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The long-term effects of fire frequency and season on the woody vegetation in the Pretoriuskop Sourveld of The Kruger National Park

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6.2 RESULTS FROM THE UNIVARIATE ANALYSIS TESTING THE EFFECTS OF FIRE ON THE DENSITY, STRUCTURE AND COMPOSITION OF THE WOODY VEGETATION OF THE PRETORIUSKOP EBP

In this section, the results from the Kolmogorov-Smirnov tests for normality, the ANOVA and ANCOVA analyses on the vegetation indices, and the Pearson-Ward cluster analyses on the Horn's similarity indices are presented.

6.2.1 Skewness and kurtosis of the data and the Kolmogorov-Smirnov one sample tests for normality

The results of the Kolmogorov-Smirnov (KS) one-sample tests for normality on the twelve vegetation indices calculated from the 1954 and 1996 survey data are presented in Figure 6-5 (p. 60) and Figure 6-6 (p. 62). The skewness and kurtosis statistics of the distributions are also presented in Figure 6-5 and Figure 6-6. The values of the vegetation indices calculated for each plot from the 1954 and 1996 survey data are presented in Appendix 4 in Table 12-1 (p. 220) and Table 12-3 (p. 222) respectively.

6.2.1.1 Testing the distribution of woody plant density per plot for normality

The distributions of the woody vegetation densities per plot in 1954 and 1996 were not significantly different from a normal distribution having Kolmogorov-Smirnov p-values of 0.810 and 0.306 respectively (Figure 6-5 and Figure 6-6). The skewness values of the plot densities in 1954 and 1996 (0.516 and 1.124 respectively) showed that the distributions had longer right tails than a normal distribution. The kurtosis values of the plot densities in 1954 and 1996 (1.084 and 2.645 respectively) showed that the distributions were more peaky than a normal distribution. The average density (plants/Ha) per plot in 1954 was 2094.5 and ranged from 401 on the Numbi February biennial plot to 4648 on the Shabeni February biennial plot (Table 12-1 and Table 13-1). The average density per plot in 1996 was 6012.7, which was 2.87 times higher than the average density per plot in 1954 (Table 12-3 and Table 13-1). The density per plot in 1996 ranged from 2298 on the Shabeni December triennial plot to 14163 on the Numbi no burn (control) plot. The lowest plot density in 1996 (2298), was greater than the average plot density in 1954 (2094.5). In general, the woody plant density increased on the Pretoriuskop EBPs between 1954 and 1996.

6.2.1.2 Testing the distribution of mean plant height per plot for normality

The distributions of the mean plant height per plot in 1954 and 1996 did not differ significantly from normality with Kolmogorov-Smirnov p-values of 0.452 and 0.221 respectively (Figure 6-5 and Figure 6-6). The skewness of the mean heights in 1954 and 1996 (0.722 and 0.587 respectively) showed that the distributions had longer right tails than a normal distribution. The kurtosis values showed that the magnitude of the distribution was slightly more peaky than a normal distribution in 1954 (0.541), and was similar to a normal distribution in 1996 (0.038). The average plant height on the plots in 1954 was 1.076m and ranged from 0.629m on the Shabeni August biennial plot to 1.668m on the Fayi December triennial (Table 12-1 and Table 13-1). The average plant height on the plots in 1996 was 1.041m and ranged from 0.640m on Numbi August annual to 1.574m on the Kambeni October triennial plot (Table 12-3 and Table 13-1).

Although the mean wood plant height frequency distribution in 1996 did not differ significantly from normality, the frequency histogram in Figure 6-6 showed that the distribution might be binomial. The first peak occurred between 0.6m and 1.05m with a highest point of 12 plots having average woody plant heights between 0.8m to 0.9 m. The second peak occurred between 1.05m and 1.7m with a highest point of 9 plots having average woody plant heights between 1.1m and 1.2m. The first peak (0.6m to 1.05m) comprised the Fayi Dec2, Feb2, Aug1, Oct3, Feb3, and Apr3 plots, the Kambeni Dec2, Feb2, Apr2, Aug1, Feb3, and Apr3 plots, the Numbi Dec2, Feb2, Aug2, Apr2, Aug1, Dec3, Oct3, Feb3, Apr3, and Aug3 plots, and the Shabeni Apr2, Aug1, Feb2, Oct2, Dec2, and Apr3 plots. The second peak (1.05m to 1.7m) comprised the Fayi Aug2, Con0, Oct2, Apr2, Dec3, and Aug3 plots, the Kambeni Con0, Oct2, Aug2, Oct3, Dec3, and Aug3 plots, the Numbi

Oct2 and Con0 plots, and the Shabeni Aug2, Con0, Dec3, Aug3, Oct3, and Feb3 plots. All the August Annual treatments occurred in the first peak and all the Control (no burn) treatments occurred in the second peak. Fourteen of the sixteen Biennial and Triennial February and April treatments and all of the December Biennial treatments occurred in the first peak. Eleven of the sixteen biennial and triennial August and October treatments and three of the four December Triennial treatments occurred in the second peak.

