 0102	Sa 0103	Sa 0107	Sa 0201	Sa 0210	Sa 0212	Sa 0110	Sa 0111	f	dfid	dis	moi	alt
Garhui									3								3								**1**				
Lepusa							2										2								**1**				
Memsch									3								3								**1**				
Morast																					2	2			**2**	**1**			**2**
Chapar									1										1						**2**	**1**		**1**	**1**
Allstu		4																							**1**	**1**			**2**
Alssch																				3					**1**	**1**			**2**
Phorec	2																								**1**	**2**	**1**	**1**	**1**
Non-differential taxa																													
Crabre				1				2	3			1					4	1							**6**	**2**			**1**
Myrhol					4	4								3			3			2		3			**6**	**1**		**1**	**1**
Vitama		3					4					2			1		3		4						**6**	**1**			**2**
Octspe	2			2							2		1	1	3							4			**7**				**1**
Oxyspe	1							3				1	4	3	4	3			2	2					**9**	**1**			**1**
Vepsto		3				1	2		3	2	3					2	2			2					**9**	**1**			**2**
Drynat	2	3							3	3		3		1	3	5	3	3							**10**	**1**			**0**
Tabpac	2	3			2								2	3	3		2		5		5	1			**10**	**2**			**1**
Newbuc		5	4	2	4				4		4		4	5		5	4	3		3					**12**	**1**		**1**	**1**
Unidentified taxa																													
Albspe			3	2						3	1										3								
Alcspe																				1									
Allspe					1											3				3									
Chaspe										1		2		1															
Colspe								1							2	2				2		3							
Craispe	2					3		3														2							
Draspe				1																									
Dryspe	3			1		4		4	3	3	1	3			3	3	4	4	4	2		3							
Eryspe															1				2			1							

	Sa 0101	**Sa 0209**	**Sa 0104**	**Sa 0105**	**Sa 0106**	**Sa 0109**	**Sa 0204**	**Sa 0211**	**Sa 0108**	**Sa 0206**	**Sa 0205**	**Sa 0207**	**Sa 0203**	**Sa 0112**	**Sa 0202**	**Sa 0208**	**Sa 0102**	**Sa 0103**	**Sa 0107**	**Sa 0201**	**Sa 0210**	**Sa 0212**	**Sa 0110**	**Sa 0111**	**f**	**dfid**	**dis**	**moi**	**alt**
Ficspe		2						2																					
Garspe	3	4	5	3	3	4	3	3	4	4	3	3	4	3	5	3	2		4	3	4	3							
Garspe											1	2			3							2							
Hunspe		1					1	2		2	3	2				2					1								
Ixospe							2	1				1			2					2									
Keespe		1							3			1					2												
Lasspe	2																												
Marspe				2																									
Mimspe											4																		
Monspe			3						3		3	3				4	4			3									
Pavspe						4		3														3							
Podspe																				1									
Polspe							2	3	1	2	2		2	2					2	2	2								
Psyspe			2									2				2						2							
Rotspe	3				2			2				1					2	2	2			3							
Tabspe							2						3																
Trispe				2			1		2			1																	
Trispe		2	3	2	3				3	1					1		2			3									

Tab. 3: Manually sorted table in typical Braun-Blanquet fashion. The matrix displays the combined dominance-abundance values for the species. A key for the species codes is given in Appendix B.

Key: f = frequency; dfd = degree of forest independence (averaged for the identified associations); dis = resilience to disturbance (averaged for the identified associations); moi = moisture indicator function (averaged for the identified associations); alt = altitudinal amplitude (averaged for the identified associations)

Vegetation plot number	Canopy cover (%)	Shrub layer (%)	Ground layer (%)	Canopy height (m)	average dbh (cm)	max dbh (cm)	tree density/plot (>10 cm dbh)	tree density/plot (>20 cm dbh)	basal area (cm)
Sa0101	10-50	>50	>50	10-20	22.85	84.70	52	21	30411.94
Sa0102	>50	>50	>50	10-20	28.48	96.00	52	25	51067.99
Sa0103	>50	>50	10-50	20-30	34.11	120.00	25	16	35967.50
Sa0104	10-50	10-50	>50	20-30	38.64	82.00	25	23	36498.60
Sa0105	10-50	10-50	10-50	10-20	18.30	65.00	62	15	22524.85
Sa0106	10-50	>50	10-50	20-30	34.60	87.00	21	12	30597.66
Sa0107	>50	>50	>50	10-20	21.37	76.70	95	40	45814.58
Sa0108	10-50	10-50	10-50	20-30	28.42	110.00	73	36	76230.45
Sa0109	>50	10-50	10-50	>30	41.63	114.00	29	22	56578.39
Sa0110					0.00	0	0	0	0.00
Sa0111					0.00	0	0	0	0.00
Sa0112	10-50	>50	10-50	>30	23.84	100.00	41	15	30256.20
Sa0201	>50	10-50	<10	20-30	27.25	90.00	65	38	54103.17
Sa0202	>50	10-50	<10	>30	23.72	78.50	63	28	36948.22
Sa0203	>50	10-50	>50	10-20	27.04	85.00	32	21	26729.11
Sa0204	10-50	>50	<10	>30	25.30	88.40	29	15	20766.03
Sa0205	>50	10-50	<10	20-30	24.51	90.00	50	21	35785.11
Sa0206	>50	10-50	<10	20-30	29.37	120.00	67	36	76090.99
Sa0207	>50	>50	10-50	>30	26.07	135.00	80	37	69797.57
Sa0208	>50	10-50	>50		26.29	95.00	78	32	71405.98
Sa0209	>50	<10	<10		30.38	110.00	47	31	48894.78
Sa0210	10-50	>50	>50	10-20	27.16	87.40	31	18	26095.55
Sa0211	10-50	>50	10-50	20-30	26.96	87.20	45	22	36708.77
Sa0212	>50	>50	<10		29.11	95.00	30	18	29608.19

Tab. 4: Vegetation structure details across sample units.

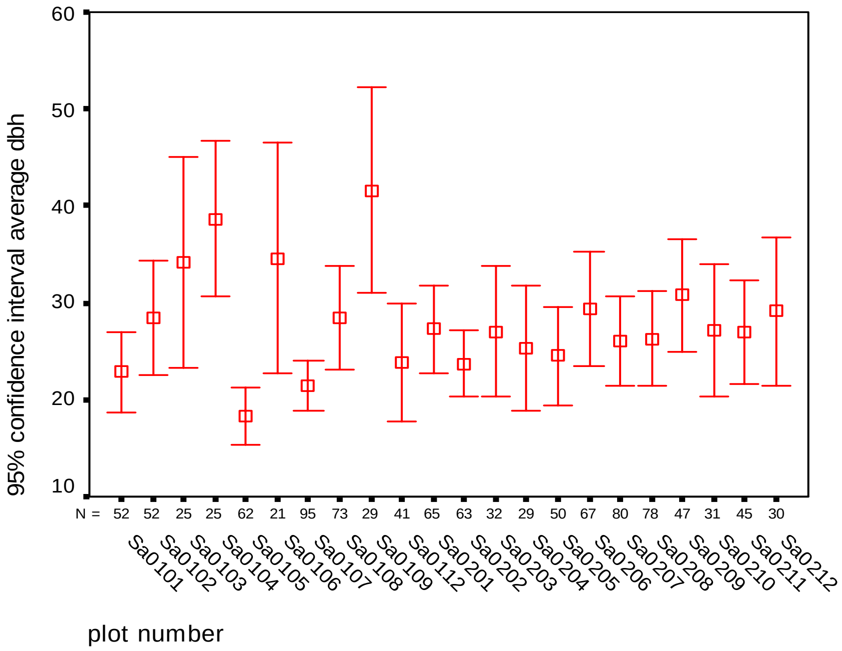

Fig. 3: 95% Confidence Intervals for average dbh across sample units.

4.1.5 Ordinations in species space and in vegetation structure space and identification interrelations

Simultaneous numeric analysis of species and vegetation structure variables

In order to gain a more detailed understanding of how the vegetation structure and the species composition are interrelated and mutually shape the vegetation, ordinations were carried out within species space and vegetation structure space and overlays performed.

Ordination in species space with vegetation structure overlay

Ordinations in species space showed confirmed the isolation of the *disturbance resilient/moist forest group*, this constituting the major divide along the first axis (Fig. 4). A conspicuous partition along the second axis was that of the *undifferentiated moist forest group* into the subgroups dominated by *Parinari excelsa* and *Xymalos monospora* respectively, however, with a continuous transition. This was also largely coherent with the vegetation structural clusters (see above). The group dominated by *Parinari excelsa* exhibited a higher basal area and greater number of large trees (>20 cm dbh), and the group dominated by *Xymalos monospora* a higher ground cover (Fig. 4 and Tab. 5). The *disturbance resilient/moist forest group* was characterised by a lower canopy cover but a higher average dbh (with the exception of Sa0105).

Axis	**1**			**2**		
	R	**R²**	**tau**	**R**	**R²**	**tau**
cancov	**-0.347**	**0.12**	**-0.249**	-0.047	0.002	0.055
shrcov	-0.13	0.017	-0.029	-0.03	0.001	-0.109
grcov	0.179	0.032	0.171	**-0.293**	**0.086**	**-0.223**
caheight	-0.293	0.086	-0.262	0.287	0.082	0.198
avdbh	**0.237**	**0.056**	**0.203**	0.195	0.038	0.212
treedens	-0.296	0.088	-0.279	0.024	0.001	0.096
basalarea	-0.353	0.124	-0.195	**0.339**	**0.115**	**0.385**
avdbhtr	0.003	0	0.004	0.315	0.099	0.238

Tab. 5: Correlation between the overlaid parameters (vegetation structure variables) and the species space ordination axes. Values are given for Pearson's correlation coefficient (R), coefficient of determination (R^2) and Kendall correlation coefficient (tau). The strongest positive and negative correlations are highlighted in bold and in grey and red colour respectively.

