A VEGETATION STUDY OF THE COMMUNITIES ON MOUNT MULANJE, MALAWI

P.N.Hooks
Honours Project 1992
Supervisor: R.M. Cowling

ABSTRACT

A vegetation study of the communities on Mount Mulanje, Malawi. Three distinct community types are identified. They are; a forest community, a forest ecotone community and a grassland community. No significant relationships exist between the distribution of these community types and the variation in soil and slope characteristics. It is suggested that the distribution of these communities is determined by a disturbance regime, namely, fire. Regeneration of the forest trees within the forests shows no relationship between tree size category and gap size. Where fire is excluded from broad ecotonal bands of vegetation, extension of the forests results.

INTRODUCTION

The present study involves an analysis of the afromontane plant communities of Mt. Mulanje. Mt. Mulanje is the most prominent mountain feature in south-central Africa and to date, no analytical study of the vegetation has taken place. Most work thus far has resulted in the production of plant species checklists (Chapman 1962, Binns 1968 and Dowsett-Lemaire 1988,1989) and the description of broad community types (Chapman 1962, Chapman and White 1970).

The aim of this study is to find out what determines the distribution of the different communities on the mountain. Corrolaries to this are as follows; 1) How different are these communities : are the boundaries between them distinct or of a continuous nature ? 2) Are the communities associated with any specific suite of environmental variables or dynamic processes ?

METHODS

Study sites:

Mount Mulanje is stuated in the south-east corner of Malawi, less than five miles from the Mozambique border. It is the most prominent mountain feature in the region, rising abruptly to 2450m (above sea level) on average. The surrounding plains lie at a general level of 600m above sea level (Chapman and White 1970). At about 2000m above sea level the steep slopes give way to plateaux which flank the higher peaks.

These plateaux may consist of large valleys as is the case with the Lichenya and Sombani basins, or in the case of the Tuchila shelf, a narrow shelf flanking the higher peaks.

I chose to undertake the vegetation analysis at these different localities on the mountain. The specific positions of the study sites are given in table 1 and figure 1. Plates 1 to 5 are photographs of three out of four sites considered in the study.

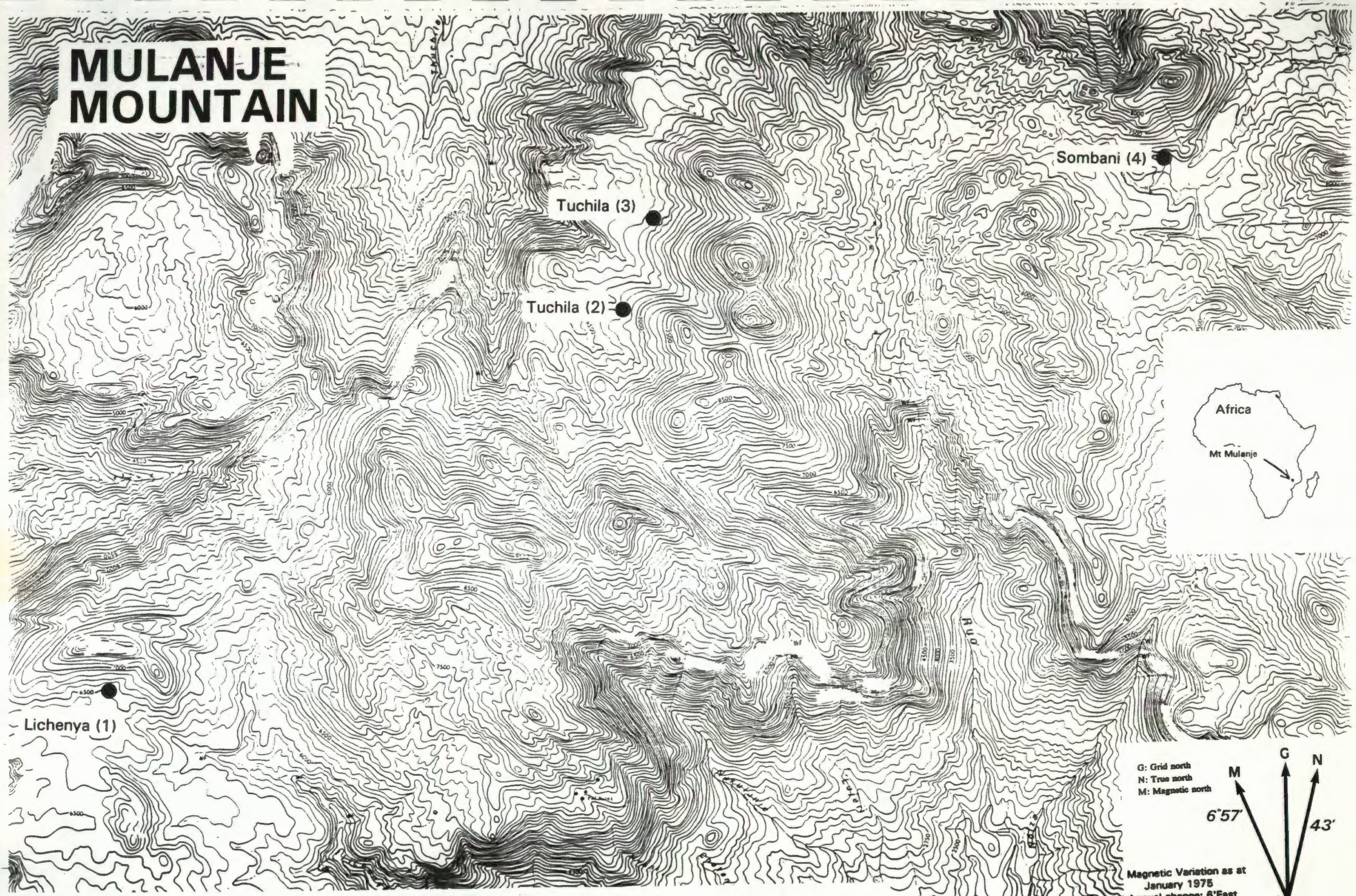

Figure 1: A map of Mount Mulanje showing the localities of the study sites. SCALE 1:85500

PLATE 1: The forest at the Lichenya site, with the ecotone vegetation in the foreground.

PLATE 2: The ecotone community at the Lichenya site, with the grassland in the background.

PLATE 3: The forest and grassland communities at the first Tuchila (2) site.

PLATE 4: The forest, narrow ecotone and the protected grassland communities at the Sombani site.

PLATE 5: The firebreak community at the Sombani site.

Table 1: Location and physical characteristics of the sites.

Locality	Site	Grid references		Aspect	Alt.
Lichenya plateau	(1)	15°57'58"S	35°32'5"E	S	1980m
Tuchila shelf	(2)	15°54'35"S	35°36'23"E	NW	1950m
Tuchila shelf	(3)	15°54'3"S	35°36'40"E	NW	1970m
Sombani basin	(4)	15°53'50"S	35°41'7"E	S	2100m

Data collection:

Species abundance and environmental variables were measured at the Lichenya (1) site and the two Tuchila sites (2 and 3). At these sites, plots of 10m x 10m were used for this sampling process. Plots were positioned within the three community types. These communities were discerned on the basis of the dominant life forms (i.e. trees, shrubs or grasses) present. Table 2 gives the community type of each plot sampled. This data was used for the first data analysis.

Table 2: The plot number, locality, site number and community types considered in Analysis 1

Locality	Site	Plot	Community
Lichenya	1	1	forest
Lichenya	1	2	ecotone
Lichenya	1	3	ecotone
Lichenya	1	4	grassland
Tuchila	2	5	grassland
Tuchila	2	6	grassland
Tuchila	2	7	ecotone
Tuchila	2	8	ecotone
Tuchila	2	9	forest
Tuchila	2	10	grassland
Tuchila	2	11	grassland
Tuchila	3	12	grassland
Tuchila	3	13	grassland
Tuchila	3	14	ecotone
Tuchila	3	15	ecotone
Tuchila	3	16	forest

The abundance categories are not cover percentages alone but include the number of individuals represented by particular species. The categories are as follows; a value of 1 represents a minimum abundance of the species which may mean that there is only a single individual present or that the percentage cover is less than 5% . A value of 2 represents the intermediate level of abundance, a percentage cover ranging from 5 to 25% . In the case of a large tree the presence of one individual will not result in a score of 1 for abundance but rather in a 2. A value of 3 represents the highest level of abundance, which includes the dominance or co-dominance (i.e. many individuals) of a species in a plot or the high percentage cover (i.e. ground or canopy) the species takes up.