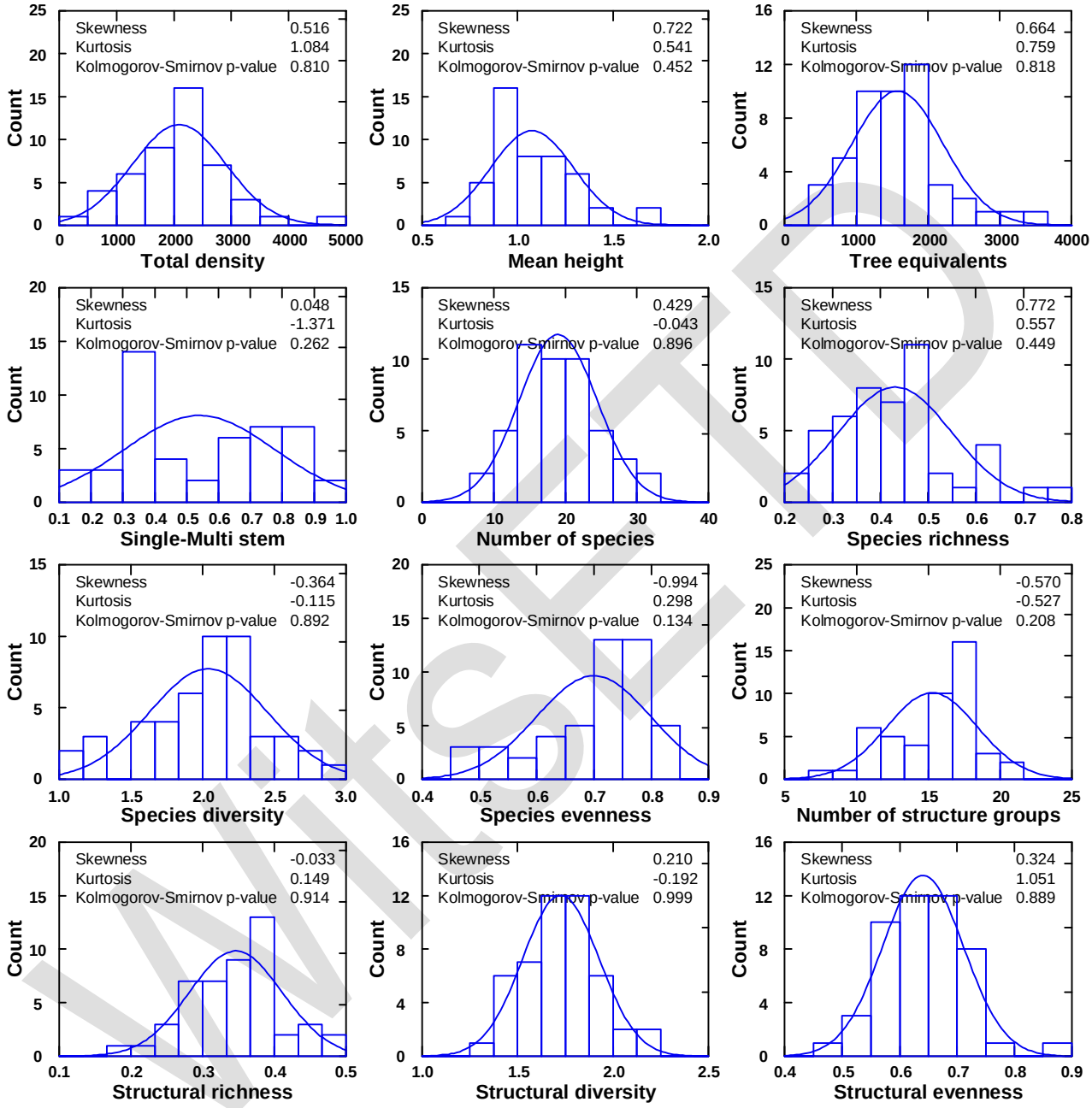


Figure 6-5: Normal curves fitted to the distribution of vegetation indices calculated for each plot using the baseline data collected in 1954. The graphs show the Skewness, Kurtosis and Kolmogorov-Smirnov p-values for the data distributions.

6.2.1.3 Testing the distribution of number of tree equivalents per plot for normality

The distributions of the number of tree equivalents per plot in 1954 and 1996 did not differ significantly from normality with Kolmogorov-Smirnov p-values of 0.818 and 0.967 respectively (Figure 6-5 and Figure 6-6). The skewness of number of tree equivalents in 1954 and 1996 (0.664 and 0.875 respectively) show that the distributions had longer right tails than a normal distribution. The kurtosis values show that the distributions

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in 1954 and 1996 were peakier than a normal distribution with values of 0.759 and 1.255 respectively. The average number of tree equivalents (tree equivalents/Ha) in 1954 was 1571.7 and 4285.9 in 1996, which was 2.73 times higher than in 1954. In 1954, the tree equivalents ranged from 398 to 3431 on the Numbi February biennial and Shabeni February biennial plots respectively. The same plots (Numbi February biennial and Shabeni February biennial) had the lowest and highest woody plant densities respectively in 1954 (Table 12-1 and Table 13-1). In 1996, the tree equivalents per plot ranged from 1551 to 10323 on Shabeni April biennial and Numbi no burn (control) plots respectively (Table 12-3 and Table 13-1).

6.2.1.4 Testing the distribution of the single-stem to multi-stem index per plot for normality

The distributions of the single-stem to multi-stem index calculated for the 1954 and 1996 surveys were not significantly different from a normal distribution with Kolmogorov-Smirnov p-values of 0.262 and 0.632 respectively (Figure 6-5 and Figure 6-6). The skewness values of the single-stem to multi-stem index in 1954 and 1996 (0.048 and -0.057 respectively) showed that the distributions were similar to a normal distribution and symmetrical about their arithmetic means. The kurtosis values in 1954 and 1996 (-1.371 and -0.263 respectively) showed that the distributions were flatter than a normal distribution. In 1954, the distribution of single-stem to multi-stem index was flatter than in 1996. In 1954, the number of single-stem individuals was approximately the same as the number of multi-stem individuals with a mean single-stem to multi-stem index of 0.541. However, in 1996 mean single-stem to multi-stem index was 0.324 which was almost half that of 1954, revealing a proportionally higher number of multi-stem individuals relative to single-stem individuals in 1996. In 1954, the single-stem to multi-stem index ranged from 0.132 (few single-stem individuals) on the Kambeni December triennial plot to 0.922 (few multi-stem individuals) on the Fayi February biennial plot (Table 12-1 and Table 13-1). In 1996, the distribution of the single-stem to multi-stem index ranged from 0.065 (very few single-stem individuals) on the Kambeni August biennial plot to 0.613 (even number of single-stem and multi-stem individuals) on the Shabeni no burn (control) plot (Table 12-3 and Table 13-1).

6.2.1.5 Testing the distribution of the number of species per plot for normality

The distributions of the number of species per plot in 1954 and 1996 were not significantly different from a normal distribution with Kolmogorov-Smirnov p-values of 0.896 and 0.145 respectively (Figure 6-5 and Figure 6-6). The skewness of the number of species per plot in 1954 and 1996 showed that the distributions had longer right tails than a normal distribution (0.429 and 0.488 respectively). The kurtosis values showed that the magnitude of the peak in 1954 was similar to that of a normal distribution (-0.043), while in 1996 it was considerably greater than that of a normal distribution (1.271). The average number of species per plot was 19.0 in 1954 and 29.6 in 1996, which is 10.667 species per plot more than in 1954. In 1954, the distribution ranged from 9 species per plot on the Kambeni August biennial and Shabeni August triennial plots to 33 species on the Numbi October triennial plot (Table 12-1 and Table 13-1). In 1996, the distribution of the number of species per plot ranged from 14 on the Fayi October triennial plot to 47 on the Numbi April triennial plot (Table 12-3 and Table 13-1). In general, the number of species recorded per plot increased between 1954 and 1996.

6.2.1.6 Testing the distribution of species richness per plot for normality

The distributions of the species richness per plot in 1954 and 1996 did not differ significantly from a normal distribution with Kolmogorov-Smirnov p-values of 0.449 and 0.557 respectively (Figure 6-5 and Figure 6-6). The skewness values of the species richness in 1954 and 1996 (0.772 and 0.632 respectively) showed that the distributions had longer right tails than a normal distribution. The kurtosis values for 1954 and 1996 (0.557 and 0.172 respectively) showed that the distributions were slightly more peaky than a normal distribution. The mean species richness on the plots was 0.431 in 1954 and 0.396 in 1996. In 1954, the species richness ranged from 0.228 to 0.763 on the Kambeni August biennial plot and the Numbi April triennial plots respectively (Table 12-1 and Table 13-1). In 1996, the species richness per plot ranged from 0.218 to 0.593 on the Fayi October triennial and the Numbi December triennial plots respectively (Table 12-3 and Table 13-1). In 1954, the Kambeni August biennial plot had the lowest species richness and it had the

lowest number of species (9). In 1996, the Fayi October triennial plot had the lowest species richness and it had the lowest number of species (14).