Key: cancov = canopy cover; shrcov = shrub cover; grcov = ground cover; caheight = canopy height; avdbh = average dbh of trees >10 cm dbh; treedens = density of trees >10 cm dbh; basalarea = basal area; avdbhtr = average dbh of trees >20 cm dbh

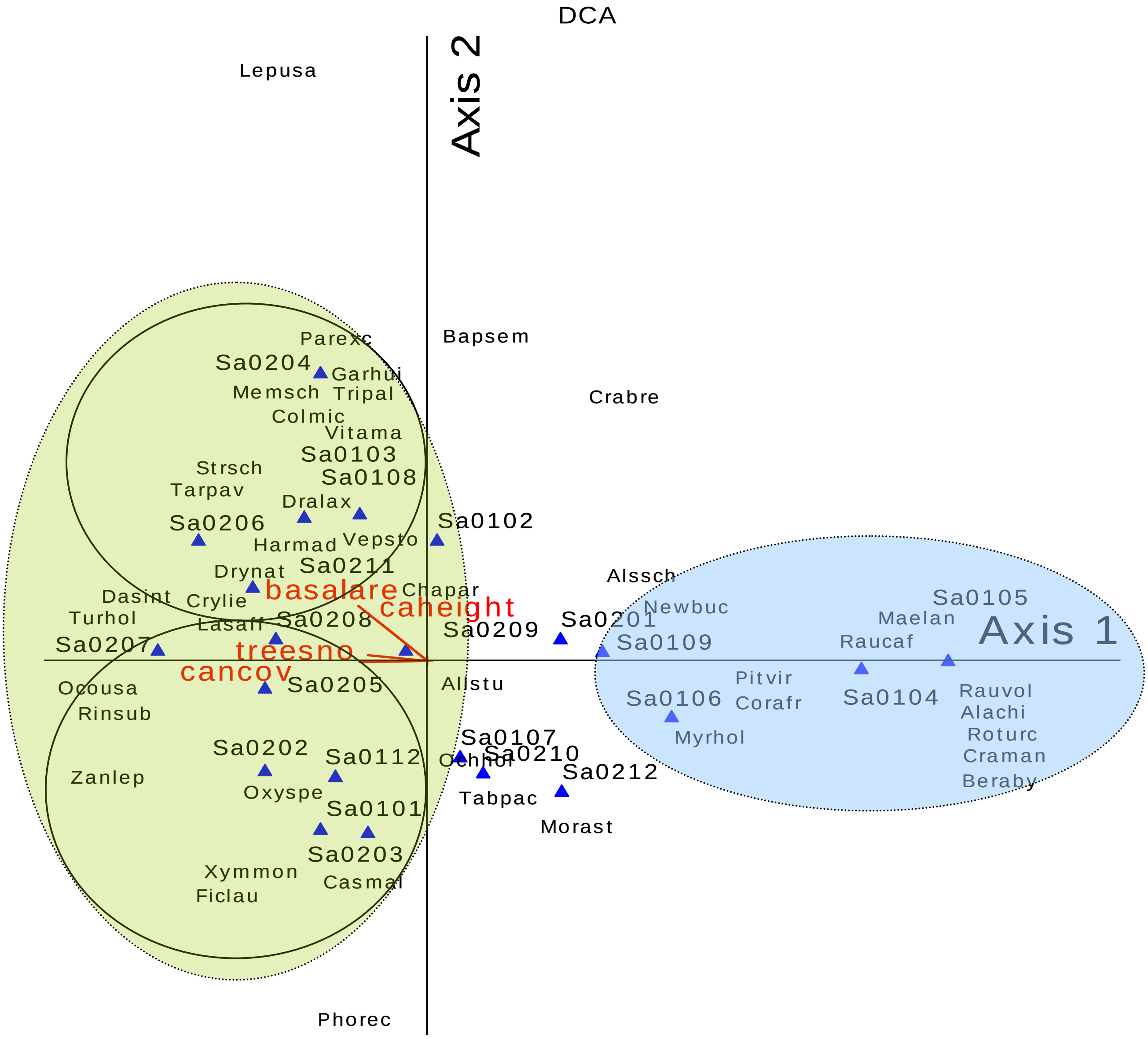

Fig. 4: Graphic ordination results of a DCA in species space. A key for the species codes is presented in Appendix B. Overlaid is are the are the vegetation structural variables. The R^2 cut-off level was set to 0.1 and the vector scaled to 100%.

Ordination in vegetation structure space with species overlay

PCA ordinations in vegetation structure space revealed three important axes with broken-stick eigenvalues of $\lambda = 2.83$, $\lambda = 1.83$ and $\lambda = 1.33$ respectively that combined explained approximately 75% of the total variation in the data. The first axis was mainly negatively associated with the basal area and density of trees (in particular large trees >20 cm dbh), and positively associated with shrub cover (Tab. 6). Axis 2 was negatively associated with average dbh and positively with the tree density, and axis 3 negatively with canopy height and positively with ground cover.

The ordination in vegetation structure space produced a different plot orientation than that in species space (Fig. 5). The plots of the *undifferentiated moist forest group* were spread widely across the first axis: plots dominated by *Parinari excelsa* exhibited a high basal area and greater number of large trees (>20 cm dbh), and plots dominated by *Xymalos monospora* a high ground and shrub cover. The *disturbance resilient/moist forest group* was separated along the second axis with Sa0104, Sa0106 and Sa0109 having a large average dbh and low tree density and Sa0105 being characterised by the opposite: a low average dbh and a high density of (mainly small) trees.

Both the first and the second axis were positively associated with the degree of species' forest independence and the disturbance resilience: the proportion of open area species and disturbance resilient species increased with decreasing basal area, large tree density and average dbh and increased with increasing shrub cover and density of small trees (Fig. 5).

Axis:	**1**			**2**			**3**		
	R	**R2**	**tau**	**R**	**R2**	**tau**	**R**	**R2**	**tau**
cancov	-0.631	0.398	-0.566	-0.182	0.033	-0.091	-0.062	0.004	-0.103
shrcov	**0.495**	**0.245**	**0.443**	0.226	0.051	0.178	0.199	0.04	0.144
grcov	0.209	0.044	0.161	0.37	0.137	0.264	**0.841**	**0.707**	**0.762**
caheight	-0.125	0.016	-0.07	-0.645	0.416	-0.434	**-0.489**	**0.239**	**-0.369**
avdbh	0.137	0.019	0.065	**-0.85**	**0.722**	**-0.619**	0.364	0.133	0.195
treedens	**-0.819**	**0.671**	**-0.619**	**0.468**	**0.219**	**0.322**	0.042	0.002	0.026
basalarea	**-0.847**	**0.718**	**-0.61**	-0.304	0.092	-0.221	0.324	0.105	0.195
avdbhtr	0.034	0.001	0.039	-0.85	0.722	-0.628	0.366	0.134	0.273

Tab. 6: Correlation between the ordination variables (vegetation structure variables) and the ordination axes, indicating how the different variables are represented in the ordination space. For further explanations refer to Tab. 5.