Within these same plots, soil profiles were described and thicknesses of the different soil horizons measured. The horizons were compared to Chapman and White's (1970) soil profile described from the Chambe plateau at 1920m on a well drained gentle slope. Each soil profile was summarised into four horizons (table 3), each a representation of one or more of their horizons (i.e. Chapman and White, 1970).

Table 3: Description of the horizons for plots 1 to 16 used in the first analysis

Horizon	1	This includes Chapman and Whites' (1970) O horizon and the two horizons found below this. The latter are of a very dark greyishbrown sandy clay loam situated above and a dark greyish brown clay below; porous
Horizon	2	Brown clay; porous
Horizon	3	Reddish yellow clay; compact
Horizon	4	Pale brown sandy clay loam

The slope of the ground was measured for each of these plots using a clinometer. This measure gives one an idea of the drainage capacity of the soil.

Species abundance was also estimated for plots at the Sombani site (4). Here, plots of 4m x 4m were sampled, with 10 plots within each community type. The grassland was divided up into a protected grassland and unprotected grassland community type. These were separated by a fifth community type, the firebreak community. All in all 50 plots were sampled. The abundance categories are as above. This site presented me with the opportunity to understand something about the effect of fire on the floristic composition of grassland which had been protected from burning, grassland which recieved fire relatively more often and grassland which received fires most often (i.e. fire break habitat). Table 4 below lists the plot numbers and the subjectively assigned community type. The data collected here was used in the second analysis.

Table 4: The plot numbers with their subjectively designated community characterisation.

Plots	Community type
1-10	forest
11-20	ecotone
21-30	protected grassland
31-40	firebreak
41-50	grassland

At this same site, data, pertaining to the regeneration of forest tree seedlings was collected within the same forest and ecotone plots. That is, the presence of tree seedlings was recorded.

Analyses:

Two analyses were undertaken. The first consists of a direct ordination (Canonical Correspondence Analysis) (Te Braak 1991) of species abundance scores and environmental variables and an indirect ordination (Detrended Correspondence Analysis) (Te Braak 1991) of species abundance scores. The data used in this analysis was that which was collected at the first three sites. A Monte Carlo permutation test, tested the significance of this relationship between the species and environmental variables. By comparing the species environmental correlations and eigenvalues of the CCA and DCA, one can assertain to what extent the underlying environmental variables explain the spatial pattern of the species (Franklin and Merlin, 1991). These analyses are carried out using the computer program CANOCO (Te Braak, 1991).

The second analysis consists of an indirect ordination (DCA) (Te Braak 1991)and a Two Way Indicator Species Analysis (TWINSPAN) (Hill 1979). The latter, calculates the site and species scores by reciprocal averaging. The sites are ordered first by divisive, hierarchical clustering, and then the species are clustered based on the classification of the samples. I set the pseudospecies cut levels to 1,2 and 3. The data used for this analysis is that which was collected at the Sombani site.

RESULTS

Analysis 1:

The environmental variables for plots 1 to 16 are given in table 5 and the description of each soil horizon is given in table 3. The soil horizons described by Chapman and White (1970) were recognised to different degrees within the soil profiles of the sampled plots. Some horizons were not present at all. Measures of thickness in centimetres of these horizons are given in table 5.

Table 5: Environmental data used in the CCA; letters A to E correspond with those of Figure 2. (F Forest E Ecotone G Grassland)

			Horizon: depth (cm)			
Site	Plot	Slope (A)	1 (B)	2 (C)	3 (D)	4 (E)
1	1 (F)	5	80	0	0	0
2	9 (F)	30	0	50	40	0
3	16 (F)	20	10	50	40	0
1	2 (E)	0	70	10	10	0
2	3 (E)	2	80	10	30	0
2	7 (E)	20	0	20	40	0
2	8 (E)	0	5	5	10	70
3	14 (E)	25	0	90	10	0
3	15 (E)	30	0	50	60	0
1	4 (G)	0	120	0	0	0
2	5 (G)	0	40	10	10	50
2	6 (G)	0	30	0	20	50
2	10 (G)	5	0	20	50	0
2	11 (G)	5	0	30	40	0
3	12 (G)	2	5	40	50	0
3	13 (G)	25	0	10	80	0

The results of the CCA are given in Table 6 in the form of eigenvalues and species environment correlations (species and their abundance values are given in appendix 1). The eigenvalues are low and the species environmental correlations are exceptionally high. However, there is no significance (Monte Carlo Test; Table 6) for this relationship when considering the first CCA axis alone. However, overall there is a little significance (Table 6) with regards this high correlation of species groupings with the measured environmental variables.

Figure 2 shows the CCA ordination diagram of the sample (plot) scores and environmental biplot scores. The samples have been enclosed by three continuous

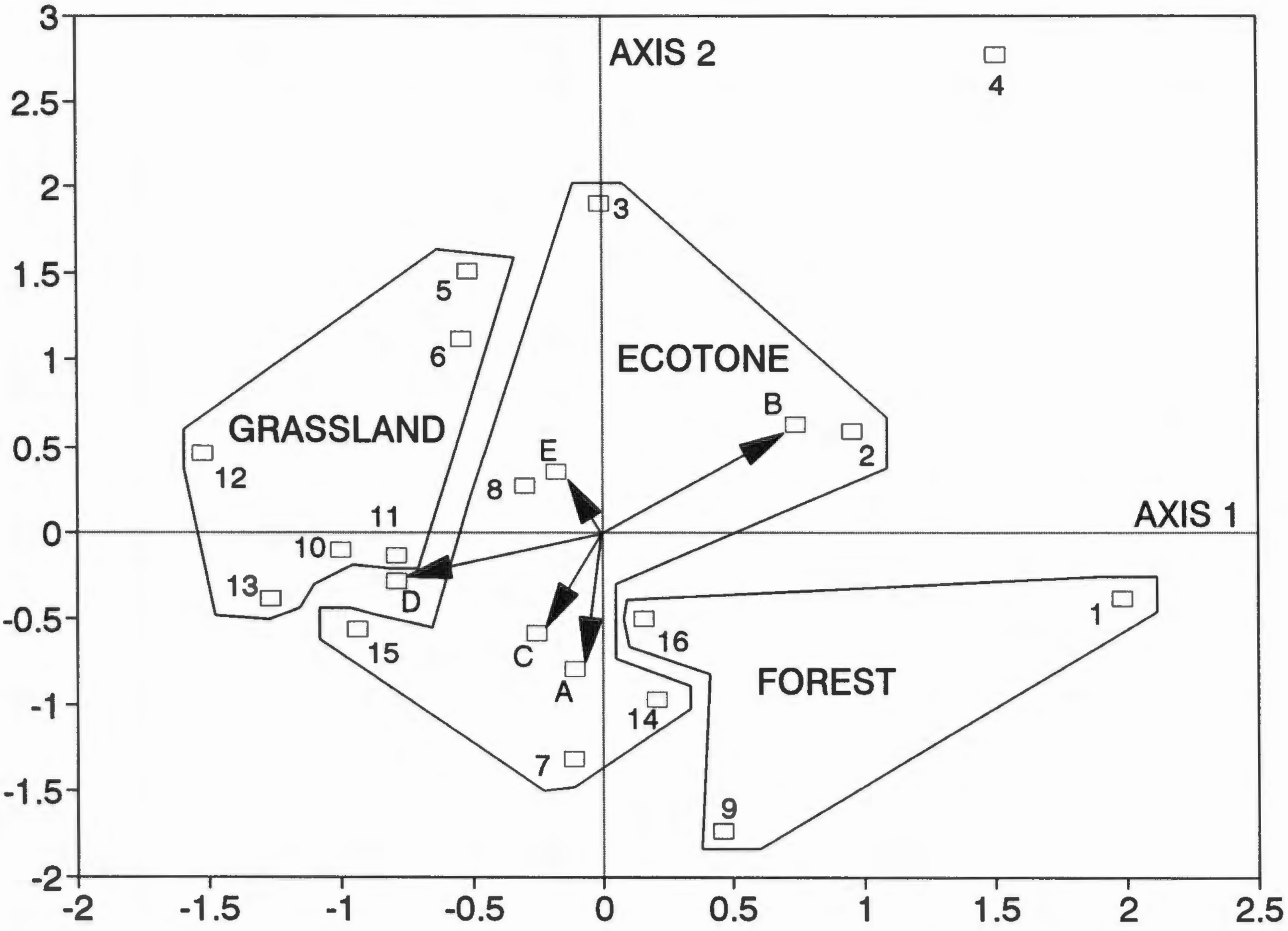

Figure 2: A CCA plot of the first and second axis for the sample scores and environmental biplot scores. Numbers 1-16 are the sample numbers and letters A to E represent the environmental variables. The arrows represent the direction of change for these environmental variables, the lengths of which represent the relative correlation with the spatial distribution of the species and samples.