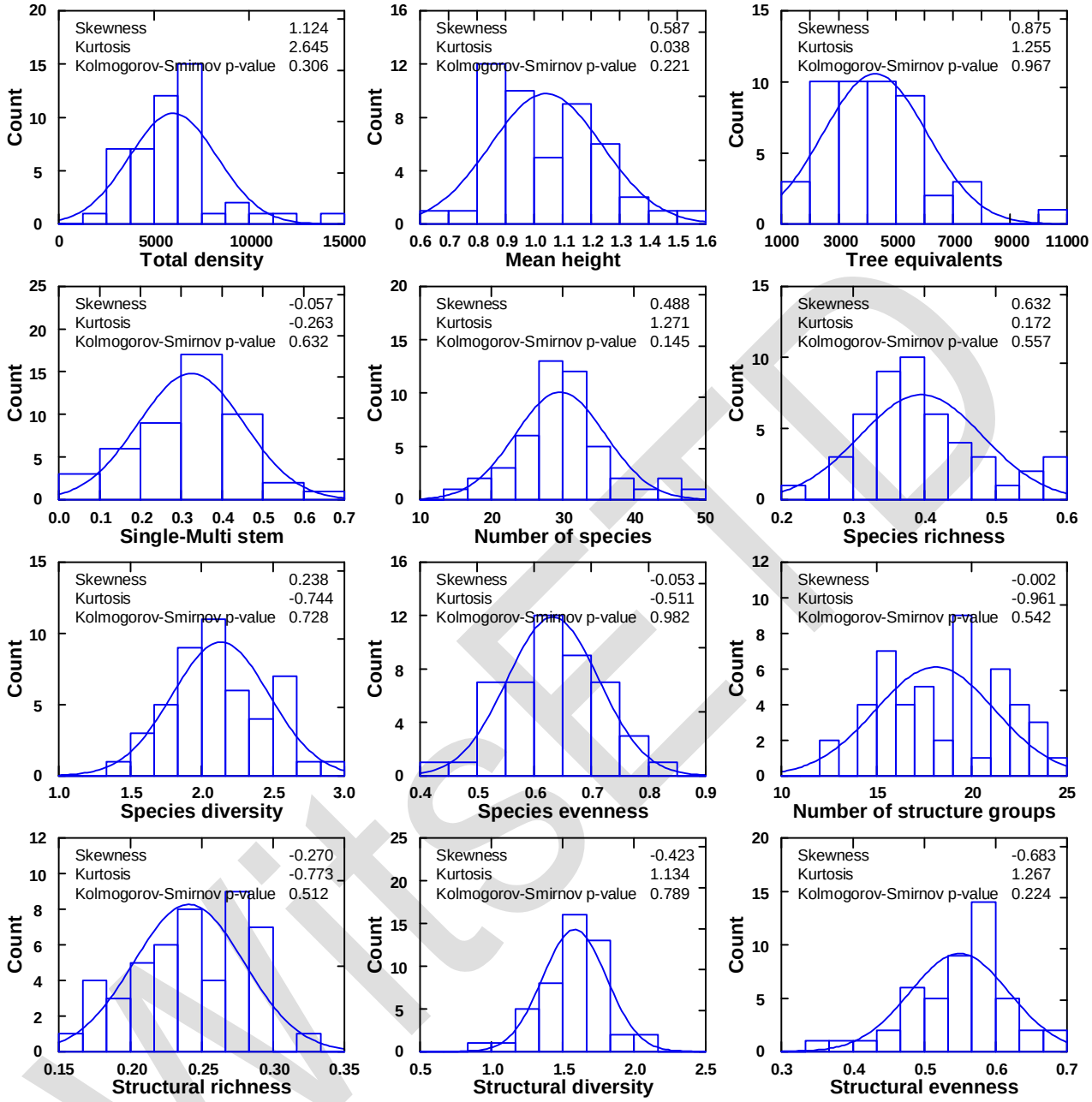


Figure 6-6: Normal curves fitted to the distribution of vegetation indices calculated for each plot using the baseline data collected in 1996. The graphs show the Skewness, Kurtosis and Kolmogorov-Smirnov p-values for the data distributions.

6.2.1.7 Testing the distribution of species diversity per plot for normality

The distributions of the species diversity per plot in 1954 and 1996 were not significantly different from a normal distribution with Kolmogorov-Smirnov p-values of 0.892 and 0.728 respectively (Figure 6-5 and Figure 6-6). The skewness of the species diversity in 1954 showed that the distribution had a longer left tail than the normal distribution (-0.364), and in 1996 it had a longer right tail than a normal distribution (0.238). The kurtosis values for 1954 and 1996 (-0.115 and -0.744 respectively) showed that the distributions were slightly flatter than a normal distribution. The average species diversity per plot in 1954 was 2.042 and 2.132 in 1996. In 1954, the species diversity ranged from 1.157 to 2.880 on the Kambeni August biennial and the Numbi October triennial plots respectively (Table 12-1 and Table 13-1). In 1996, the species diversity ranged

from 1.481 to 2.849 on the Kambeni August biennial and Numbi December triennial plots respectively (Table 12-3 and Table 13-1). In 1954, the Kambeni August biennial plot had the lowest species diversity and it had the lowest number of species, and the lowest species richness. The Numbi October triennial plot had the highest species diversity in 1954 and it had the highest number of species. In 1996, Numbi December triennial plot had the highest species diversity and it had the highest species richness.

6.2.1.8 Testing the distribution of species evenness per plot for normality

The distributions of the species evenness per plot in 1954 and 1996 did not differ significantly from normality with Kolmogorov-Smirnov p-values of 0.134 and 0.982 respectively (Figure 6-5 and Figure 6-6). The skewness of the species evenness in 1954 showed that the distribution has a longer left tail than the normal distribution (-0.994), and in 1996 it was symmetrical about the arithmetic mean (-0.053). The kurtosis showed that the distribution in 1954 was slightly peakier than a normal distribution (0.298), and in 1996, the distribution was flatter than a normal distribution (-0.511). The average species evenness on the plots in 1954 was 0.700, and in 1996, it was 0.633. In 1954, the species evenness ranged form 0.453 on the Kambeni December triennial plot to 0.844 on the Numbi August biennial plot (Table 12-1 and Table 13-1). In 1996, the species evenness ranged from 0.444 to 0.801 on the Kambeni August biennial and Numbi December triennial plots respectively (Table 12-3 and Table 13-1). In 1996, the Numbi December triennial plot had the highest species evenness and it had the highest species richness (0.593), and species diversity (2.849). The Kambeni August biennial plot had the lowest species evenness in 1996 and it had the lowest species diversity (1.481).

6.2.1.9 Testing the distribution of the number of structure groups per plot for normality

The distributions of the number of structure groups per plot in 1954 and 1996 were not significantly different from a normal distribution with Kolmogorov-Smirnov p-values of 0.208 and 0.542 respectively (Figure 6-5 and Figure 6-6). The skewness value of the number of structure groups in 1954 showed that the distribution had a longer left tail than a normal distribution (-0.570), and in 1996 it was symmetrical about the arithmetic mean (-0.002). The kurtosis values for 1954 and 1996 (-0.527 and -0.961 respectively) showed that the distributions were flatter than a normal distribution. The average number of structure groups per plot in 1954 was 15.3 while it was 18.1 in 1996. In 1954, the number of structure groups ranged from 8 to 21 groups on the Numbi August triennial and Fayi August annual plots respectively (Table 12-1 and Table 13-1). In 1996, the number of structure groups ranged from 12 on the Numbi August triennial and Shabeni April biennial plots to 24 on the Kambeni December triennial plot (Table 12-3 and Table 13-1).

6.2.1.10 Testing the distribution of structural richness per plot for normality

The distributions of the structural richness per plot in 1954 and 1996 did not differ significantly from normality with Kolmogorov-Smirnov p-values of 0.914 and 0.512 respectively (Figure 6-5 and Figure 6-6). The skewness of the structural richness in 1954 showed that the distribution was symmetrical about the arithmetic mean (-0.033), and in 1996 it had a slightly longer left tail than a normal distribution (-0.270). The kurtosis value in 1954 showed that the distribution was slightly more peaky than a normal distribution (0.149), and that the distribution was flatter than a normal distribution (-0.773) in 1996. The mean structural richness on the plots in 1954 was 0.347 and ranged from 0.184 to 0.494 on the Numbi August triennial plot and the Kambeni October triennial plots respectively (Table 12-1 and Table 13-1). The mean structural richness on the plots in 1996 was 0.241, and ranged from 0.158 to 0.320 on the Shabeni October biennial plot and the Numbi October biennial plot respectively (Table 12-3 and Table 13-1). In 1954, the Numbi August triennial plot had the lowest structural richness and it had the lowest number of structure groups (9).