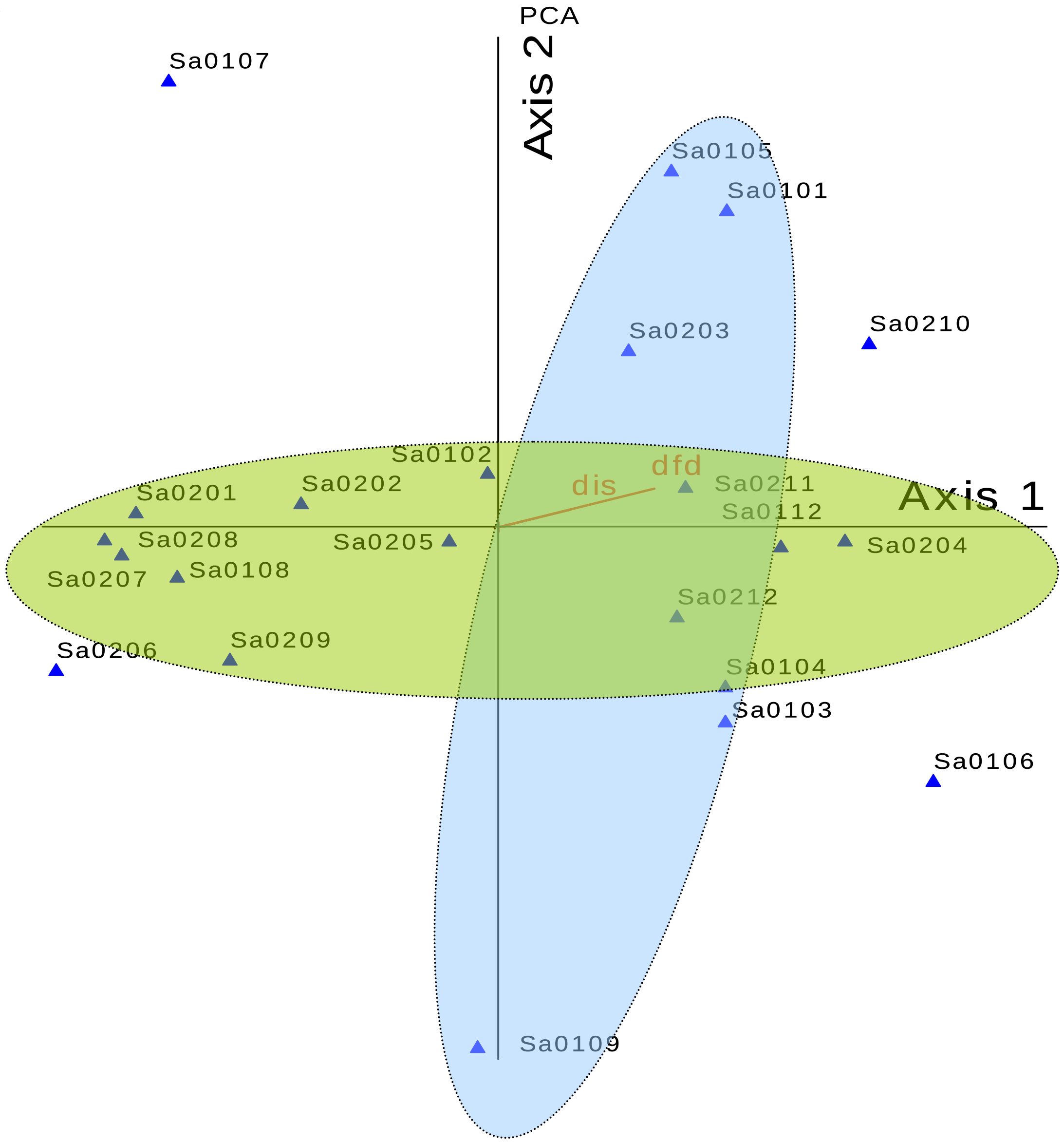

Fig. 5: Graphic ordination results of a PCA in vegetation structure space. Overlaid are the species indicator values (Methods and Appendix B). It is evident that there was a positive correlation between the first axis and the species disturbance resilience (R = 0.35; R^2 = 0.12; tau = 0.15) and the degree of species forest independence (R = 0.513; R^2 = 0.263; tau = 0.389). The R^2 cut-off level was set to 0.1 and the vector scaled to 100%.

4.2 *Identification of environmental gradients shaping vegetation*

4.2.1 Environmental gradients shaping the species composition

A DCA ordination in species space with environmental parameter overlay revealed that the most important parameters were the presence of rocky outcrops and of roads and clearances (Tab. 7 and Fig. 6) – these benefiting the establishment of open area, disturbance resilient and of moisture indicating species. The most important parameters along the second ordination axis were the position along the slope (with plots on more upper positions comprising a greater number of forest dependent and montane species), and the water association (with plots were streams, dry river beds or wetlands were present containing a greater number of forest independent and lowland species).

Axis:	**1**			**2**		
	R	**R2**	**tau**	**R**	**R2**	**tau**
altitude	-0.097	0.009	-0.004	0.182	0.033	0.101
slope	-0.11	0.012	-0.154	0.276	0.076	0.208
aspect	0.073	0.005	0.108	0.073	0.005	-0.012
slopedes	0.045	0.002	0.016	0.09	0.008	0.049
position	-0.135	0.018	-0.146	**0.332**	**0.11**	**0.252**
rocky	**0.473**	**0.224**	**0.273**	-0.012	0	-0.043
roadclea	**0.419**	**0.176**	**0.27**	0.171	0.029	0.125
water	-0.017	0	0.032	**-0.389**	**0.151**	**-0.368**
dfid	**0.594**	**0.353**	**0.415**	**-0.333**	**0.111**	**-0.272**
dis	**0.458**	**0.209**	**0.113**	-0.092	0.008	0
moi	**0.644**	**0.414**	**0.401**	0.065	0.004	0.041
alt	0.218	0.048	0.085	-0.189	0.036	-0.21

Tab. 7 Correlation between the overlaid parameters and the ordination axes. For further explanations refer to Tab. 5 and Appendix A.

Key: altitude = altitude in m; slope = slope in degree; aspect = prevalence of eastern aspect yes/no; slopedes = slope inclination in four classes; position = position along the slope; rocky = presence/absence of rocky outcrops; roadclea = existence of roads and clearances; water = water association; dfid = species' degree of forest independence; dis = species' resilience to disturbance; moi = species' moisture indicating function; alt = species' altitudinal amplitude

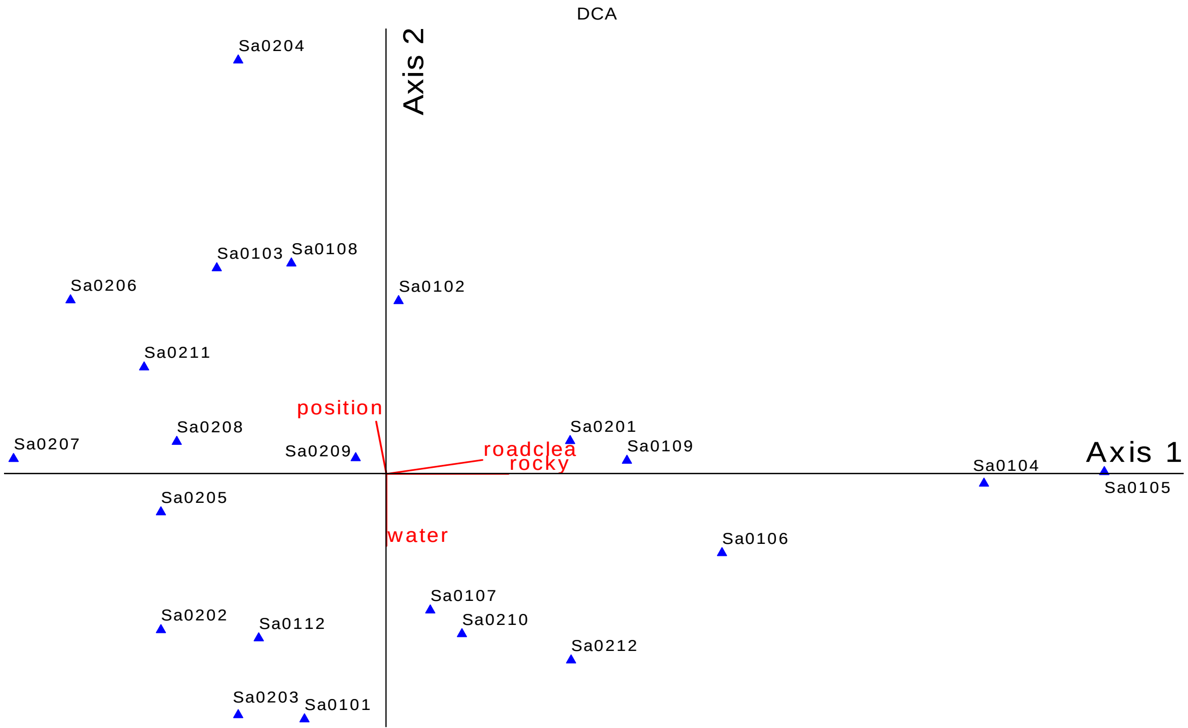

Fig. 6: Graphic ordination results of a DCA. A key to the coding of the overlaid parameters is given in Tab. 7. The R^2 cut-off level was set to 0.1 and vectors scaled to 100%.

4.2.2 Environmental gradients shaping the vegetation structure

The ordination in vegetation structure space (PCA) overlaying environmental parameters showed that the most important gradients along the first axis were the position at the slope (upper positions being associated with a higher basal area and density of larger trees, and the water association (plots containing streams or wetlands exhibiting a higher shrub cover (Tab. 6, Tab. 8 and Fig. 7). An important gradient along the second axis was the presence of roads and clearances – increasing the density of small trees. The third axis was strongly negatively correlated with the slope inclination. Steeper slopes were associated with a higher canopy less shrub coverage.

Axis:		**1**			**2**			**3**	
	R	**R2**	**tau**	**R**	**R2**	**tau**	**R**	**R2**	**tau**
altitude	-0.387	0.15	-0.145	0.42	0.176	0.207	-0.073	0.005	-0.075
slope	-0.17	0.029	-0.154	-0.034	0.001	-0.009	**-0.558**	**0.312**	**-0.434**
aspect	0.094	0.009	0.072	-0.134	0.018	-0.084	-0.383	0.146	-0.276
slopedes	-0.182	0.033	-0.178	-0.062	0.004	-0.038	-0.419	0.176	-0.307
position	**-0.532**	**0.283**	**-0.369**	0.185	0.034	0.087	-0.014	0	-0.039
rocky	0.175	0.031	0.129	-0.167	0.028	-0.215	**0.241**	**0.058**	**0.244**
roadclea	0.09	0.008	0.021	**0.314**	**0.098**	**0.312**	0.137	0.019	0.125
water	**0.341**	**0.116**	**0.249**	-0.086	0.007	-0.087	0.079	0.006	0.087

Tab. 8: Correlation between the overlaid parameters and the ordination axes. For a key to the variable code refer to Tab. 7, for information on the variable calculation to Appendix A, and for further explanations to Tab. 5.