(A increasing slope, B inreasing thickness of Horizon 1, C increasing thickness of Horizon 2, D increasing thickness of Horizon 3, E increasing thickness of Horizon 4)

outlines. These outlines are not the groupings based on those produced by this ordination diagram but are the initial subjective sample groupings made in the field. Observed deviations from these subjective groupings are discussed later, in the context of the actual species present. Figure 3 shows the sample scores of the first two axes of the DCA output. Likewise, lines enclosing certain sites show the initial groupings based on my subjective observations.

Table 6: The eigenvalues, species environment correlations, gradient lengths and results of the Monte Carlo test for the Correspondence Analyses (DCA and CCA)

	AXIS 1	AXIS 2	AXIS 3	AXIS 4
Eigenvalues				
CCA	0.580	0.527	0.408	0.337
DCA	0.784	0.555	0.235	0.083
Species environmental correlation				
CCA	0.962	0.950	0.974	0.984
DCA	0.722	0.852	0.441	0.792
Monte Carlo Permutation Test:		F-ratio	P-value	
CCA(axis 1)		1.13	0.74	
CCA(overall)		1.21	0.10	
DCA(axis 1)		1.13	0.72	
DCA(overall)		1.21	0.09	

The species environment correlations are slightly higher for the CCA axes. This is expected as the axes in CCA are calculated based on the species scores and environmental variables simultaneously. The eigenvalues for the CCA are different from those of the DCA, suggesting that the environmental variables which were measured are not good predictors of species occurrence. This is further substantiated by the short lengths of the environmental arrows of figure 1. This poor relationship is also reflected in the non significance of the permutation test (table 6).

The environmental variables of the CCA axes provide the following interpretation for the CCA ordination diagram (figure 1): axis 1 represents increasing thickness of Horizon 1 (table 5) and decreasing thickness of Horizon 3, and axis 2 is represented by decreasing slope angle and decreasing thickness of Horizon 2.

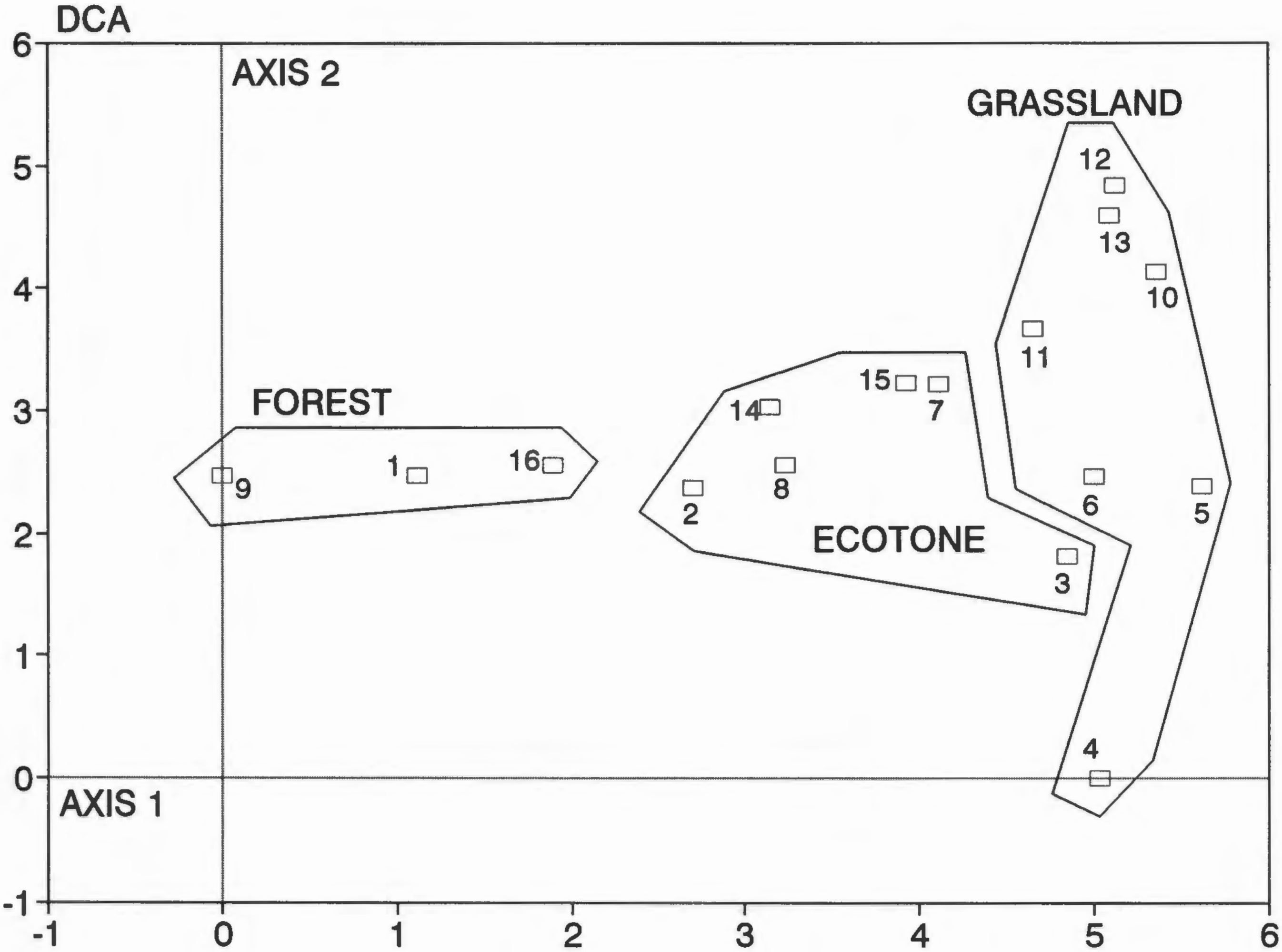

Figure 3: A DCA plot of the first and second axis for the sample scores. Numbers 1-16 are the sample numbers corresponding to the first analysis.

Analysis 2:

Results of the DCA are as follows; the eigenvalue for the first axis is 0.9058, 0.3199 for the second, 0.2559 for the third and 0.2056 for the fourth. The sample scores are represented graphically in figure 4. Results of the TWINSPAN analysis are given in appendix 2. The sample plot groupings made by TWINSPAN are better illustrated in figure 5. Three large groups are observed, with some discrepancies between my subjective groupings and those of figure 4.

The regeneration of forest tree species within the forest, under differing light conditions, is described using the presence of adults and seedlings in table 8. The presence of these species within the forest ecotone vegetation is also listed in table 8. It is seen that most regeneration occurs within the forest. No statistical test could be carried out and so the results are insignificant.