6.2.1.11 Testing the distribution of structural diversity per plot for normality

The distributions of the structural diversity per plot in 1954 and 1996 were not significantly different from a normal distribution with Kolmogorov-Smirnov p-values of 0.999 and 0.789 respectively (Figure 6-5 and Figure 6-6). The skewness value of the structural diversity in 1954 showed that the distribution had a slightly

longer right tail than a normal distribution (0.149), and in 1996 the distribution had a longer left tail than a normal distribution (-0.423). The kurtosis value in 1954 showed that the distribution was slightly flatter than a normal distribution (-0.192), and in 1996 the distribution was more peaky than a normal distribution (1.134). The average structural diversity per plot in 1954 was 1.726, and in 1996, it was 1.582. In 1954, the structural diversity ranged from 1.313 to 2.200 on the Fayi February biennial plot and the Kambeni no burn (control) plot respectively (Table 12-1 and Table 13-1). In 1996, the structural diversity ranged from 0.912 to 2.081 on the Numbi August annual and the Shabeni no burn (control) plots respectively (Table 12-3 and Table 13-1).

6.2.1.12 Testing the distribution of structural evenness per plot for normality

The distributions of the structural evenness per plot in 1954 and 1996 did not differ significantly from normality with Kolmogorov-Smirnov p-values of 0.889 and 0.224 respectively (Figure 6-5 and Figure 6-6). The skewness of the structural evenness in 1954 showed that the distribution had a slightly longer right tail than a normal distribution (0.324), and in 1996 it had a longer left tail than that of a normal distribution (-0.683). The kurtosis values in 1954 and 1996 (1.051 and 1.267 respectively) showed that the distributions were more peaky than a normal distribution. The average structural evenness on the plots in 1954 was 0.641 and it was 0.549 in 1996. In 1954, the structural evenness ranged from 0.463 to 0.858 on the Fayi February biennial plot and the Kambeni no burn (control) plot respectively (Table 12-1 and Table 13-1). In 1996, the structural evenness ranged from 0.337 to 0.698 on the Numbi August annual and the Kambeni no burn (control) plots respectively. In 1954, the Fayi February biennial plot had the lowest structural evenness and it had the lowest structural diversity. The Kambeni no burn (control) had the highest structural evenness in 1954 and it had the highest structural diversity. In 1996, the Numbi August annual plot had the lowest structural evenness and it had the lowest structural diversity. These associations are because Shannon's diversity index is a measurement of both the number of groups and the abundance evenness of the groups. When the abundance evenness or is low, the diversity tends to be low even if the number of groups is high.

None of the distributions of the indices that were calculated from the data collected in the 1954 and 1996 surveys on the Pretoriuskop EBP experiment differed significantly from normality, and this justified the use of parametric analyses for testing the experimental hypotheses.

6.2.2 Analyses of Variance and Analyses of Covariance statistical analyses

6.2.2.1 Testing for differences in the woody vegetation density, structure and composition on the Pretoriuskop EBPs between 1954 and 1996

The results from the Analysis of Variance testing for change in the woody vegetation between 1954 and 1996 are displayed in Table 6-2 (p. 65) and Figure 6-7 (p. 66). A summary of the data used in these analyses is presented in Appendix 5 in Table 13-1 (p. 223). The results of correlation and regression analyses testing for linear relationships between the woody vegetation in 1954 and 1996 are displayed in Table 6-3 (p. 67).

6.2.2.1.1 Change in woody plant density between 1954 and 1996

The average woody plant density (plants/Ha) on the Pretoriuskop EBPs increased from 2094.5 in 1954 to 6012.7 in 1996 (Figure 6-7 and Table 13-1). This increase of 187 % was statistically significant at $p < 0.001$ (Table 6-2). The correlation and regression analyses show that there was a very weak relationship ($r^2 = 0.064$) between the plot densities in 1954 and 1996, however, this relationship was significant at $p = 0.084$ (Table 6-3).

6.2.2.1.2 Change in woody plant mean height between 1954 and 1996

The mean height of the woody vegetation on the Pretoriuskop EBPs decreased from 1.076m to 1.041m (Figure 6-7 and Table 13-1), however this decrease was not statistically significant (Table 6-2).The correlation and regression analyses suggest that there was no relationship ($r^2 = 0.003$) between the woody vegetation height in 1954 and 1996 (Table 6-3).

Table 6-2: Results of the ANOVA analyses on the vegetation indices calculated to test for changes in the woody vegetation on the treatment plots between 1954 and 1996.

					Taxonomic diversity				Structural diversity			
Statistic	Density	Mean height	Tree equivalents	Single:Multi-stem	Number of species	Species richness	Species diversity	Species evenness	Number of structural groups	Structure richness	Structure diversity	Structure evenness
df	1	1	1	1	1	1	1	1	1	1	1	1
df error	94	94	94	94	94	94	94	94	94	94	94	94
F-ratio	122.834	0.665	95.417	78.449	30.821	2.673	1.438	13.108	19.124	93.505	11.035	40.697
p value	< 0.001	0.417	< 0.001	< 0.001	< 0.001	0.105	0.233	< 0.001	< 0.001	< 0.001	0.001	< 0.001

Note: The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.1.3 Change in number of tree equivalents between 1954 and 1996

The number of tree equivalents increased significantly on the Pretoriuskop EBPs from 1954 to 1996 ($p < 0.001$) (Table 6-2 and Figure 6-7). There was a 173 % increase in the average number of tree equivalents per hectare from 1571.7 in 1954 to 4285.9 in 1996 (Table 13-1). This increase in the number of tree equivalents between 1954 and 1996 was expected because the number of tree equivalents is a composite measure of the number of individuals relative to the total height that those individuals represent. The woody plant density increased significantly from 1954 to 1996 and the mean plant height remained the same, therefore the number of tree equivalents was expected to increase between 1954 and 1996. The correlation and regression analyses show that there was no relationship ($r^2 = 0.040$) in the number of tree equivalents between 1954 and 1996 (Table 6-3).

6.2.2.1.4 Change in the single-stem to multi-stem ratio between 1954 and 1996

In 1954, there were approximately equal numbers of single-stem and multi-stem individuals on the Pretoriuskop EBPs with a single-stem to multi-stem ratio of 0.541 (Table 13-1). In 1996, the single-stem to multi-stem index was 0.324 showing that in 1996 there were more multi-stem individuals than there were single-stem individuals (Table 13-1). This decrease in the relative numbers of single-stem to multi-stem individuals from 1954 to 1996 was significant at $p < 0.001$ (Table 6-2 and Figure 6-7). The correlation and regression analyses show that there was no relationship ($r^2 = 0.001$) in the single-stem to multi-stem ratios between 1954 and 1996 (Table 6-3).

6.2.2.1.5 Change in the number of species between 1954 and 1996

The mean number of species per plot increased significantly ($p < 0.001$) between 1954 and 1996 from 19.0 to 29.6 (Table 6-2, Figure 6-7, and Table 13-1). The number of species found in a vegetation survey is related to the sample area, and as the sample area increases the likelihood of finding more species increases. The survey area per plot was 29% bigger in 1996 ($1200m^2$) than in 1954 ($929.64m^2$). This increase in sample area may account for part of the increase in the number of species observed per plot. However, the number of species observed per plot increased by 42% from 1954 to 1996. It is believed that part of this increase was due to the increase in sample area and part was due to an actual increase in the number of species found on the plots between 1954 and 1996. The correlation and regression analyses suggest that there is a very weak yet significant relationship ($r^2 = 0.091$, $p = 0.037$) in the number of species per plot between 1954 and 1996 (Table 6-3).