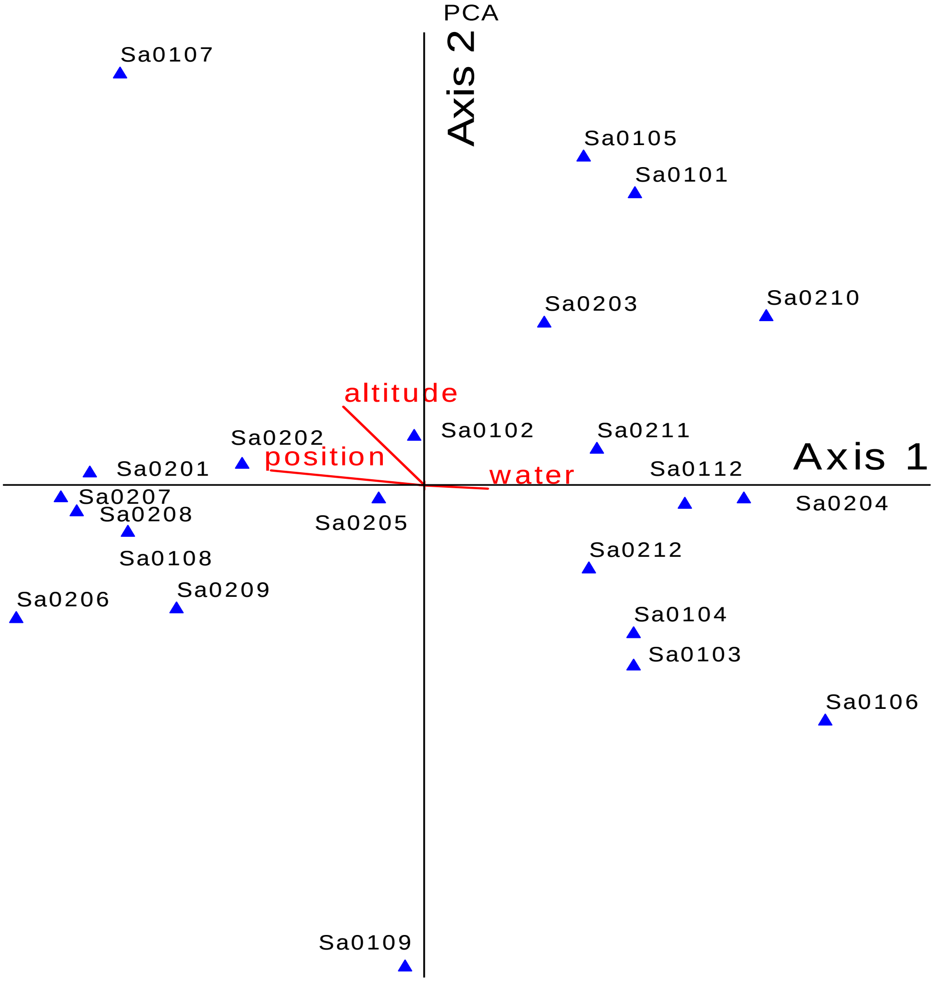

Fig. 7: Graphic ordination results of a PCA. A key to the coding of the overlaid parameters is given in Tab. 7. The R^2 cut-off level was set to 0.1 and vectors scaled to 100%.

4.3 *Analysis of regeneration properties*

4.3.1 Analysis of regeneration properties

The analysis of regeneration properties was constrained by the small regeneration plot size that might have captured little of the overall variation in species regeneration, and by a number of unidentified species. In total, only 25 species were identified to the species level and 18 to the genus level; amongst these there were two (potentially three) threatened species (*Alsodeiopsis schumannii, Baphia semseiana and Lasianthus peduncculatus*[1] (IUCN, 2006; Oldfield et al., 1998), the first two of which are also endemic to the Eastern Arc hotspot.

The available data suggested that regeneration was 'stable' in the majority of the plots in work unit 2, with canopy species restocking as saplings in five plots (*Alsodeiopsis schumanii* in Sa0201, *Xymalos monospora* in Sa0202, *Parinari excelsa* in Sa0204 and *Newtonia buchananii* in Sa0205 and Sa0208) and sub-canopy species restocking in the remainder. No regeneration was recorded for Sa0110, where the area had been burned, and regeneration of open-area species was recorded in plots Sa0111 (*Parinari curatellifolia*), which had also been impacted by fire, and Sa0112 (*Clerodendrum scheffleri*).

4.3.2 Analysis of factors associated with regeneration species composition properties

A species indicator value based PCA ordination showed that there was only one main axis (broken-stick eigenvalue of λ = 2.08) accounting for a substantial overall variation in the data of 62%. This axis was mainly associated with the presence of pioneering species opposed to the degree of regeneration stability (Tab. 9 a). With respect to potential environmental correlates there was a prominent relationship to the water association and the position on the slope; the presence of streams or wetlands being associated with a greater number of pioneers (Tab. 9 b and Fig. 8), and plots being situated at higher (and steeper) slopes exhibiting a more stable the regeneration.

Axis:	**1**		
	R	**R^2**	**tau**
stability	**-0.931**	**0.867**	**-0.757**
dfid	0.724	0.524	0.649
pioneer	**0.885**	**0.783**	**0.592**
moi	0.558	0.311	0.422

a

Axis:	**1**		
	R	**R^2**	**tau**
altitude	-0.151	0.023	-0.326
slope	-0.267	0.071	-0.453
aspect	-0.116	0.013	-0.201
slopedes	-0.053	0.003	-0.152
position	**-0.596**	**0.355**	**-0.521**
rocky	0.115	0.013	0.226
roadclea	0.211	0.045	0.276
water	**0.611**	**0.373**	**0.229**

b

Tab. 9 a: Correlation between the ordination variables and the ordination axes.

Key: stability = canopy or sub-canopy species regenerating yes/no; dfid = degree of species' forest independence; pioneer = number of pioneering species in the regeneration; moi = number of moisture indicating species in the regeneration

Tab. 9 b: Correlation between environmental correlates and a combined measure for past and present use and the regeneration ordination axes. For a key to the variable code refer to Tab. 7.

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[1] Listed as aff. *penduncculatus*

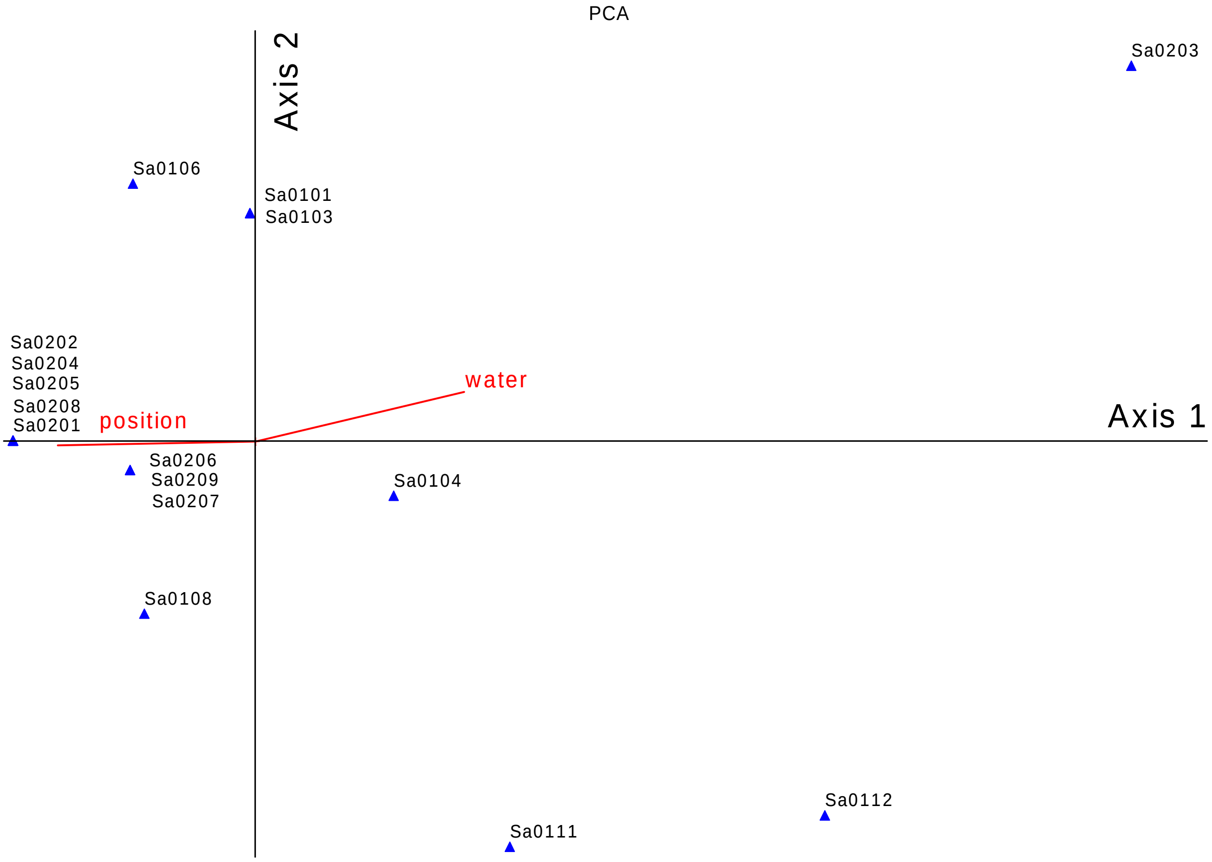

Fig. 8: Graphic ordination results of a PCA in regeneration species indicator values space. A key to the coding of the overlaid parameters is given in Tab. 7. The R^2 cut-off level was set to 0.3 and vectors scaled to 100%.

4.3.3 Analysis of factors associated with regeneration structure properties

A PCA ordination of the regeneration structure properties showed that there was a lot of variation in multidimentional space. It produced three axes jointly accounting for only 60% of the overall variation in the data (broken-stick eigenvalues λ = 2.72, λ = 1.72 and λ = 1.22 respectively). The first axis mainly represented the percentage cover of herbaceous vegetation and forbs dominance, opposing the cover percentage of stones and dominance of grasses; the second axis accounted for the litter cover opposed to the percentage of bare ground (Tab. 10 a). The third axis represented again the dominance of grasses opposed by the dominance of forbs and ferns. The first axis was positively correlated with the water association and negatively with the altitude: the higher the plot location the more dominant herbaceous/forbs vegetation, and if streams are present, the more prevalent the dominance of grasses and cover with stones (Tab. 10 b and Fig. 9). The second axis was positively associated with the position on the slope and negatively with the presence of roads and clearances.

a

Axis:	1			2		
	R	**R²**	**tau**	**R**	**R²**	**tau**
herbaceous	**-0.879**	**0.772**	**-0.707**	0.227	0.052	0.128
bare	-0.305	0.093	-0.275	**-0.664**	**0.441**	**-0.241**
litter	0.46	0.212	0.268	**0.788**	**0.62**	**0.552**
stones	**0.365**	**0.133**	**0.132**	0.173	0.03	0.099
grasses	**0.302**	**0.091**	**0.419**	-0.486	0.236	-0.283
forbs	**-0.861**	**0.742**	**-0.707**	0.222	0.049	0.181
moss	0.241	0.058	0.214	-0.414	0.171	-0.388
ferns	-0.102	0.01	-0.174	-0.091	0.008	-0.278

b

Axis:	1			2		
	R	**R²**	**tau**	**R**	**R²**	**tau**
altitude	**-0.614**	**0.377**	**-0.338**	0.091	0.008	0.129
slope	0.226	0.051	0.124	-0.097	0.009	-0.099
aspect	0.039	0.001	0.121	-0.136	0.018	-0.077
slopedes	0.047	0.002	0.102	-0.079	0.006	-0.112
position	-0.047	0.002	-0.013	**0.336**	**0.113**	**0.306**
rocky	0.053	0.003	0	-0.061	0.004	-0.134
roadclea	-0.13	0.017	-0.179	**-0.456**	**0.208**	**-0.227**
water	**0.372**	**0.139**	**0.3**	-0.146	0.021	-0.29

Tab. 10 a: Correlation between the ordination variables and the ordination axes.