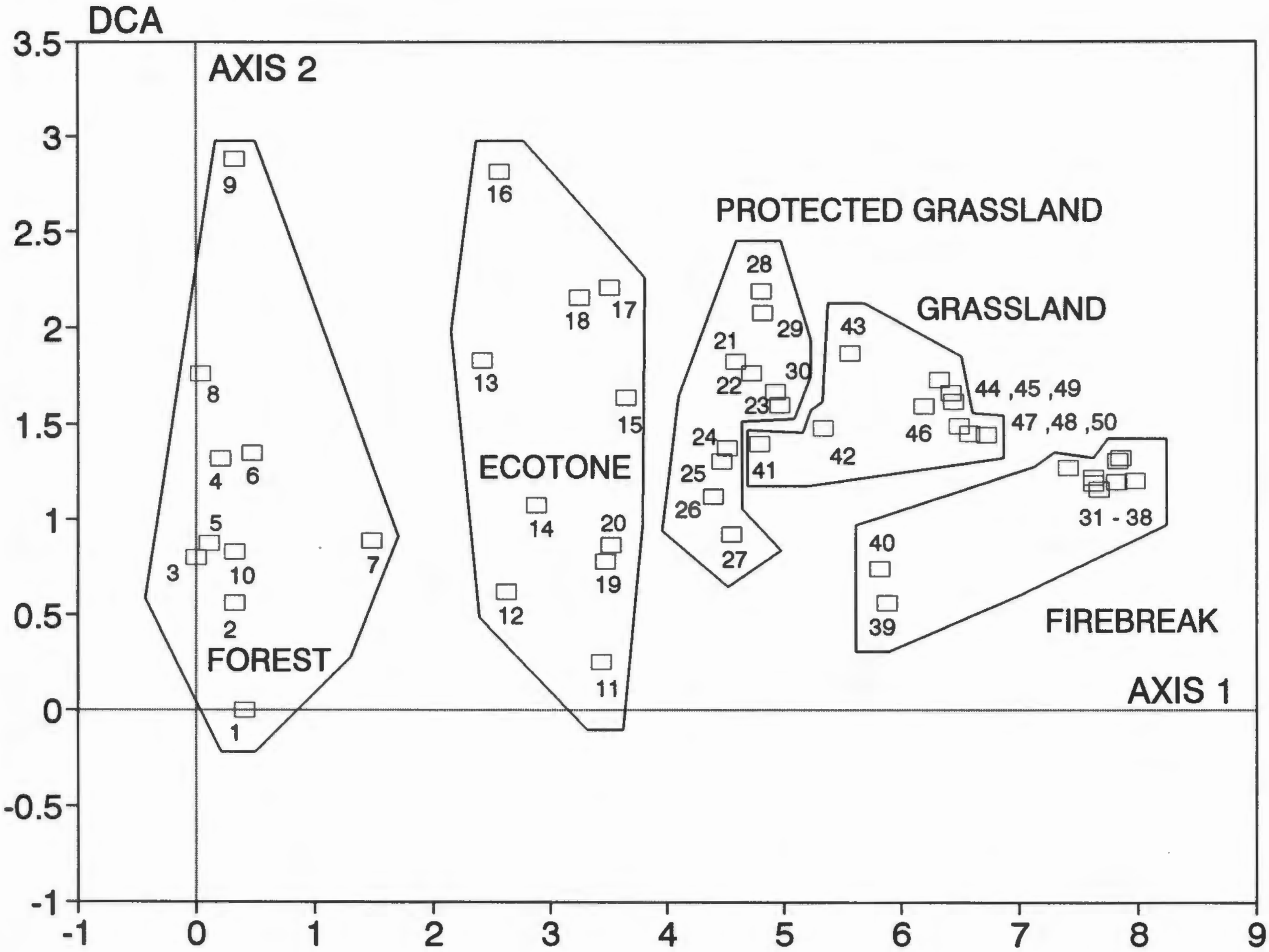

Figure 4: A DCA plot of the first and second axis for the sample scores. Numbers 1-50 are the sample numbers corresponding to the second analysis.

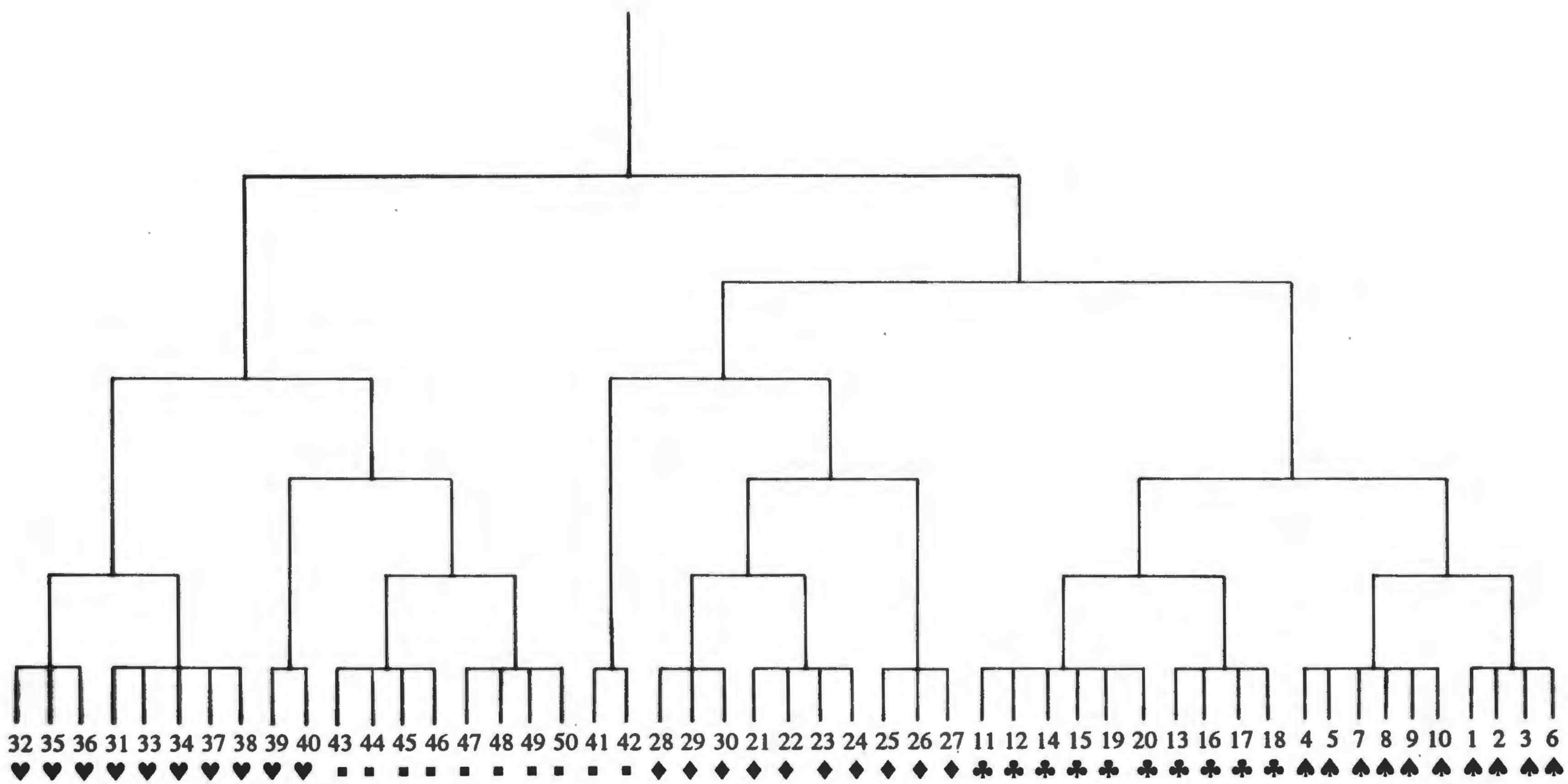

Figure 5: A dendrogram of the ordinated samples of the Sombani site, produced by TWINSPAN.
(♥ Firebreak ▪ Grassland ♦ Protected grassland ♣ Ecotone ♠ Forest)

Table 8: A comparison of the regeneration niches of forest tree species. Actual frequencies of occurrences (i.e. number of sample plots they are found in) are given for the adult and juvenile stages of the tree species.

	Frequency					
Percentage canopy cover	80-100% (n=6)		20-70% (n=4)		Ecotone (n=10)	
Adults (A), Juvenile (J):	(A)	(J)	(A)	(J)	(A)	(J)
Large sized trees:						
Ilex mitis	4	0	1	1	0	2
Podocarpus latifolius	1	4	0	1	0	0
Rapanea melanophloeos	1	0	0	3	0	0
Cussonia spicata	0	0	1	0	0	0
Cryptocarya liebertiana	1	0	0	0	0	0
Drypetes gerradii	1	0	0	0	0	0
Widdringtonia whytei	0	0	1	0	0	0
Total	8	4	3	5	0	2
Medium sized trees:						
tree 2	2	1	1	1	0	2
Xymalos monospora	4	1	1	1	0	0
tree 3	3	0	1	0	0	0
tree 11	1	0	0	0	0	0
Psychotria sp. a	4	5	0	2	0	0
Psychotria sp. b	3	1	1	2	0	3
Kiggelaria africana	2	0	3	3	1	0
Maesa lanceolata	2	1	1	0	0	1
Total	21	9	8	9	1	6
Small sized trees:						
Myrsine africana	0	0	0	0	0	1
Dracaena laxissima	5	0	4	0	0	0
Meytenus acuminata	2	2	1	1	0	0
Diospyros whyteana	0	0	0	1	0	0
Total	7	2	5	2	0	1

DISCUSSION

Community distinctness:

One expects the forest community to be quite distinct from a forest ecotone and most definitely from a grassland community. Figure 3 shows this to be true, with axis one explaining most of the variation on the DCA plot (table 6). There is some overlap between the ecotone and grassland community. My subjective grouping of sample three into an ecotone community could be changed on the basis of this overlap. The second axis appears to draw out the samples of the grassland communities and this may be explained in terms of local habitat. Samples 3,4,5 and 6 represent those plots found along stream banks while 10,11,12 and 13 are plots sampled on open, drier sites. Figure 2 shows that slope is correlated with this characterisation, as well as the presence of a thick peaty upper horizon (B of figure 2). Presumably, slope plays a major role in drainage and as a result relates to and perhaps changes soil structure.