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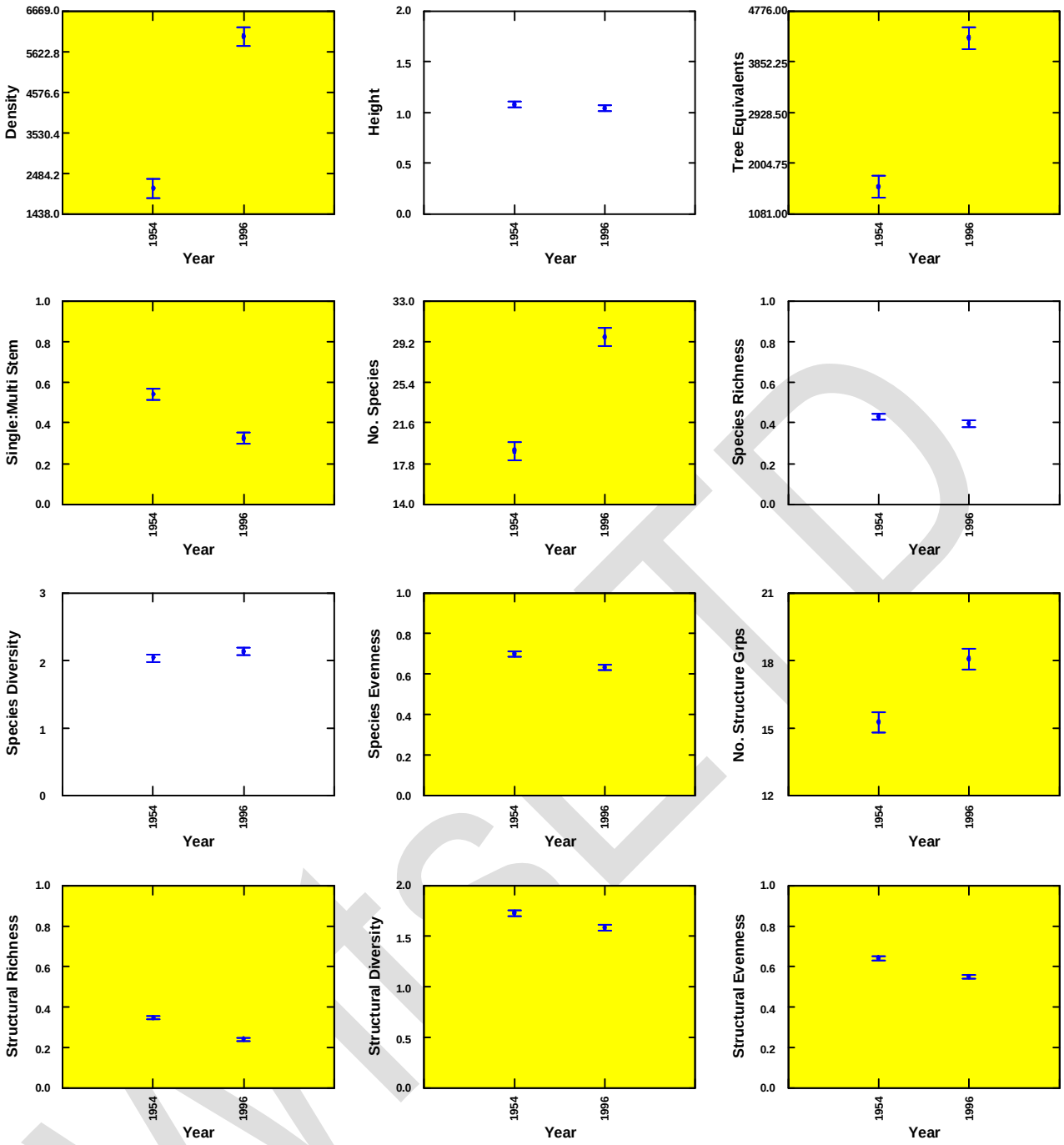


Figure 6-7: The least squares means and standard errors of the vegetation indices from the ANOVA analyses between the 1954 and 1996 data testing for change in woody vegetation over time. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.1.6 Change in the species richness between 1954 and 1996

The species richness on the Pretoriuskop EBP experiment decreased slightly from 0.431 in 1954 to 0.396 in 1996 (Figure 6-7 and Table 13-1). This decrease in species richness was not significant (Table 6-2). Species richness is a measure of the number of species observed relative to the size of the sample. The total sample size in 1954 was 9294 woody plants, and in 1996, the total sample size was 35111 woody plants. It is because of the simultaneous increase in the number of species observed and the number of plants surveyed that the species richness decreases slightly between 1954 and 1996. The correlation and regression analyses suggest that there is a very weak yet significant relationship (r^2 = 0.097, p = 0.031) in the species richness per plot between 1954 and 1996 (Table 6-3).

Table 6-3: The results from correlation and linear regression analyses testing the relationships between the woody vegetation in 1954 and 1996 using the vegetation indices calculated. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

	r	r^2	p-value	Regression equation
Density	0.252	0.064	0.084	$y = 4520.721 + 0.712 * x$
Mean height	0.051	0.003	0.730	$y = 0.992 + 0.046 * x$
Tree equivalents	0.199	0.040	0.175	$y = 3394.607 + 0.567 * x$
Single:Multi stem	-0.030	0.001	0.849	$y = 0.333 + -0.015 * x$
Number of species	0.301	0.091	0.037	$y = 23.002 + 0.35 * x$
Species richness	0.312	0.097	0.031	$y = 0.298 + 0.227 * x$
Species diversity	0.486	0.236	< 0.001	$y = 1.317 + 0.4 * x$
Species evenness	0.229	0.479	0.001	$y = 0.361 + 0.389 * x$
Number of structural groups	0.418	0.175	0.003	$y = 11.77 + 0.413 * x$
Structure richness	0.053	0.003	0.721	$y = 0.23 + 0.031 * x$
Structure diversity	0.102	0.010	0.489	$y = 1.384 + 0.115 * x$
Structure evenness	0.081	0.007	0.582	$y = 0.498 + 0.08 * x$

6.2.2.1.7 Change in species diversity between 1954 and 1996

The species diversity on the Pretoriuskop EBP experiment increased slightly from 2.042 in 1954 to 2.135 in 1996 (Figure 6-7 and Table 13-1). However, the increase in species diversity was not statistically significant (Table 6-2). The correlation and regression analyses suggest that there is a significant relationship (r^2 = 0.236, $p < 0.001$) between the species diversity on the plots in 1954 and 1996 (Table 6-3).

6.2.2.1.8 Change in species evenness between 1954 and 1996

There was a significant ($p < 0.001$) decrease in species evenness on the Pretoriuskop EBPs from 0.700 in 1954 to 0.633 in 1996 (Table 6-2, Figure 6-7, and Table 13-1). The correlation and regression analyses show that the correlation between the species evenness in 1954 and 1996 was the strongest of all the vegetation indices with an r^2 value of 0.479 ($p = 0.001$) (Table 6-3). This is interesting because there has been a significant change in species evenness between 1954 and 1996, but almost 50% of the variation in species evenness between plots in 1996 is attributable to the species evenness before the experiment began 42 years earlier.

6.2.2.1.9 Change in number of structure groups between 1954 and 1996

The average number of structure group per plot increased significantly ($p < 0.001$) from 15.3 in 1954 to 18.1 in 1996 (Table 6-2, Figure 6-7, and Table 13-1). The correlation and regression analyses suggest that there was a significant relationship (r^2 = 0.175, $p = 0.003$) in the number of structure groups per plot between 1954 and 1996 (Table 6-3).

6.2.2.1.10 Change in structural richness between 1954 and 1996

The structural richness on the Pretoriuskop EBP experiment decreased significantly ($p < 0.001$) from 0.347 in 1954 to 0.241 in 1996 (Table 6-2, Figure 6-7, and Table 13-1). The correlation and regression analyses suggest that there was no relationship (r^2 = 0.003) in the structural richness on the Pretoriuskop EBPs between 1954 and 1996.