Key: herbaceous = cover percentage of herbaceous vegetation; bare = cover percentage of bare soil; litter = cover percentage of litter; stones = cover percentage of stones; grasses = dominance percentage of grasses amongst the herbaceous vegetation; forbs: dominance percentage of forbs amongst the herbaceous vegetation; moss = dominance percentage of moss/lichens amongst the herbaceous vegetation; ferns = dominance percentage of ferns amongst the herbaceous vegetation

Tab. 10 c: Correlation between environmental correlates and a combined measure for past and present use and the ordination axes. For a kev to the variable code refer to Tab. 7.

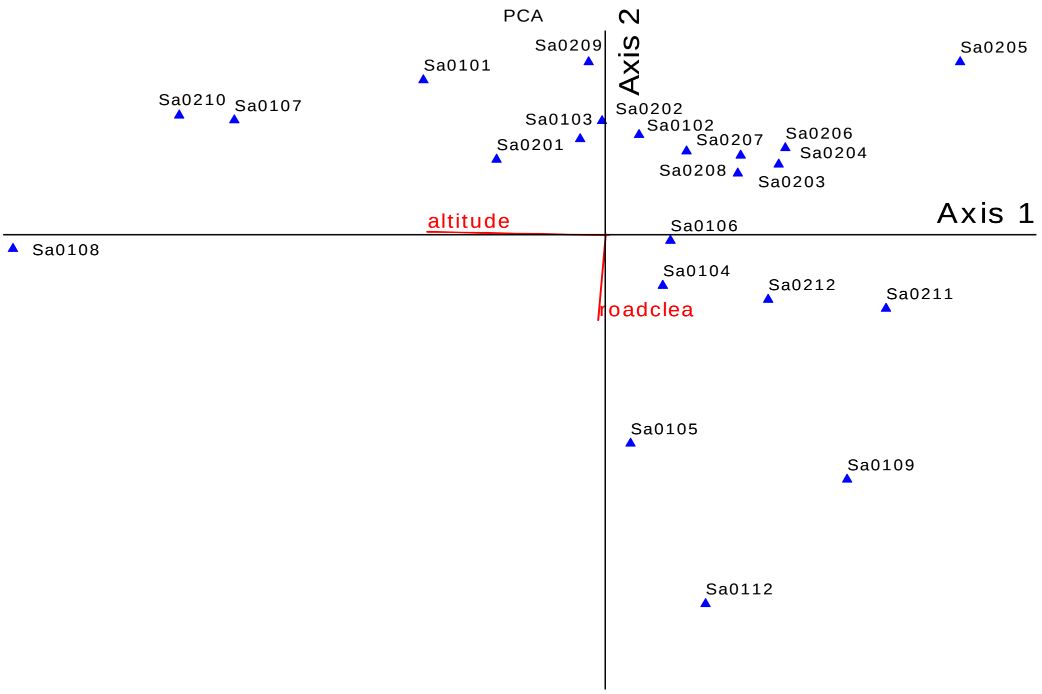

Fig. 9: Graphic ordination results of a PCA in regeneration structure space. A key to the coding of the overlaid parameters is given in Tab. 7. The R² cut-off level was set to 0.3 and vectors scaled to 100%.

4.4 *Further questions of conservation and scientific interest:*

4.4.1 Analysis of the factors associated with high species richness and diversity

With nearly half of the recorded individuals not yet being identified to the species level this analysis would not be very meaningful at this stage and will be postponed until the full species identifications are available.

4.4.2 Quantification of the share of species of conservation concern and their properties

As above, this analysis will be suspended until full species identifications are available. Thus far, six (potentially seven) species (A*llanblackia stuhlmanii, Alsodeiopsis schumannii, Baphia semseiana, Dasylepsis integra, Morinda asteroscepa, Vitex amaniensis* and (*Lasianthus pedunculatus*)) have been identified that are classified as vulnerable (IUCN, 2006; Oldfield et al., 1998), of which five (A*llanblackia stuhlmanii, Alsodeiopsis schumannii, Baphia semseiana, Dasylepsis integra* and *Vitex amaniensis* are also (near) endemic to the region (e.g. White, 1988; Ministry of Natural Resources and Tourism, 2006). All of these species are forest dependent and non-resilient to disturbances.

4.4.3 Broad-scale vegetation comparison

Sali Forest is classified as one of the Eastern Arc Mountain forests (originally delineated based on climate and geology) (Lovett et al., 2000). The vast majority of the species were montane or widespread in both lowland and montane areas. Very few were predominantly lowland species (*Baphia semseiana, Crassocephalum mannii, Drypetes natalensis* and *Garcinia huillensis*). Both the Jaccard's Coefficient and Sørensen Index showed that the floristic affinity to the the Nguru Mountain forests (Appendix C) and the West- and East Usambaras, sharing species that are predominantly widespread motanes, some of which can also occur at lower altitudes. Beta diversity was highest between Sali and the lowland coastal forests, and to Sanje Forest in South Pare.

4.4.4 Detailed summary of the apparent impact of different forms of disturbance.

A detailed break-down of the impact of different forms of disturbances proved infeasible as the sampling sizes of plots being affected by different disturbances was too low.

5 Discussion

5.1 Exploration of suitable approaches to a vegetation classification

5.1.1 Performance of conventional methods in general

Application of conventional methods, and variations of these, to classify the vegetation included (i) the establishment of phyto-sociological groups using TWINSPAN, (ii) a variation of the Braun-Blanquet approach, (iii) the establishment of phyto-ecological groups using species indicator values, and (iv) clustering of structural groups. These were of limited use to produce a convincing classification of the vegetation: they consistently detected the two main groups in the vegetation, but when it came to the identification of sub-groups the applied methods provided erratic results. TWINSPAN, in particular, reacted very sensitive to small changes in the data, meaning that newly available species identifications might generate a different classification. The poor performance of TWINSPAN owes to the fact there was not a single most important environmental gradient. In such a situation, the RA underlying TWINSPAN performs erratically. The assignment of strategy groups (i.e. forest specialist, forest generalist, pioneer) and further indicator properties (i.e. moisture indicator and disturbance resistant) to the individual species s was relatively consistent with the floristic groups. The analysis of structural and regeneration properties diverged slightly, showing that a floristic analysis alone would not have sufficed to classify the vegetation. Thus, conventional methods typically focusing on a single or a few vegetation properties failed to produce a coherent and widely applicable vegetation classification; the fuller picture only emerging when different approaches were combined. In addition, the analysis of vegetation was hampered by the great number of unidentified species.

5.1.2 Specific limitations to the performance of the conventional methods

The necessity for combining different approaches and maximising information that the classifications are based upon was further emphasised by the fact that each of the single approaches suffered substantial shortfalls, in particular with respect to the representativity of the data. The species group based analyses (i, ii, and iii) were impacted by poor taxonomic resolution and, to a degree, by the small number of plots[2]. The feasibility of establishing phyto-ecological groups using species indicator values was limited by the majority of the species having poorly known ecologies. Typically, the species specific ecological amplitudes had been established on a very coarse level (e.g. *lowland to submontane*, or *submontane to upper montane*), if at all, and therefore only suitable for broad-scale comparisons. This rendered a phyto-ecological vegetation classification across a small gradient those established in the work units relatively arbitrary.

In general, a strong continuum was apparent in the vegetation, rendering any classification analysis unsuitable.

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[2] As a rule of thumb, in order to delineate a vegetation association this particular association should ideally be represented with at least five assessments. Thus, depending on how many vegetation associations appear to exist in the field, the number of plots should be fivefold or more, especially when the plots are not located subjectively but randomly or systematically. While the available number of plots allowed to identify the major divide in the vegetation, further sub-associations could not be identified. This might however also owe to the fact that a strong continuum was present in the vegetation.

5.1.3 Suggestions for a classification scheme

With the conventional vegetation classification methods proving unsuitable due to the high variability of the vegetation and the various shortfalls in data availability, it seemed most appropriate to (i) opt for a coarser approach and (ii) combine information on species composition, species' ecological requirements, vegetation structure and site characteristics for the classification. This approach is typically featured in ecosystems where the vegetation is not known in enough detail, where high species richness combined with a low sample number elude a traditional classification focusing on species composition or vegetation structural properties alone. The inclusion of regeneration properties added further useful information and temporal depth to the interpretation. The scheme that was used here was the following:

1. Exploration of overlap and divergences between species composition groups and vegetation structure groups and preliminary delineation of those groups that appear consistent to attempt a broad classification identifying character species for the respective vegetation types.
2. Refinement and interpretation of the potential associations in the light of site conditions and species indicator functions.
3. Refinement and interpretation of the potential associations in the light of the regeneration properties.
4. Derivation of a name for the potential associations as exemplary: [most conspicuous vegetation structural characteristics] + [characteristic and/or differential species] + [general vegetation type description according to Greenway (1973)] + [description of prevalent and potentially vegetation shaping environmental site conditions] + [state as indicated by the regeneration properties] If the vegetation association is strongly dominated by certain processes, these might be placed right at the beginning, for example *disturbed, recovering,* or *fire induced*.