Again as shown in figure 4 the forest community is very distinct from the ecotone. The protected grassland and grassland are similar with respect to plots 41,42 and 43. This may be a result of the greater proximity of these plots to the protected grassland and thus a function of site. As far as the remaining grassland sites are concerned I do not think that site alone plays a role in the differing species composition. The role of succession must not be ruled out in this instance. Certain grass species found in the protected grassland are also found in the open grassland. It seems reasonable to assume that these species, namely *Merxmuelera davyi* and *Eragrostis volkensii*, have the ability to live longer and outcompete the other grass species.

The fire break presents an interesting situation in which most if not all the species showed signs of resprouting. Under normal circumstances resrouters are the first species to regenerate after fire. In this case the high frequency of fire has excluded most reseeding species. Perhaps it is the strategy of most species in the grassland, allowing the continued existence under extreme environmental pressures (eg. fire).

Floristically three groups appear to have been identified in the dendrogram of figure 5 ~~4~~. plots 1 to 20 represent the forest and ecotone communities with a further separation of this group into forest and ecotone communities. As far as the species are concerned there are a number of specific associations which have been identified. A group which was correlated with the forest, and which represents species that were common and dominant in the forest is that of *Ilex mitis*, *Dracaena laxissima*, *Psychotria sp.* a, an *Impatiens sp.*, a species of Lamiaceae and *Behnia reticulata* (a climber). Another common forest group which was less abundant at each plot was *Xymalos monospora*, *Maytenus acuminata*, *Podocarpus latifolius*, *Piper capense* (forest floor shrub) and two unknown species, one of which was a ground fern, the other an epiphytic plant of sorts. Species which were found in both the forest and ecotone were grouped together, examples of which are, *Kiggelaria africana*, *Maesa lanceolata* and another *Psychotria* species. Another such group included *Rapanea melanophloeos* and another group included a grass species, *Festuca sylvaticus*, and a common ecotone shrub, *Halleria elyptica*, but this latter group was less commonly found in the forest.

A large group of species were correlated with each other for the ecotone community, a few important indicator species being *Hypericum revolutum*, *Pteridium aquilinum*, *Phillipia nyassana*, *P.benguelensis*, a *Taraxicum sp.* and a Cyperaceae sp. The former two of this group being found in some forest plots and also grassland and protected grassland.

The remaining communities are lumped into two groups, the protected grassland being more closely related to the ecotone-forest grouping. The firebreak community is separated from the grassland community but two of the plots, namely 39 and 40, which were stream side plots, were found to be more closely related to the grassland community. However, they remain an outgroup to the grassland community.

Another overlap occurs between the two plots of the grassland and that of the protected grassland. Like above, these are outgroups of the protected grassland. Naturally, the common denominater of these three communities (i.e. grassland, firebreak, protected grassland) is that they are indeed grassland and the distinctness of each is lessened by this fact. What does seem to make them different is the frequency of fire. Under lowered fire frequency I would predict that the open grassland would in time give over to a situation similar to that of the protected grassland. A decrease in the number of geophytes present, as is seen in the protected grassland, would also be predicted.

Community distribution:

It is possible to make some conclusions regarding the distribution of the different communities. Fire probably plays a large role in the turnover of grassland communities, allowing for the local adaptation of certain species to particular habitats, producing a somewhat patchy distribution of species. Fire has almost definitely played a role in reducing the forest communities to isolated patches on the plateaux. All over the mountain fire breaks are visible, placed in strategic positions around the forest patches. If fire was the major factor restricting the distribution of forest sites then all the forests on the plateaux should be restricted to ravines and rocky scree slopes where either moister conditions or lack of fuel is a factor in restraining the movement of fire. In some intances this the case. However, this is not completely true for the forest at the Lichenya site and at the second Tuchila site. In fact I observed many burnt tree stumps within the forests. This suggests that the present position of the forests boundary is not static and that reduced fire frequencies have resulted in the extension of some forests.

There is a very low significant species environment correlation overall ($P=0.10$) with most of the variation explained by the first two axes of the CCA (figure 1). The forests seem to be found upon sloping plots, with ecotones and grassland showing no restriction to either level or sloped plots. Along the first axis there is a correlation of forest communities with increasing thicknesses of Horizon 1 (B, figure 1) and grassland communities and increasing thichnesses of Horizon 3 (D, figure 1). The remaining variables are relatively insignificant. The ecotone shows intermediate tendencies with some extreme plots showing grassland characteristics and others, showing forest characteristics. However, plot 4, an outlier, does not follow this "rule".

It seems more likely that the soil characteristics are both functions of which community overlies the soil and the degree of drainage, which is a function of slope. In the case of this outlier on figure 1 (i.e. plot 4), I conclude that this is probably the case.

These relationships with the environmental variables are all rather weak, indicating that the communities are not restricted by site factors but rather by disturbance. In conclusion the environmental factors are inadequate to explain the species spatial variation.

Studies similar to this one have also been carried out in environments where fire plays a major role in the ecosystem functioning. Conflicting results, regarding the determinants of forest distribution have been published. Within the fynbos biome, Meadows and Dewey (1986) showed clear distinctions between the soil collected from within forests and that collected from the grassland-heathland communities. Masson and Moll (1987) found similar correlations with environmental variables in a fire protected environment, showing that forest expansion was determined by a composite effect of soil moisture, parent rockmaterial, degree of rockiness and soil nutrient status. Masson (1990) found conflicting evidence, showing very little difference between forest, forest margin or ecotone and fynbos soils. The latter suggests that fire is the overriding factor determining the distribution of the afromontane forests. This is the view point of Van Daalen (1981) who observed that no colonization of the fynbos "islands" of the Southern Cape took place.

Masson (1990) found that moisture availability was the only other major factor in determining forest distribution.

Other investigations of vegetation changes and the effects of fire on forest boundary dynamics in southern Africa have been carried out by Granger (1976) and Everard (1986) in the Natal Drakensberg. Granger found that soil nutrient staus differed between grassland and forest areas and that fire exclusion resulted in the development of a more mesic environment, usually associated with the invasion of woody species such as *Phillipia evansii* and *Leucosidea sericea*. A comparison of burnt and unburnt forest ecotones of *Podocarpus latifolius forests* in the

Drakensberg (Everard 1986) showed clear differences in vegetation composition and abundance between sites but little variation in soil properties were detected.

Studies carried out overseas (eg. Ellis and Graley 1987) suggest that the distribution of vegetation types and any differences in soils of grassland/eucalypt-rainforest successional sequence were probably influenced by vegetation (Masson 1990). A progressive decrease in pH, total phosphorous and magnesium was noted from these grasslands to rainforests, with pH providing the most consistent index of change during succession (Masson 1990).

It would appear that correlations between differences in floristics and differences in soil characteristics do not neccessarily imply causation. That is, that soil does not neccessarily determine the distribution of communities. In this study the correlations are not even significant, suggesting that the environmental variables (i.e. soil and slope) measured are inadequate in showing a significant correlation. This does not mean, however that no correlations with other environmental variables exist.

Where forest ecotones have been protected from fires on Mount Mulanje, the ecotones have increased in size (eg. along the Tuchila Shelf).

Forest regeneration:

The extent to which the forests are able to expand their borders depends on the regeneration requirements of the individual species. Some tree species are regarded as pioneer species, that is, those that are the first to colonise open ground adjacent to the forests. They may have specific seed germination requirements which are only apparent in particular habitats. There may also be less competition from other tree species within this habitat.

Other tree species require protection from other plants for germination and seedling growth. Within the forests there is also a need for the turnover of species as old trees die. Within this tree-fall forest gap environment different trees are capable of outcompeting other tree species under different light conditions. There are also trees which require no gap for regeneration within the forest. How different species are able to regenerate under different conditions is a function of many things.