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6.2.2.1.11 Change in structural diversity between 1954 and 1996

There was a significant ($p = 0.001$) decrease in structural diversity on the Pretoriuskop EBPs from 1.726 in 1954 to 1.582 in 1996 (Table 6-2, Figure 6-7, and Table 13-1). The correlation and regression analyses show that there was no relationship ($r^2 = 0.010$) in the structural diversity between 1954 and 1996 (Table 6-3).

6.2.2.1.12 Change in structural evenness between 1954 and 1996

The structural evenness on the Pretoriuskop EBP experiment decreased significantly ($p < 0.001$) from 0.641 in 1954 to 0.549 in 1996 (Table 6-2, Figure 6-7, and Table 13-1). The correlation and regression analyses show that there was no relationship ($r^2 = 0.007$) in the woody vegetation structural evenness between 1954 and 1996 (Table 6-3).

6.2.2.2 Testing for differences in the woody vegetation density, structure and composition between Pretoriuskop EBPs found on the four replicates, Fayi, Kambeni, Numbi, and Shabeni

The results of the Analysis of Variance and Analysis of Covariance testing for differences in woody vegetation between the four Pretoriuskop EBP replicates (Fayi, Kambeni, Numbi and Shabeni) in 1954 and 1996 are presented in Table 6-4 (p. 70), Figure 6-8 (p. 72), Figure 6-9 (p. 73), and Figure 6-10 (p. 74). Results of Tukey Studentized *post hoc* analyses that were performed when significant differences were found between replicates are presented in Appendix 6 in Table 14-1 (p. 236), Table 14-2 (p. 237) and Table 14-3 (p. 238). Summaries of the 1954 and 1996 data used in these analyses are presented in Appendix 5 in Table 13-2 (p. 224) and Table 13-3 (p. 225) respectively.

6.2.2.2.1 Differences in woody plant density between replicates

There was no significant difference in the woody plant density per plot between the four EBP replicates in the Pretoriuskop region in 1954 and in 1996 (Table 6-4). In 1954, the density (plants/Ha) of woody vegetation per plot was highest on the Fayi replicate (2338.9), and lowest on the Kambeni replicate (1846.2), the Shabeni replicate had the second highest woody vegetation density per plot (2204.0), and the Numbi replicate had the second lowest woody density per plot (1988.8) (Table 13-2 and Figure 6-8). In 1996, the woody vegetation density per plot was highest on the Fayi replicate (6564.3) and lowest on the Shabeni replicate (5126.3), the Kambeni replicate had the second highest woody vegetation density per plot (6281.0), and the Numbi replicate had the second lowest woody vegetation density per plot (6079.0) (Table 13-3 and Figure 6-9).

The density of the woody vegetation increased on all of the Pretoriuskop EBP replicates between 1954 and 1996. The annual rate of increase in the woody plant density (plants/Ha/year) between 1954 and 1996 was highest on the Kambeni replicate (105.6), second highest on the Fayi replicate (100.6), second lowest on the Numbi replicate (97.4), and lowest on the Shabeni replicate (69.6). The Fayi replicate had the highest woody plant density in 1954 and 1996. The Kambeni replicate had the lowest woody plant density in 1954, and it had the second highest woody plant density in 1996. The Shabeni replicate had the second highest woody plant density in 1954 and the lowest woody plant density in 1996. Despite these large changes in the woody plant density between 1954 and 1996, the density between the four Pretoriuskop replicates remained remarkably similar. This suggests that the changes that were observed may well reflect the kind and magnitude of change that occurred in the vegetation of the Pretoriuskop landscape between 1954 and 1996.

6.2.2.2.2 Differences in woody plant mean height between replicates

There was no significant difference between mean plant heights of the Pretoriuskop EBP replicates in 1954 (Table 6-4). In 1954, the Numbi replicate had the tallest mean plant height per plot (1.215m), and the Kambeni replicate had the shortest mean plant height per plot (1.041m) (Table 13-2 and Figure 6-8). The Fayi replicate had the second tallest mean plant height per plot (1.160m) in 1954, and the Shabeni replicate had the second shortest mean plant height per plot (1.045m) (Table 13-2 and Figure 6-8). In 1996, the

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Kambeni replicate had the tallest mean plant height per plot (1,111m), and the Numbi replicate had the shortest mean plant height per plot (0.925m) (Table 13-3 and Figure 6-9). The Fayi replicate had the second tallest mean plant height per plot (1.084m) in 1996, and the Shabeni replicate had the second shortest mean plant height per plot (1.045m) (Table 13-3 and Figure 6-9). ANOVA and ANCOVA analyses showed that there was a significant difference in the mean plant height between the Pretoriuskop EBP replicates in 1996 (ANOVA: p = 0.092, ANCOVA: p = 0.096) (Table 6-4). Tukey Studentized *post hoc* analyses showed that the mean plant height on the Kambeni replicate was significantly taller than the mean plant height on the Numbi replicate in 1996 (ANOVA: p = 0.087, ANCOVA: p = 0.091) (Table 14-2 and Table 14-3).

Between 1954 and 1996, mean plant height per plot increased on the Kambeni replicate, decreased on the Fayi and Numbi replicates, and remained the same on the Shabeni replicate. The annual rate of increase in the woody plant height (mm/year) between 1954 and 1996 was highest on the Kambeni replicate (1.68), second highest on the Shabeni replicate (-0.01), second lowest on the Fayi replicate (-1.83), and lowest on the Numbi replicate (-6.90). The Kambeni replicate had the shortest mean plant height per plot in 1954 and the tallest mean plant height in 1996, and the Numbi replicate had the tallest mean plant height in 1954 and the shortest mean plant height in 1996.

6.2.2.2.3 Differences in tree equivalents between replicates

There was no significant difference in the number of tree equivalents between the four Pretoriuskop EBP replicates in 1954 (Table 6-4). In 1954, the Fayi replicate had the highest number of tree equivalents per plot (tree equivalents/Ha) (1893.2), and the Numbi replicate had the lowest number of tree equivalents per plot (1449.5) (Table 13-2 and Figure 6-8). The Shabeni replicate had the second highest number of tree equivalents per plot (1555.6) in 1954, and the Kambeni replicate had the second lowest number of tree equivalents per plot (1521.0) (Table 13-2 and Figure 6-8). In 1996, the Kambeni replicate had the highest number of tree equivalents per plot (5343.7), and the Shabeni replicate had the lowest number of tree equivalents per plot (3248.2) (Table 13-3 and Figure 6-9). The Fayi replicate had the second highest number of tree equivalents per plot (4766.2) in 1996, and the Numbi replicate had the second lowest number of tree equivalents per plot (3785.6) (Table 13-3 and Figure 6-9). In 1996, the number of tree equivalents between the replicates was significantly different (ANOVA: p = 0.016, ANCOVA: p = 0.019) (Table 6-4). Tukey Studentized *post hoc* analyses showed that the Kambeni replicate had significantly more tree equivalents than the Shabeni replicate in 1996 (ANOVA: p = 0.018, ANCOVA: p = 0.016) (Table 14-2 and Table 14-3).

Number of tree equivalents increased on all replicates between 1954 and 1996. The annual rate of increase in the number of tree equivalents (tree equivalents/ha/year) between 1954 and 1996 was highest on the Kambeni replicate (91.0), second highest on the Fayi replicate (68.4), second lowest on the Numbi replicate (55.6), and lowest on the Shabeni replicate (40.3). In 1954, the Kambeni replicate had the lowest number of tree equivalents, and in 1996, it had the highest number of tree equivalents. The increase in the number of tree equivalents on the Kambeni replicate between 1954 and 1996 was related to the increase in woody plant density and an increase in mean plant height on the Kambeni replicate between 1954 and 1996.