A relatively underdeveloped ecological classification concept, and potentially promising for the type of analysis Frontier Tanzania are undertaking, is that of Plant Functional Types (based on plant traits such as pollination mode, seed type, leaf shape, etc.). Within the framework of the KITE project, the potential of this classification will be explored in the context of the Eastern Arc flora and results be made available.

5.1.4 Establishment of the actual vegetation classification[3]

The floristic classification analyses coherently identified similarities in the vegetation between Sa0104, Sa0105, Sa0106, Sa0109, but Sa0105 exhibited a different vegetation structure. Sa0105 was characterized by a disturbance (clearing), which was reflected in the vegetation structure. Interestingly, Sa0104, Sa0106 and Sa0109 shared disturbance resilient species with Sa0105 (e.g. *Alangium chinense* and *Maesa lanceolata*), however, no disturbances had been noted for these sites. On the contrary, they exhibited the highest average dbh and a high basal area, suggesting a good forest environment. Sa0104, Sa0106 and Sa0109 were characterised by the presence of a stream. It is possible that streams, in particular when they are large and fast flowing, constitute a vegetation shaping factor that operates similar to disturbances by creating larger tree gaps. In addition, they

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[3] It should be noted that this classification initially is very coarse, but could be subject to further review and refinement once more species identifications (and more data in general through further fieldwork that Frontier Tanzania is conducting) have become available.

introduce an additional species dispersal factor, potentially carrying seeds of widespread and resilient species. Without knowing the actual site, it is not possible to know whether any of these hypothesises approximates the reality on the ground.

The remaining vegetation plots were extremely difficult to classify. There were a great number of species with overlapping distribution between all these plots. From a species composition point of view, the overlap was greatest between Sa0108, Sa0112, Sa0202, Sa0203, Sa0204, Sa0205, Sa0206, Sa0207 and Sa0211. These had been grouped together, while not further associations were identified for the remainder of the plots (the initially established associations proving little robust to sensitivity analyses and across the different methodologies applied). The most dominant species in the identified group were *Parinari excelsa* and *Xymalos monospora*. They appeared mutually exclusive, however, this impression might simply be an artefact of the paucity of the available data, and the division in two sub-groups dominated by these species respectively is therefore unsure. It was however also conspicuous that those plots dominated by *Parinari excelsa* differed from those that were dominated by *Xymalos monospora*.

In general, it was found extremely difficult to establish any vegetation classification, a strong continuum being apparent. It is possible that, for the Eastern Arc Mountain vegetation in general, vegetation analyses methodologies that allow for a continuum (gradient analyses) might be more appropriate than classification analyses. Further research is warranted to further elucidate this.

5.2 Identification of environmental gradients shaping vegetation

Potential environmental correlates (altitude, topography, slope, aspect and water association in addition to past and present disturbance) were explored using different ordination, regression or general linear modelling techniques as appropriate. The analysis showed that the vegetation was not influenced by a single most important environmental factor, but by a combination of factors with similar weight. These were the presence of roads and clearances (increasing the number of open area and disturbance resilient species and the density of small trees), the position on the slope (with plots higher on slope comprising a greater number of forest dependent and montane species, and exhibiting a higher basal area and density of larger trees), and water (with plots were steams, dry river beds or wetlands were present containing a greater number of forest independent and disturbance resilient species and exhibiting a higher shrub cover). While the impact of roads and clearances is expected, the fact that plots situated higher at the slope seem to exhibit a better forest environment and that plots that have a water association less so, is difficult to explain. It is possible that plots located higher on the slopes have not been subjected to disturbances (e.g. agricultural encroachment) and therefore retain relatively undegraded forest. As detailed in 5.1.3, the presence of streams might be a vegetation shaping factor that operates similar to disturbances. Further research is warranted to better understand the function of the agent ‘water’.

The slope inclination and the exposition seemed to be less important gradients. The same applied for altitude, however, the work units had only captured a small altitudinal gradient.

5.3 Analysis of regeneration properties

The analysis of regeneration confirmed the above gradient analysis. The most important factors were again the position on the slope (with plots situated at a higher altitude exhibiting a more stable regeneration), water association (with plots were streams and dry river beds were present having a greater number of pioneers and greater cover with rocks and of grasses), and the presence of roads and clearances (with a greater number of pioneers and more bare ground).

5.4 Further questions of conservation and scientific interest

With seven threatened (including four endemic) species being identified despite the yet poor taxonomic resolution, Sali appears of great importance to species conservation. The threat classification for the hotspot’s forest species classification for the region is in urgent need of review (Gereau and Luke, 2006) as, for instance, locally forest loss and disturbance have been much more sever than was assumed (Ahrends, 2006), and a much greater number of species endangered. The Mahenge Mountains region in general is of great conservation and scientific interest. An indication of the high level of endemism in the overall Mahenge region is given by the presence of *Allanblackia stuhlmannii, Garcinia semseii, Pterocarpus mildbraedii* subsp. *usambarensis* and *Octoknema orientalis* (Ministry of Natural Resources and Tourism, 2005). The area is fairly under-researched and further floristic inventory are needed. Great scientific interest owes to their pivotal position at the south-eastern range of the Eastern Arc Mountains. While the floristic overlap between Sali and the Uluguru and Udzungwa forests yet has to be established, there was low floristic affinity to South Pare at the northern end of the Eastern Arc Mountains[4].

5.5 Technical suggestions

In general, the analysis benefited from the outstanding field effort that Frontier Tanzania had undertaken. Despite the low number of plots, the fact that those plots were relatively large and that extensive data was available - most notably on topographic position, present disturbances, vegetation structure and regeneration quality – meant that extensive analysis was possible. While in this particular analysis it was generally not possible to distinguish between ‘signal and noise’, the high field effort will certainly pay off as more plot data become available. The technical suggestions are the same as in the Mselezi Report. It should however be noted that the fact that for Sali two work units and twice as many plots were available increased the reliability of the analysis. Working with just one work unit where there are spatial autocorrelations might lead to ‘too easy’ conclusions and conceil the great amount of local variation and the complex interactions that cannot easily be captured.

References

As in Mselezi Report.

Appendix A

As in Meselzi Report

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[4] Further research within the framework of the KITE project will determine whether floristic and genetic beta-diversity is greatest between areas that are farthest, or whether this is not strictly true.

Appendix B

Species and their ecological requirements and distributions

Family	Genus	Species	Species code	Ecology according to Lovett et al. (*in press*)	Ecology according to Clarke (1995a)	Ecology according to Beentje (1994)	distribution according to Lovett et al. (*in press*)[5]	(near) end[6]	RL[7]	dfid[8]	dis[9]	moi[10]	reg.[11]
Acanthaceae	Mellera	lobulata	Mellob		forest only					**1**			**1**
Agavaceae	Dracaena	afromontana	Draafr	Montane forest.	n/a	Moist forest or bamboo.	EA, N, LN, LT. Rwanda, Burundi.			**1**		**1**	**1**
Alangiaceae	Alangium	chinense	Alachi	n/a	n/a	Wet upland forest or semideciduous upland forest. (Quick growing, possibly a pioneer species.)				**2**	**1**		
Annonaceae	Monodora		Monspe										
Apocynaceae	Hunteria		Hunspe										**1**
Apocynaceae	Rauvolfia	caffra	Raucaf	Montane forest.	n/a	Riverine forest or thicket, less often in forest away from water.	C, EA, N, LN, LT. Widespread in Tropical and Southern Africa.			**1**		**1**	

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[5] For key to distribution codes see end of table

[6] According to Beentje (1994); Burgess and Clarke (2000); Clarke (1995a); Lovett et al. (*in press*)

[7] Red List status according to IUCN (2006)

[8] Degree of species' forest independence (coded as in Appendix A)

[9] Species' disturbance resilience (coded as in Appendix A)

[10] Species' moisture indicator function (coded as in Appendix A)

[11] 1 = present in regeneration plots

Family	Genus	Species	Species code	Ecology according to Lovett et al. (*in press*)	Ecology according to Clarke (1995a)	Ecology according to Beentje (1994)	distribution according to Lovett et al. (*in press*)[5]	(near) end[6]	RL[7]	dfid[8]	dis[9]	moi[10]	reg.[11]
Apocynaceae	Rauvolfia	volkensii	Rauvol	n/a	n/a	n/a							1
Apocynaceae	Tabernaemontana	pachysiphon	Tabpac	n/a	Forest only.	Forest (margins).	C, EA, N, LN, LT, LV. Widespread in Tropical Africa.			2			
Apocynaceae	Tabernaemontana		Tabspe										
Araceae	Culcasia	falcifolia	Culfal	n/a	n/a	n/a							1
Bignoniaceae	Markhamia		Marspe										
Boraginaceae	Cordia	africana	Corafr	Riverine, groundwater, dry montane and secondary forest. Grassland.	n/a	Wooded grassland, forest, riverine.	C, EA, N, LN, LT.			3	1		
Celastraceae	Saloacia												1
Chrysobalanaceae	Parinari	curatellifolia	Parcur	n/a	Not forest. Woodland, bushland, grassland.	Wooded grassland, often in rocky sites.	n/a			3			1
Chrysobalanaceae	Parinari	excelsa	Parexc	Riverine, lowland, submontane, montane forest.			C, EA, LN, LT, LV. Widespread in Tropical Africa.			1			
Compositae (Asteraceae)	Crassocephalum (Beentje (1994): = Solanecio)	mannii	Craman	n/a	n/a	Dry or evergreen forest edges, degraded or secondary forest, also riverine and on rocky slopes in bushland.				2	1		