It possible that seed size is important in germination under particular light conditions (Kemp 1992). That is that large seeded plants can germinate under low light conditions and survive extended periods of time, long enough for survival into adulthood. On the other hand, the architecture of a tree determines the extent to which a tree can gain height (King 1990b, Givnsh 1986) but also the efficiency with which the tree can utilise low levels of light (King 1990b, Kohyama 1987, Kohyama and Hotta 1990). Usually, but not in all cases, trees which are shade tolerant, and are classified as small understorey trees, have developmental architectures producing lateral growth instead of extension growth (Sakai 1987, 1990). Large, emergent trees on the other hand are usually shade intolerant and relative growth rates are low under low light conditions, because of their photosynthetically inefficient developmental architecture.

Accordingly, one may predict that in relatively small forest gaps those species with lateral growth developmental architectures will outcompete the canopy tree seedlings because of their efficient light capturing devices. In large gaps one would predict the opposite.

Those tree species with monopodial-like developmental architectures will outcompete species with sympodial-like developmental architectures under high light conditions.

Within the forest at Sombani, data pertinent to these predictions was collected (table 7 8 ~~9~~). The sample number is low and the overall pattern does not prove anything about the predictions made above. However, I discuss here individual species and tentative proof for the predictions. For *Ilex mitis* and *Rapanea melanophloeos* there were no seedlings found under low light conitions. *Podocarpus latifolius* presents one with a contradiction to the prediction regarding tree architecture. However, the large seed enables the species to germinate under low light conditions (Kemp 1992), and by virtue of a sparsely branched seedling (pers. observations) the plant might be able to compete with shade tolerant species. *Meytenus acuminata* and *Psychotria sp. a* are possible competitors under these low light conditions.

Regeneration of forest tree species within the ecotone (table 9) was restricted to *Widdringtonia whytei* (separate observation), *Ilex mitis*, *Psychotria sp. b* and tree sp. 2. General observations of the forest ecotone communities along the Tuchila shelf suggest that the regeneration of forest from the ecotone vegetation can be extensive if fire is kept out. The data collected at the Sombani site is representative of a very narrow ecotone with, so it seems, only recent extension of the forest edge. The data does not present significant differences between the large and smaller trees with regards regeneration. However, the use of tree architecture as illustrated above presents with a tool for simplifying the study of forest tree regeneration.

CONCLUSION

The communities at the studies sites show distinct floristic traits. These communities are not distributed as a function of the environmental variables measured. The results of this study suggest that fire is more important in determining community distribution. Along the Tuchila shelf the ecotones seem to be a lot more mature with definite increases in vertical growth. It is probable that forests are not restricted to the specific sites encountered in this study. Closer attention needs to be drawn to these expanding forest ecotones in order to note specific successional trends in the floristic traits. Further research should be channelled towards understanding the regeneration patterns of the forest trees of Mount Mulanje. The knowledge of the relationships between regeneration and developmental tree architecture as well as relationships with seed size (Kemp 1992) may play a leading role in simplifying the complexity of interactions within the forest and ecotone communities.

The ecotone community is a distinct community and an important part of the mountains ecosystem. For successful regeneration of *Widdringtonia whytei* and many other important tree species, these communities should be managed carefully as this is where the giant cedar and other tree species regenerate. I propose that for many of the afromontane forests on the plateaux, firebreaks should be placed at a greater distance from the forest patches so larger habitable area can be allocated to this important community type. It may in fact be impossible to implement an alternative management plan due to the obvious shortages of skilled labour and funds observed.

Acknowledgements:
I would like to thank Alice Wiseman, for without her organization, the field trip would not have been possible. I would like also to thank Tony Verboom for his assistance with of my field work. Richard Cowling is thanked for advice covering all aspects of the project.

REFERENCES

Binns, B. 1968. **A first checklist of the herbaceous flora of Malawi.** Government Printer, Zomba, Malawi

Chapman, J.D. 1962. **The vegetation of the Mulanje Mountains, Nyasaland.** Government Printer, Zomba, Malawi

Chapman, J.D. and White, F. 1970. **The evergreen forests of Malawi:**196p. Oxford, Commonwealth For. Inst.

Dowsett-Lemaire, F. 1988. The forest vegetation of Mt. Mulanje: a floristic and chorological study along an altitudinal gradient (650-1950m). **Bull.Jard.Bot.Nat.Belg. 58:77-107**

Dowsett-Lemaire, F. 1989. The flora and phytogeography of the evergreen forests of Malawi. I. Afromontane and mid altitude forests. **Bull.Jard.Bot.Nat.Belg. 59:3-131**

Ellis, R.C. and Graley, A,M. 1987. Soil chemical properties as related to forest succession in a highland area in north east Tasmania. **Australian Journal of Ecology 12:307-317**

Everard, D.A. 1986. The effects of fire on the *Podocarpus latifolius* forests of the Royal Natal National Park, Natal Drakensberg. **South African Journal of Botany 52:60-66**

Franklin, J. and Merlin, M. 1992. Species-environment patterns of forest vegetation on the uplifted reef limestone of Atiu, Mangaia, Ma'uke and Miti'aro, Cook Islands. **Journal of Vegetation Science 3:3-14**

Granger, J.E. 1976. **The vegetation changes, some related factors and the changes in water balance following 20 years of fire exclusion in catchment IX Cathedral Peak Forestry Research Station**. Phd. Thesis, Pietermaritzburg, University of Natal.

Hill, M.O. 1979. **TWINSPAN, a fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes**. Cornell University, Ithaca, New York

Kemp, R. 1992. **(The relationship between seed size and light requirements for regeneration)** Ecology honours project. Botany Dept., University of Cape Town

King, D.A. 1990a. The adaptive significance of tree height. **The American Naturalist 135:809-828**

King, D.A. 1990b. Allometry of saplings and understorey trees of a panamanian forest. **Functional Ecology 4:27-32**

Kohyama, T. 1987. Significance of architecture and allometry in saplings. **Functional Ecology 1:399-404**

Kohyama, T. and Hotta, M. 1990. Significance of allometry in tropical saplings. **Functional Ecology 4:515-521**

Masson, P.H. 1990. **The dynamics of the afromontane forest remnants in the Southwestern Cape**. Masters thesis. U.C.T.

Masson, P.H. and Moll E.J. 1987. The factors affecting forest colonization of fynbos in the absence of recurrent fire at Orange Kloof, Cape Province, South Africa. **South African Forestry Journal 143:5-10**

Meadows, M.E. and Dewey, F.E. 1986. The relationship between soils and vegetation, Beggar's Bush Forest Reserve, Grahamstown. **South African Geographical Journal 68:144-153**

Sakai, S. 1987. Patterns of branching and extension growth of vigorous saplings of Japanese *Acer* species in relation to their regeneration strategies. **Can.J.Bot. 65:1549-1553**

Te Braak, C.J.F. 1991. **CANOCO computer program, version 3.12**. Agricultural Mathematics Group, Wageningen, Netherlands

Van Daalen, J.C. 1981. The dynamics of the indigenous forest-fynbos ecotone in the Southern Cape. **South African Forestry Journal 119:14-23**

Appendix 1: The floristic classificatory data produced by TWINSPAN, using the data collected at Lichenya and Tuchila.

Sample number	1111 11 1 2345601237845196	
Pavetta abyssinica	-----------23-2-	0000
Helichrysum chrysophorum	---1---1--111--1	00010
Aeschynomene megalophylla	-----------32--1	00010
Agauria salicifolia	----1-------2---	000110
Myrica humilus	---------1------	000111
Aristea johnstoniana	---------1------	000111
Cyperaceae sp. 10	---------1------	000111
Crotalaria aculeata	---------1------	000111
Ground fern 10	----------1-----	000111
Geranium arabicum	----------1-----	000111
Ground herb 11	----------13----	000111
Apiaceae sp.	----------1-----	000111
Mondia whightei	----------1-1---	000111
Widdringtonia whytei	----------1-2---	000111
Rhamnus prinoides	----------1-----	000111
Cassine aethiopica	----------1-----	000111
Climber 7	-----------1----	000111
Glycine wightii	-----------1----	000111
Boraginaceae sp	-----------22---	000111
Bidens pinnatipartita	------------2---	000111
Helichrysum bullulatum	------------1---	000111
Rosaceae sp. 2	------------1---	000111
Epiphytic fern 21	-----------1----	000111
Indigofera lyalli	------2--2-32---	000111
Alepidea gracilis	-------1---11---	000111
Protea cafra ssp. nyassae	-------1---2----	000111
Helichrysum nudifolium	------1221121---	00100
Rhyncosia clivorum	---------11------	00100
Kotschya scaberima	------212-2-3---	00100
Cyperaceae sp. 11	------1---1-----	00100
Cyperaceae sp. 15	-------2---11---	00100
Dodonaea sp.	--------2---3---	00100
Crotalaria sp.	--------1---1---	00100
Heteromorpha trifoliata	-----232----2---	001010
Phillipia benguelensis	-----2--2--1----	001010
Helichrysum sp.15	--------2---1---	001010
Helichrysum whyteanum	-----1----------	001011
Poaceae sp. 4	-----2----------	001011
Nuxia congesta	------2---------	001011
Asteraceae sp. (yellow)	-------1--------	001011
Panicum sp.	-------2--------	001011
Asteraceae sp 4	-------1--------	001011