6.2.2.2.4 Differences in single-stem to multi-stem index between replicates

In 1954, the single-stem to multi-stem index per plot was significantly different between the four EBP replicates in the Pretoriuskop region (p = 0.027) (Table 6-4). Tukey Studentized *post hoc* analyses showed that the Fayi and Numbi replicates had significantly higher single-stem to multi-stem indices than the Kambeni replicate with p values of 0.035 and 0.083 respectively (Table 14-1). In 1954, the single-stem to multi-stem index per plot was highest on the Fayi replicate (0.652), and lowest in the Kambeni replicate (0.398), the Numbi replicate had the second highest value (0.618) and the Shabeni replicate had the second lowest value (0.494) (Table 13-2 and Figure 6-8). The single-stem to multi-stem index was not significantly different between the four Pretoriuskop EBP replicates in 1996 (Table 6-4). In 1996, the single-stem to multi-stem indices were very similar ranging from 0.311 on the Fayi replicate to 0.338 on the Numbi replicate in comparison with 1954, which ranged from 0.398 on Kambeni replicate to 0.652 on the Fayi replicate (Table 13-3 and Figure 6-9).

The single-stem to multi-stem index decreased on all replicates between 1954 and 1996. This indicates that there was a relative increase in the number of multi-stem individuals relative to single-stem individuals between 1954 and 1996 on all the Pretoriuskop EBP replicates. The Fayi replicate had the largest decrease in the number of single-stem individuals relative to multi-stem individuals of the four Pretoriuskop EBP replicates between 1954 and 1996.

6.2.2.2.5 Differences in the number of species between replicates

In 1954, the Numbi replicate had the highest number of survey species per plot (20.5), and the Kambeni replicate had the lowest number of species per plot (16.8) (Table 13-2 and Figure 6-8). The Shabeni replicate had the second highest number of species per plot (20.3), and the Fayi replicate had the second lowest number of species per plot (18.3) (Table 13-2 and Figure 6-8). In 1996, the Numbi replicate had the highest number of species per plot (31.8), and the Fayi replicate had the lowest number of species per plot (28.1) (Table 13-3 and Figure 6-9). The Shabeni replicate had the second highest number of species per plot (30.0), and the Kambeni replicate had the second lowest number of species per plot (28.7) (Table 13-3 and Figure 6-9). The number of species was not significantly different between the four Pretoriuskop EBP replicates in 1954 or 1996 (Table 6-4).

Between 1954 and 1996, the number of species per plot increased on all the replicates. The Numbi replicate had the highest number species per plot and the Shabeni replicate had the second highest number of species per plot in 1954 and 1996. The Kambeni replicate had the lowest number of species per plot in 1954 and had the second lowest number of species per plot in 1996. The Fayi replicate had the second lowest number of species per plot in 1954 and had the lowest in number of species in 1996.

Table 6-4: Results of the ANOVA and ANCOVA analyses on the vegetation indices calculated to test for homogeneity between the replicates in the Pretoriuskop region.

						Taxonomic diversity				Structural diversity			
Year	Statistic	Density	Mean height	Tree equivalents	Single:Multi stem	Number of species	Species richness	Species diversity	Species evenness	Number of structural groups	Structure richness	Structure diversity	Structure evenness
1954 (ANOVA)	df	3	3	3	3	3	3	3	3	3	3	3	3
	df error	44	44	44	44	44	44	44	44	44	44	44	44
	F-ratio	0.858	0.929	1.088	3.369	1.275	1.233	3.277	4.049	1.381	1.188	2.22	0.424
	p value	0.470	0.435	0.364	0.027	0.295	0.309	0.030	0.013	0.261	0.325	0.099	0.737
1996 (ANOVA)	df	3	3	3	3	3	3	3	3	3	3	3	3
	df error	44	44	44	44	44	44	44	44	44	44	44	44
	F-ratio	0.868	2.282	3.832	0.836	0.822	4.047	6.674	8.345	4.021	0.609	1.222	0.844
	p value	0.465	0.092	0.016	0.481	0.489	0.013	0.001	< 0.001	0.013	0.613	0.313	0.477
1996:1954 (ANCOVA)	df	3	3	3	3	3	3	3	3	3	3	3	3
	df error	43	43	43	43	43	43	43	43	43	43	43	43
	F-ratio	1.02	2.252	3.663	0.752	0.484	3.093	3.627	4.663	2.726	0.606	1.042	0.793
	p value	0.393	0.096	0.019	0.528	0.695	0.037	0.020	0.007	0.056	0.614	0.384	0.504

Note: The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.2.6 Differences in species richness between replicates

The species richness per plot between replicates was not significantly different in 1954 (Table 6-4). In 1954, the species richness per plot was highest on the Numbi replicate (0.474) and lowest in the Fayi replicate (0.395) (Table 13-2 and Figure 6-8). The species richness per plot was second highest on the Shabeni

replicate (0.451) and second lowest on the Kambeni replicate in 1954 (0.403) (Table 13-2 and Figure 6-8). In 1996, the species richness per plot was highest on the Shabeni replicate (0.444) and lowest on the Fayi replicate (0.346) (Table 13-3 and Figure 6-9). The species richness per plot was second highest on the Numbi replicate (0.425) and second lowest on the Kambeni replicate in 1996 (0.369) (Table 13-3 and Figure 6-9). The species richness per plot was significantly different between the Pretoriuskop EBP replicates in 1996 (ANOVA: $p = 0.013$, ANCOVA: $p = 0.037$) (Table 6-4). Tukey Studentized *post hoc* analyses showed that the species richness was significantly lower on the on the Fayi replicate than on the Shabeni (ANOVA: $p = 0.021$, ANCOVA: $p = 0.040$) and Numbi (ANOVA: $p = 0.087$) replicates in 1996 (Table 14-2 and Table 14-3).

Species richness decreased on all the Pretoriuskop EBP replicates between 1954 and 1996. As explained above (p. 66), this decrease in species richness may be an artefact of the calculation of species richness, which is the number of species observed relative to the sample size. The Numbi replicate had the highest species richness in 1954 and the Shabeni replicate had the highest species richness in 1996. The Fayi replicate had the lowest species in 1954 and in 1996.

6.2.2.2.7 Differences in species diversity between replicates

Species diversity increased on all the Pretoriuskop EBP replicates between 1954 and 1996. The rank of each replicate from lowest species diversity to highest species diversity remained the same between 1954 and 1996. In 1954 and 1996, the Numbi replicate had the highest species diversity per plot with a diversity value of 2.287 in 1954 and 2.380 in 1996 (Table 13-2, Table 13-3, Figure 6-8 and Figure 6-9). The Kambeni replicate had the lowest species diversity per plot in 1954 and 1996 with a diversity value of 1.835 in 1954 and 1.946 in 1996. The Shabeni replicate had the second highest species diversity per plot in 1954 and 1996 with a diversity value of 2.118 in 1954 and 2.256 in 1996. In 1954 and 1996, the Fayi replicate had the second lowest species diversity per plot with a diversity value of 1.927 in 1954 and 1.957 in 1996. In 1954, species diversity on the Pretoriuskop EBP replicates was significantly different ($p = 0.030$) (Table 6-4). Tukey Studentized *post hoc* analyses showed that the species diversity was significantly higher on the Numbi replicate than on the Kambeni ($p = 0.031$) replicate in 1954 (Table 14-1). The species diversity was also significantly different between the Pretoriuskop EBP replicates in 1996 (ANOVA: $p < 0.001$, ANCOVA: $p = 0.020$) (Table 6-4). *Post hoc* analyses showed that the species diversity was significantly higher on the Numbi replicate than on the Fayi (ANOVA: $p = 0.005$, ANCOVA: $p = 0.040$) and Kambeni (ANOVA: $p = 0.004$, ANCOVA: $p = 0.062$) replicates in 1996 (Table 14-2 and Table 14-3). In 1996, the Shabeni replicate also had a significantly higher species diversity than the Fayi (ANOVA: $p = 0.036$) and Kambeni (ANOVA: $p = 0.014$) replicates (Table 14-2 and Table 14-3).