Family	Genus	Species	Species code	Ecology according to Lovett et al. (*in press*)	Ecology according to Clarke (1995a)	Ecology according to Beentje (1994)	distribution according to Lovett et al. (*in press*)[5]	(near) end[6]	RL[7]	dfid [8]	dis [9]	moi [10]	reg. [11]
Dracaenaceae (Agavaceae)	Dracaena	laxissima	Dralax	n/a	n/a	Moist or riverine forests; in dry forets usually near water.				1		1	
Dracaenaceae (Agavaceae)	Dracaena		Draspe										1
Euphorbiacea	Drypetes	natalensis var. natalensis	Drynat	Riverine, dry lowland forest.	Forest only.	(Riverine) forest.	C, N, LT. Eastern Tropical and Southern Africa.			1			1
Euphorbiaceae	Alchornea		Alcspe										1
Euphorbiaceae	Drypetes		Dryspe										1
Euphorbiaceae	Erythrococca		Eryspe										1
Flacourticeae	Dasylepis	integra	Dasint	Montane forest.	n/a	Upland moist forest.	EA, N (Mbulu). Southeast Kenya.	1	VU B1+2b	1		1	
Guttiferae (Clusiaceae)	Allanblackia	stulhmanii	Allstu	Submontane and montane forest.	n/a	n/a	EA (EUs, Ul, Udz) only.	1	VU B1+2c	1			
Guttiferae (Clusiaceae)	Allanblackia		Allspe										
Guttiferae (Clusiaceae)	Garcinia	huillensis (Beentje (1994): = buchananii)	Garhui	G. buchananii: riverine, dry lowland and lowland forest.	G. buchananii: forest, riverine forest, thicket, grassland.	G. buchananii: moist forest or dense wooded grassland.				2			

Family	**Genus**	**Species**	**Species code**	**Ecology according to Lovett et al. (*in press*)**	**Ecology according to Clarke (1995a)**	**Ecology according to Beentje (1994)**	**distribution according to Lovett et al. (*in press*)[5]**	**(near) end[6]**	**RL[7]**	**dfid[8]**	**dis[9]**	**moi[10]**	**reg.[11]**
Guttiferae (Clusiaceae)	Garcinia		Garspe										1
Guttiferae (Clusiaceae)	Harungana	madagascariensis	Harmad	Lowland, submontane and montane forest. Pioneer.	WE forest only.	Moist forest margins (or remnants of forests).	C, EA, LN, LT, LV. Tropical Africa. Madagascar.			2	1		
Icacinaceae	Alsodeiopsis	schumannii	Alssch	Submontane, montane and upper montane forests.	n/a	n/a	EA (EUs, Ul) only.	1	VU B1+2b	1			1
Lauraceae	Cryptocarya	liebertiana	Crylie	Submontane, montane and upper montane forest.	n/a	Moist forest.	EA, LN. Malawi.			1		1	
Lauraceae	Ocotea	usambarensis	Ocousa	Submontane, montane and upper montane forests.	n/a	Moist forest.	C, EA, N, LN. Central and Eastern Tropical Africa.			1		1	
Fabaceae: Mimosoideae	Albizia	gummifera	Albgum	Riverine, dry lowland, montane and dry montane forest.	Forest only.	Dry or wet, lowland or upland forest edges; also riverine forest; may locally be common.	C, EA, N, LN, LT, LV. Tropical Africa. Madagascar.			1			1
Fabaceae: Mimosoideae	Albizia		Albspe										
Fabaceae: Mimosoideae	Newtonia	buchananii	Newbuc	Riverine, groundwater, lowland, submontane and montane forest.	n/a	Riverine, swamp or mist forest; may be locally common.	C, EA, N, LN, LT, LV. Eastern, Central, and Southern Tropical Africa.			1		1	1

Family	Genus	Species	Species code	Ecology according to Lovett et al. (*in press*)	Ecology according to Clarke (1995a)	Ecology according to Beentje (1994)	distribution according to Lovett et al. (*in press*)[5]	(near) end[6]	RL[7]	dfid [8]	dis [9]	moi [10]	reg. [11]
Fabaceae: Papilionoideae	Baphia	semseiana	Bapsem	Riverine, lowland forest.	n/a	n/a	EA only (Ng, Udz).	1	VU B1+2b	1			1
Fabaceae: Papilionoideae	Craibia	brevicaudata	Crabre	Ssp. baptistarum: montane forest; ssp. Brevicaudata: riverine, lowland forest; ssp. schliebenii: montane forest.	Forest only.	Evergreen coastal forest, rocky wooldand, bush/woodland, and along rivers in rocky sites.	Ssp. baptistarum: LN, LT. Southern Tropical Africa; ssp. brevicaudata: C. Kenya; ssp. schliebenii: EA (EUs, Rubeho, Ulu). Mozambique.			2			1
Fabaceae: Papilionoideae	Craibia		Craspe										1
Melastomataceae	Memecylon	schliebenii	Memsch	n/a	n/a	n/a							
Meliaceae	Trichilia		Trispe										1
Meliaceae	Turraea	holstii	Turhol	Lowland, submontane and montane forests.	n/a	Forest.	C, EA, N, LN. Eastern Africa, Arabian Peninsula.			1			1
Melianthaceae	Bersama	abyssinica	Beraby	Ssp. abyssinica: lowland, submontane, montane, upper montane forest, forest edge; ssp. paullinioides: lowland, montane and	Forest, riverine forest, woodland, grassland.	Both ssp.: upland grassland, dry and wet montane and riparian forest glades and edges.	Ssp. abyssinica: C, EA, N, LN, LT, LV. Eastern Africa, Rwanda, Burundi; ssp. paullinioides: C, EA, N, LN,			3	1		1

Family	**Genus**	**Species**	**Species code**	**Ecology according to Lovett et al. (*in press*)**	**Ecology according to Clarke (1995a)**	**Ecology according to Beentje (1994)**	**distribution according to Lovett et al. (*in press*)[5]**	**(near) end[6]**	**RL[7]**	**dfid** [8]	**dis** [9]	**moi** [10]	**reg.** [11]
				upper montane forest.			LT, LV. Tropical Africa.						
Monimiaceae	Xymalos	monospora	Xymmon	Submontane, montane and upper montane forest.	n/a	n/a	EA, N, LN, LT, LV. Eastern and Southern Africa, Cameroon highlands, Equatorial Guinea (Bioko).			1			1
Moraceae	Ficus		Ficspe										
Moraceae	Myrianthus	holstii	Myrhol	n/a	n/a	Moist forest. Often near rivers.				1		1	
Myrsinaceae	Maesa	lanceolata	Maelan	Montane, upper montane and dry montane forests. Forest edge.	n/a	Widespread. Often in secondary forest. A pioneer in forest margins.	EA, N, LN, LT, LV. Tropical and Southern Africa. Madagascar. Arabian Peninsula.			2	1		
Ochnaceae	Ochna	holstii	Ochhol	Submontane and montane forest.	Forest only.	Dry forrest (remnants) and mist forest.	C, EA, N, LN, LT. Eastern and Southern Africa including Eastern Democratic			1			1

Family	**Genus**	**Species**	**Species code**	**Ecology according to Lovett et al. (*in press*)**	**Ecology according to Clarke (1995a)**	**Ecology according to Beentje (1994)**	**distribution according to Lovett et al. (*in press*)[5]**	**(near) end[6]**	**RL[7]**	**dfid[8]**	**dis[9]**	**moi[10]**	**reg.[11]**
							Republic of Congo.						
Olacaceae	Strombosia	scheffleri	Strsch	Submontane and montane forest.		moist forest, sometimes dominant	EA, N, LN, LT, LV. Tropical Africa.			**1**			
Oleaceae	Chionanthus	mildbraedii	Chimil	Submontane, montane and upper montane forest.	Forest only.	Wet upland forest.	EA, N. Kenya, Uganda, Central and West-central Africa.			**1**			
Palmae (Arecaceae)	Phoenix	reclinata	Phorec	Dry lowland, montane and riverine forest. Thicket.	n/a	Along watercourses in the lowlands, higher up on open rocky hillsides and in disturbed forest.	C, EA, N, LN, LT, LV.			**2**	**1**	**1**	**1**
Pittosporaceae	Pittosporum	viridiflorum	Pitvir	Submontane, montane, upper montane and dry montane forest.	n/a	Dry evergreen forest or riverine thickets/forests, wooded grassland; also in forest clump remnants.	EA, N, LN, LT, LV. Tropical and Southern Africa. Madagascar, Southern India.			**2**			**1**
Podocarpaceae	Podocarpus		Podspe										
Proteaceae	Protea												**1**