Cyperaceae sp. 13	-------2--------	001011
Cyperaceae sp. 14	-------2--------	001011
Restio mahoni	-------2--------	001011
Thesium whteanum	-------1--------	001011
Xerophyta splendida	-------2--------	001011
Whalenbergia virgata	-------22-------	001011
Iridaceae sp.	-------1--------	001011
Helichrysum kirkii	-------22-------	001011
Trifoliate herb 1	-------11-------	001011
Cyperaceae sp. 16	-------1--------	001011
Polygala sp.	--------2-------	001011
Cyperaceae sp. 4	-1-11--21--32---	00110
Lamiaceae sp. 5	--1---1----1----	00110
Panicum ecklonii	---213233112----	00110
Lamiaceae sp. 6	---1----1---1---	00110
Helichrysum odoratissimum	----2-22211-----	00110
Helichrysum lastii	---12-22-11-----	00110
Helichrysum nitens	-2---22---------	00111
Helichrysum bucanannii	-2-1-2-121------	00111
Koeleria capensis	---22-2231--1---	00111
Exotheca abyssinica	---223233-------	00111
Cyperaceae sp. 9	----1--2--------	00111
Halleria elyptica	2-----21--------	01000
Hypericum revolutum	31--223--222---1	01000
Phillipia nyassana	-2-1-2--2-------	01000
Ground fern 9	1---------1-----	01001
Helichrysum sp. 2	22---2-1--11----	01001
Lamiaceae sp. 3	1---------1-----	01001
Helichrysum brassi	---1--------1---	01001
Asteraceae sp. herb 4	---11--1----1---	01001
Rubus elypticus	2-2-------1-----	010100
Kiggelaria africana	2---------1-----	010100
Helichrysum sp. 8	-2--1-----1-----	010100
Cyperaceae sp. 8	---11-----1-----	010100
Impatiens sp. 2	--1-------------	010101
Forest herb 4	1---------------	010101
Crassulaceae sp.	1---------------	010101
Helichrysum dilucidum	2---------------	010101
Cyperaceae sp. 3	1---------------	010101
Ground herb 1	2---------------	010101
Buddleja salvifolia	-2-1------------	010101
Asteraceae sp. 3	-2--1-----------	010101
Cyperaceae sp. 5	-12-------------	010101
Anthoxanthum ecklonii	-2--------------	010101
Themeda triandra	-2--------------	010101
Eragrostis volkensii	-3333-----------	010101
Merxmuelera davyii	-3333-----------	010101
Digitalis purpurea	--1-------------	010101

Ground herb 5	--2-------------	010101
Ground herb 6	--1-------------	010101
Cyperaceae sp.6	--1-------------	010101
Poaceae sp. 10	---11-----------	010101
Gnidia sp.	---1------------	010101
Cyperaceae sp. 7	---1------------	010101
Ground herb 7	---1------------	010101
Ground herb 8	---1------------	010101
Lamiaceae sp. 7	---1------------	010101
Poaceae sp. 14	----1-----------	010101
Epiphytic fern 10	----1-----------	010101
Strawberry like herb	----1-----------	010101
Ground herb 9	----1-----------	010101
Buchnera hispida	2212--2---1-----	010101
Anthospermum whyteanum	2------1--------	010101
Pteridium aquilinum	22--2--1-1-11--1	01011
Epiphytic fern 8	1---------11---1	0110
Peucedanum sp.	-1-----11------1	0110
Helichrysum sp. 5	-1----------1--1	0110
Lamiaceae sp. 4	-1--------1-1--1	0110
Epiphytic fern 11	----1------1---1	0110
Epiphytic fern 20	----1------1---1	0110
Phyllanthus confusus	2-1----1-----1--	0111
Stephania abyssinica	----------11-2--	1000
Asparagus sp.	----------1---1-	1000
Diospyros whyteana	----------2---3-	10010
Maesa lanceolata	-----------2---3	10010
Epiphytic fern 6	----------1--2--	10011
Ground fern 3	----------1--2--	10011
Festuca sylvaticus	1---1------22212	10011
Aphloia theiformis	1----------3-32-	10011
Ilex mitis	1--------1-1-22-	10011
Rapanea melanophloeos	------------1--2	10011
Ground fern 4	11---------1-2--	1010
Cyperaceae sp. 2	1-------------1-	1010
Ground fern 6	-11--------1-2-1	1011
Ground fern 7	--------1----1-1	1011
Selaginella sp.	1------------2--	1011
Climber sp. 1	1------------2--	1011
Myrsine africana	-1----11---112-3	1011
Mellera lobulata	2------------32-	1100
Piper capense	1------------3--	1100

Ground fern 2	--------1----2-1	11010
Epiphytic fern 1	-------------2--	11011
Epiphytic fern 2	-------------2--	11011
Epiphytic fern 3	-------------2--	11011
Epiphytic fern 4	-------------2--	11011
Epiphytic fern 5	-------------2--	11011
Epiphytic fern 7	-------------2--	11011
Ground fern 1	-------------1--	11011
Ground fern 5	-------------2--	11011
Epiphytic herb 1	-------------22-	11011
Impatiens sp. 1	-------------3-3	11011
Asteraceae sp. 2 (forest)	-----------1-311	11011
Behnia reticulata	-------------212	11011
Lamiaceae sp. 1	-------------11-	11011
Forest herb 2	-------------3--	11011
Xymalos monospora	-------------232	11011
Podocarpus latifolius	1------------223	11011
Tree sp. 2	-------------21-	11011
Schefflera goetzenii	-------------2--	11011
Pittosporum viridiflorum	1------------2-2	11011
Cussonia spicata	--------------11	11011
Bechemia sp.EM	--------------1-	11011
Cassipourea malosana	--------------2-	11011
Lasianthus kilimandscharicus	--------------3-	11011
Forest herb 3	--------------1-	11011
Epiphytic herb 3	--------------1-	11011
Epiphytic fern 12	--------------2-	11011
Epiphytic fern 13	--------------2-	11011
Epiphytic fern 14	--------------2-	11011
Epiphytic fern 15	--------------2-	11011
Epiphytic fern 16	--------------2-	11011
Epiphytic fern 17	--------------21	11011
Epiphytic fern 18	--------------2-	11011
Epiphytic fern 19	--------------2-	11011
Tree sp. 17	--------------1-	11011
Psychotria sp.	--------------2-	11011
Ground fern 22	---------------1	11011
Transparent fern	---------------1	11011
Carissa bispinosa	---------------3	11011
Cayrattia gracilla	---------------2	11011
Streptocarpus sp.	---------------1	11011
Epiphytic fern 23	---------------1	11011
Epiphytic fern 24	---------------1	11011
Maytenus acuminata	---------------1	11011
Lamiaceae sp. 8	---------------1	11011
Epiphytic orchidaceae sp.	----------1--111	111
Lycopodium sp.	---------1---2-1	111
Cyperaceae sp. 1	-----------1-2-2	111
Asteraceae sp. 1 (forest)	-----------1-3-1	111
	0000000000000111	
	0000011111111	
	00001111	

Appendix 2: The floristic classificatory table produced by TWINSPAN using the data collected at the Sombani site.

```
                Sample     3333333334444444454422322222221111121111     1
                number     25613478903456789012890123456712459036784578901236

Scabiosa columbaria        --------32----------------------------------------
Chlorophytum sp.           --------1-----------------------------------------
Diclis tenella             --------1-----------------------------------------
Eucomis undulata           ---------1----------------------------------------
Chlorocorys sp..           1--1-1---1----------------------------------------
Crotalaria sp.             2221-------------------------1--------------------
Cyperaceae sp.1            21-11---------------------------------------------
Cyperaceae sp.2            2-2----2------------------------------------------
Gladiolus sp.              1-1--1--------------------------------------------
Asteraceae sp. (purple)    1-1-----------------------------------------------
Thesium whyteanum          2-1-----11----------------------------------------
Helichrysum nitens         323-3-221-----------------------------------------
Apiaceae sp.               2222222232-------------------2--------------------
Asteraceae sp.2            -1-1-22-------------------------------------------
Asteraceae sp.4            -1-112-1------------------------------------------
Viola abyssinica           ---111--------------------------------------------
Cyperaceae sp. (black)     22222222-----1------------------------------------
Hypoxis angustifolia       --121211-----1------------------------------------
Andropogon schirensis      -22222-2------------------------------------------
Herb 11                    ---1111-------------------------------------------
Herb 12                    -1111-11------------------------------------------
Herb 13                    ---1----------------------------------------------
Eriosema buchanannii       -------1------------------------------------------
Asteraceae sp.5            -----2-2------------------------------------------
Cyperaceae sp.3            -------2------------------------------------------
Cyperaceae sp.4            -----111------------------------------------------
Orchidaceae sp.            --1-1--1------------------------------------------
Asteraceae sp. (yel/purp)  ----11--------------------------------------------
Eragrostis sp. a           22--222------------2------------------------------

Asteraceae sp.1            111222121---2--1----------------------------------
Whalenbergia sp.           2--22211---2--2-----------------------------------

Exotheca abyssinica        22222-22-1-----22--------3------------1-----------
Asteraceae sp.3            112112-11--22222-2----1---------------------------
Gnidia sp.                 2-22-222---22-11-----1----------------------------
Koeleria capensis          2221-22211222122-2--------------------------------
Othonna sp.                2-2--2----1--111----------------------------------

Kniphofia ensifolia        ------------1-------------------------------------
Hairy herb (chamaephyte)   -----------1-2------------------------------------
Ericaceae sp.              ------------1-------------------------------------
Cyperaceae sp. 5           ------------2-2222-2------------------------------
Helichrysum sp.5           -----------2---222--------------------------------
Helichrysum bucanannii     ---------122232-2222------------------------------
Cyperaceae sp.6            --------------1221--------------------------------
Eragrostis sp. b           -----------------1--------------------------------
Helichrysum lastii         --------------22-2--------------------------------
Helichrysum sp.8           ----------------22--------------------------------
Cyphia sp.                 ---1--1-----1-2-22--------------------------------
Helichrysum sp.6           ----------------22--------------------------------

Agrostis sp.               -----------22-----21------------------------------

Panicum ecklonii           -22-222221-22--22--2----2222-----2----------------

Festuca costata            ----------3333----23-2212-211-1--221--------------
```

Rendlia altera	212--222-12--22-22222221--222---------------------
Asteraceae sp.6	--------1----2-------1-22-2-----------------------
Asteraceae sp.7	--------1-------------------1---------------------
Anthospermum sp.	------------------22------------------------------
Taraxicum sp. (purple)	------------------2-------------------------------
Poaceae sp.6	---------------------2-22-222------1--1-----------
Dierama pendula	---------------------------222--------------------
Rosaceae sp.	-----------------------------1--------------------
Fern plot 9	-----------------------------1--------------------
Fern plot 10	--------------------1-----------------------------
Eragrostis volkensii	----------1-------223-233-3333---122-111----------
Helichrysum sp. small/yel	----------2----2--2-21111-1111--1111-11-----------
Selago thomsonii var whyteana	------------------2----22-222212-221-22-----------
Knowltonia transvaalensis	------------------2---------2-2---1---------------
Buddleja salvifolia	----------212---1-1122222-2-11--23-11112----------
Aristea johnstoniana	--------------------------------------1-----------
Hypericum revolutum	--------1----111-1---1-1--1-11332321--22--1-------
Pteridium aquilinum	---1--1-22------------2-1-1112322332--13--1-------
Ground herb 2 (hemi-crypt)	----------------------------2-2--22---------------
Cyperaceae sp.7	------------------22------------111-1-------------
Merxmuellera davyii	--------------------------1---2---1---------------
Taraxicum sp. (yellow)	--------------------------2---212-11--------------
Poaceae sp. 7	---------------------1-----------21--1-1----------
Myrsine africana	------------------------------1-------------------
Geranium arabicum	------------------------------11--11--------------
Agrostis producta	------------------------------2-1-----------------
Streblochaete longiarista	--------------------------------1-11--11----------
Cyperaceae sp.black,banded	-------------------------------111---211----------
Euphorbiaceae sp.	-------------------------------1----1-11----------
Scilla sandersonii	-------------------------------1------------------
Helichrysum sp.2	-------------------------------1-1----12----------
Phillipia nyassana	--------------------------------12--1222----------
Pinus patula	----------------------------1----2-2-21-----------
Poaceae sp. 5	-------------------------------------1------------
Lamiaceae sp.6	--------------------------------1-1---------------
Widdringtonia nodiflora	--------------------------------1-----------------
Phillipia benguelensis	---------------------1----------12---221----------
Cyperaceae sp. 8	--------------------------------1-----------------
Ecotone herb 2	--------------------------------1-----------------
Fabaceae sp.	--------------------------------------1-----------
Helichrysum sp.4	--------------------------------------2-----------
Grassland herb 1	--------------------------------------121---------
Oxalis obliquifolia	---------------------------------------1----------
Lamiaceae sp.7	-----------------------------------1--------------
Impatiens sp.2	--------22--------23------2122121222--2---1-1-----
Halleria elyptica	------------------------------11121111----2----2--
Helichrysum dilucidum	-------------------------------11---------1-------
Festuca sylvaticus	-------------------------------11--1------1-------
Forest asteraceae sp.1	-------------------------------2--------------2---
Fern 2	---------------------------1-11---1-----------111-
Fern 3	--------------------------------1-----11---1-1----
Lycopodium sp.	--------------------------------1----1111-----2---

```
Forest asteraceae sp.2     -------------------------------1-1----3--2-1-2----3

Tree 2                     --------------------------------1---1------1--122--
Rapanea melanophloeos      --------------------------------21-------1-1-2---2-
Lamiaceae sp.1             --------------------------------1-11-----11-12-22-2
Lamiaceae sp.3             -----------------------------------11----21---12--2
Fern 7                     -------------------------------------11-----111-111

Tree 4                     -----------------------------------------------1---
Tree 11                    -------------------------------------------------2-
Streptocarpus sp.          -----------------------------------------------1---
Epiphytic fern             -----------------------------------------------1---
Smilax kraussiana          ------------------------------------------------1--
Momordica boivinii         ------------------------------------------------11-

Ilex mitis                 --------------------------------11---------1--22212
Dracaena laxissima         -----------------------------------------2112223332
Psychotria (spoon)         -----------------------------------------22-2123332
Impatiens sp.1             -----------------------------------------11-1-12111
Lamiaceae sp.2             -----------------------------------------21-1212222
Behnia reticulata          --------------------------------------------1---2--

Tree 3                     ------------------------------------------11---11--
Fern 1                     -----------------------------------------1111111111
Fern  (transparent)        -----------------------------------------11---1111-
Fern 4                     -----------------------------------------1----1-11-

Xymalos monospora          -----------------------------------------22-2-12--2
Maytenus acuminata         -----------------------------------------121--11--1
Podocarpus latifolius      ------------------------------------------112---11-
Piper capense              -----------------------------------------2113211111
Epiphytic herb 1           --------------------------------------------11--1--
Fern 5                     -------------------------------------1---1--111-11-

Tree 13                    -----------------------------------------1---------
Fern 8                     -----------------------------------------11-1------
Fern 10                    -------------------------------------------1-------
Widdringtonia whytei       -------------------------------------------1-------
Lamiaceae sp.5             --------------------------------------------1------
Drypetes gerrardii         --------------------------------------------12-----
Cryptocarya liebertiana    --------------------------------------------1------
Fern 11                    ---------------------------------------------1-----
Fern 12                    ---------------------------------------------1-----
Fern 13                    ---------------------------------------------1-----
Diospyros whyteana         ---------------------------------------------1-----
Cussonia spicata           ---------------------------------------------2-----
Asteraceae sp forest,3     ----------------------------------------------1----

Psychotria sp. b           --------------------------------21---1---1122-1-1--
Fern 9                     --------------------------------------1---11------1
Maesa lanceolata           ----------------------------------1------1211-2----
Kiggelaria africana        --------------------------------------1--32-221---1
Cyperaceae sp.9            --------------------------------------1----1111---1

                           000000000000000000000000000000000000000001111111111
                           000000000000000000111111111111111111111110000001111
                           00000000001111111100000000000001111111111
                           00000000110000111100111111111110000001111
                           00011111            0000000111
                                               0001111
```