Family	**Genus**	**Species**	**Species code**	**Ecology according to Lovett et al. (*in press*)**	**Ecology according to Clarke (1995a)**	**Ecology according to Beentje (1994)**	**distribution according to Lovett et al. (*in press*)[5]**	**(near) end[6]**	**RL[7]**	**dfid [8]**	**dis [9]**	**moi [10]**	**reg. [11]**
Rhizophoraceae	Cassipourea	malosana	Casmal	Montane and dry montane forest.	Forest only.	Drier forest (Podo/cedar/olive), or understorey in moister forest; also in forest remnants.	EA, N, LN, LT, LV. Eastern, Central and Southern Africa.			**1**			
Rubiaceae	Chassalia	parvifolia	Chapar	n/a	n/a	Evergreen mist forest.				**1**		**1**	
Rubiaceae	Chassalia		Chaspe										**1**
Rubiaceae	Gardenia		Gardsp										**1**
Rubiaceae	Ixora		Ixospe										
Rubiaceae	Keetia		Keespe										**1**
Rubiaceae	Lasianthus	aff. L. pedunculatus	Lasaff	n/a	n/a	n/a			(VU B1+2b)				**1**
Rubiaceae	Lasianthus		Lasspe										
Rubiaceae	Morinda	asteroscepa	Morast	Submontane forest.	n/a	n/a	EA. Malawi.		VU B1+2b	**1**			
Rubiaceae	Oxyanthus	speciosus	Oxyspe	Riverine, lowland, submontane, montane and upper montane forest. Thicket.	n/a	(Riverine) forest.	In Tanzania there are three subspecies with different geographical distributions: subsp. *globosus* Bridson (LV), subsp. *mollis* (Hutch.) Bridson (LT), subsp. *stenocarpus* (K.Schum.) Bridson (EA,			**1**			

Family	**Genus**	**Species**	**Species code**	**Ecology according to Lovett et al. (*in press*)**	**Ecology according to Clarke (1995a)**	**Ecology according to Beentje (1994)**	**distribution according to Lovett et al. (*in press*)**[5]	**(near) end**[6]	**RL**[7]	**dfid** [8]	**dis** [9]	**moi** [10]	**reg.** [11]
							N, LN, LT).						
Rubiaceae	Pavetta		Pavspe										1
Rubiaceae	Polysphaeria		Polspe										1
Rubiaceae	Psychotria		Psyspe										1
Rubiaceae	Rothmannia	urcelliformis	Roturc	Submontane and montane forest.	n/a	Forest; in dry forest usually near rivers.	EA, N, LT, LV. Tropical Africa.			1		1	
Rubiaceae	Rothmannia		Rotspe										
Rubiaceae	Tarenna	pavettoides	Tarpav	Lowland, submontane and montane forest.	n/a	(Riverine) forest or secondary bushland near forest.	subsp *affinis*: C, EA, LN. South-eastern Tropical Africa. subsp. *gillmannii*: EA, LN, LT, LV. Eastern, Central, and Southern Tropical Africa.			2	1		

Family	**Genus**	**Species**	**Species code**	**Ecology according to Lovett et al. (*in press*)**	**Ecology according to Clarke (1995a)**	**Ecology according to Beentje (1994)**	**distribution according to Lovett et al. (*in press*)[5]**	**(near) end[6]**	**RL[7]**	**dfid [8]**	**dis [9]**	**moi [10]**	**reg. [11]**
Rubiaceae	Tricalysia	pallens	Tripal	Riverine, lowland and submontane forest.	Forest, riverine forest, forest edge, bushland.	Moist evergreen forest (margin) or riverine forest.	C, EA, LT. Tropical Africa.			**2**	**1**	**1**	
Rubiaceae	Tricalysia		Tricasp										**1**
Rutaceae	Clausena	anisata	Claani	n/a	Forest, forest edge, bushland, grassland.	Moist for dry forest (margins), secondary bushland, riverine; in western Kenya sometimes in wooded grassland.	C, EA, N, LN, LV. Tropical and Southern Africa, Comoros Islands.			**2**	**1**		**1**
Rutaceae	Vepris	stolzii	Vepsto	Montane forest.	n/a	n/a	EA, LN, LT. Eastern and Central Tropical Africa, Angola.			**1**			**1**
Rutaceae	Zanthoxylum	leprieurii	Zanlep	Submontane and montane forest.	n/a	n/a	C, EA, LV. Tropical and Southern Africa.			**1**			
Sapindaceae	Deinnbollia	kilimandscharica	Deikil	Submontane and montane forest.	n/a	Moist for dry forest, riverine forest.	EA, N, LN. Eastern Tropical Africa.			**1**			**1**
Sapotaceae	Mimusops		Mimspe										
Sapotaceae	Synsepalum	cerasiferum	Syncer	Lowland, submontane, montane, riverine and groundwater forest.	n/a		EA, LT, LV. Tropical Africa.						**1**
Sterculiaceae	Cola	microcarpa	Colmic	n/a	Forest only.	n/a				**1**			

Family	**Genus**	**Species**	**Species code**	**Ecology according to Lovett et al. (*in press*)**	**Ecology according to Clarke (1995a)**	**Ecology according to Beentje (1994)**	**distribution according to Lovett et al. (*in press*)[5]**	**(near) end[6]**	**RL[7]**	**dfid[8]**	**dis[9]**	**moi[10]**	**reg.[11]**
Sterculiaceae	Cola		Colspe										1
Sterculiaceae	Leptonychia	usambarensis	Lepusa	Lowland, submontane and montane forest.	n/a	Moist forest.	C, EA, N.			1		1	1
Sterculiaceae	Octolobus	spectabilis	Octspe	n/a	n/a								
Theacaeae	Ficalhoa	laurifolia	Ficlau	Montane forest.	n/a	n/a	EA, LN, LT. Uganda, Central and South-eastern Tropical Africa. Angola.			1			
Verbenaceae	Clerodendrum	myricoides (=scheffleri)	Clemyr	n/a	Riverine forest, forest edge, woodland, bushland, grassland, rocky sites.	(Secondary) dry or semi-evergreen bushland, bushed grassland, or wooded grassland; often on rocky sites.	n/a			3	1		1
Verbenaceae	Vitex	amaniensis	Vitama	Submontane and montane forest.	n/a	n/a	EA only (EUs, Ul, Udz).	1	VU B1+2b	1			
Violaceae	Rinorea	subintegrifolia	Rinsub	n/a	n/a								1

Key for 'distribution according to Lovett et al. (*in press*):

Coastal (C). Eastern Arc (EA). Northern (N). Lake Nyasa (LN). Lake Tanganyika (LT). Lake Victoria (LV). Mountains (north to south): Teita Hills (Te), Pare (P), Usambara (Us), East Usambara (EUs), West Usambara (Wus), Northern Nguru (NNg), Southern Nguru (SNg), Nguru (Ng), Uluguru (Ul), Malundwe (Mal), Udzungwa (Udz), Mahenge (Ma).

Appendix C

Floristic affinity to other forests

	EUS and WUS[12]	Khi and Muf	Maz	Ngu	San	Cho[13]	Ulu	Udz	Coastal forets[14]	Genus	Species
	150	**45**	**66**	**62**	**145**	**77**	**112**	**320**	**418**		
	1			1						Alangium	chinense
	1	1	1	1	1	1			1	Albizia	gummifera
	1	1	1	1	1					Allanblackia	stulhmanii
	1									Alsodeiopsis	schumannii
										Baphia	semseiana
	1		1							Bersama	abyssinica
										Cassipourea	malosana
										Chassalia	parvifolia
										Chionanthus	mildbraedii
										Cola	microcarpa
	1								1	Cordia	africana
	1		1	1	1					Craibia	brevicaudata
										Crassocephalum (Beentje (1994): = Solanecio)	mannii
				1	1					Cryptocarya	liebertiana
	1		1			1				Dasylepis	integra
									1	Deinnbollia	kilimandscharica
										Dracaena	afromontana
										Dracaena	laxissima
					1					Drypetes	natalensis var. natalensis
	1		1	1	1	1				Ficalhoa	laurifolia
										Garcinia	huillensis (Beentje (1994): = buchananii)
	1								1	Harungana	madagascariensis
										Lasianthus	aff. L. pedunculatus
	1	1		1	1	1				Leptonychia	usambarensis
	1		1	1	1	1				Maesa	lanceolata
										Memecylon	schliebenii
	1									Morinda	asteroscepa
	1	1	1	1	1	1				Myrianthus	holstii
	1	1	1	1	1	1				Newtonia	buchananii

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[12] Data for East- and West Usambara, Khihansi and Mufindi, Mazumbai and Sanje: J.C. Lovett
[13] Data Sokoine University
[14] Data A. Ahrends

	EUS and WUS[12]	Khi and Muf	Maz	Ngu	San	Cho[13]	Ulu	Udz	Coastal forets[14]	Genus	Species
	1			1	1	1			1	Ochna	holstii
	1		1	1		1				Ocotea	usambarensis
										Octolobus	spectabilis
										Oxyanthus	speciosus
										Parinari	curatellifolia
	1	1	1	1	1	1				Parinari	excelsa
	1									Phoenix	reclinata
										Pittosporum	viridiflorum
	1								1	Rauvolfia	caffra
										Rauvolfia	volkensii
										Rinorea	subintegrifolia
		1		1		1				Rothmannia	urcelliformis
	1		1	1	1	1				Strombosia	scheffleri
	1	1			1	1				Tabernaemontana	pachysiphon
	1									Tarenna	pavettoides
										Tricalysia	pallens
									1	Turraea	holstii
		1	1	1						Vepris	stolzii
	1									Vitex	amaniensis
	1		1			1				Xymalos	monospora
										Zanthoxylum	leprieurii
Total	**25**	**9**	**14**	**16**	**14**	**14**	*outstanding*	*outstanding*	**7**		
SJ	**0.11**	**0.09**	**0.11**	**0.13**	**0.07**	**0.1**			**0.0148**		
CC	**0.25**	**0.19**	**0.24**	**0.29**	**0.14**	**0.22**			**0.03**		

Colour key: blue: lowland species; grey: montane species; white: species with overlapping distribution

Abbreviation key:
EUS and WUS = East Usambara and West Usambara; Khi and Muf = Khihansi and Mufindi; Maz = Mazumbai; Ngu = Nguru; San = Sanje; Cho = Chome; Tai =Taita; Ulu = Uluguru; Usa = Usambara, Udz = Udzunga; Ks = Kisiju; Ki = Kiwengoma; Mch = Mchungu; Na = Namakutwa; Ng = Ngumburuni; Pa = Pande; Pu = Pugu; Vi = Vikindu