6.2.2.2.8 Differences in species evenness between replicates

Species evenness decreased on all the Pretoriuskop EBP replicates between 1954 and 1996. The rank of each replicate from lowest species evenness to highest species evenness was the same in 1954 and 1996. The Numbi replicate had the highest species evenness per plot in 1954 and 1996 with an evenness value of 0.769 in 1954 and 0.693 in 1996 (Table 13-2, Table 13-3, Figure 6-8, and Figure 6-9). The Kambeni replicate had the lowest species evenness per plot in 1954 and 1996 with an evenness value of 0.653 in 1954 and 0.581 in 1996. The Shabeni replicate had the second highest species evenness per plot in 1954 and 1996 with an evenness value of 0.711 in 1954 and 0.667 in 1996. In 1954 and 1996, the Fayi replicate had the second lowest species evenness per plot with an evenness value of 0.665 in 1954 and 0.591 in 1996. In 1954, species evenness on the Pretoriuskop EBP replicates was significantly different ($p = 0.013$) (Table 6-4). Tukey Studentized *post hoc* analyses showed that the species evenness was significantly higher on the Numbi replicate than on the Fayi ($p = 0.035$) and Kambeni ($p = 0.016$) replicates in 1954 (Table 14-1). In 1996, species evenness in the Pretoriuskop EBP replicates was significantly different (ANOVA: $p < 0.001$, ANCOVA: $p = 0.007$) (Table 6-4). *Post hoc* analyses show that the species evenness was significantly higher on the Numbi replicate and than on the Fayi (ANOVA: $p = 0.003$, ANCOVA: $p = 0.039$) and Kambeni (ANOVA: $p = 0.001$, ANCOVA: $p = 0.023$) replicates in 1996 (Table 14-2 and Table 14-3). Species evenness was also significantly higher on the Shabeni replicate than on the Fayi (ANOVA: $p = 0.036$, ANCOVA: $p =$

0.079) and Kambeni (ANOVA: p = 0.014, ANCOVA: p = 0.044) replicates in 1996 (Table 14-2 and Table 14-3).

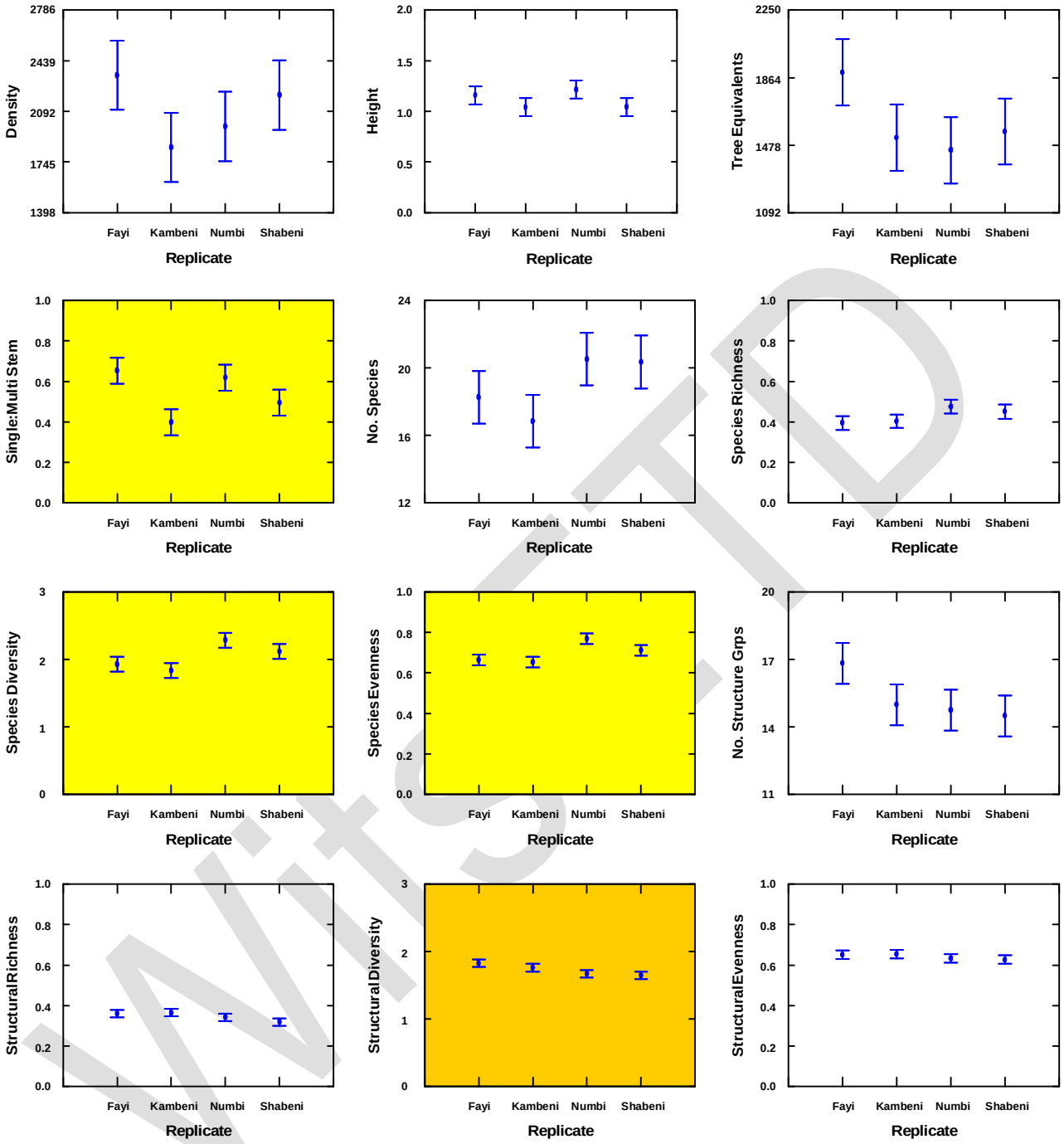


Figure 6-8: The least squares means and standard errors of the vegetation indices from the ANOVA analyses on the 1954 data testing for pre-treatment differences between the four replicates in the Pretoriuskop region. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.2.9 Differences in the number of structural groups between replicates

The number of structure groups per plot increased on all the Pretoriuskop EBP replicates between 1954 and 1996. The rank of each replicate from highest to lowest number of structure groups per plot was the same in 1954 and 1996. The Fayi replicate had the highest number of structure groups per plot with 16.833 in 1954 and 20.250 in 1996 (Table 13-2, Table 13-3, Figure 6-8, and Figure 6-9). The Shabeni replicate had the lowest number of structure groups per plot in 1954 and 1996 with 14.500 in 1954 and 16.417 in 1996. The

Kambeni and Numbi replicates had the second and third highest number of structure groups per plot. There was no significant difference in the number of structure groups between the replicates in 1954 (Table 6-4). However in 1996, there was a significant difference in the number of structure groups between the Pretoriuskop EBP replicates (ANOVA: p = 0.013, ANCOVA: p = 0.056) (Table 6-4). Tukey Studentized *post hoc* analyses showed that the Fayi replicate had a significantly higher number of structure groups than the Numbi (ANOVA: p = 0.064) and Shabeni (ANOVA: p = 0.011, ANCOVA: p = 0.048) replicates (Table 14-2 and Table 14-3).

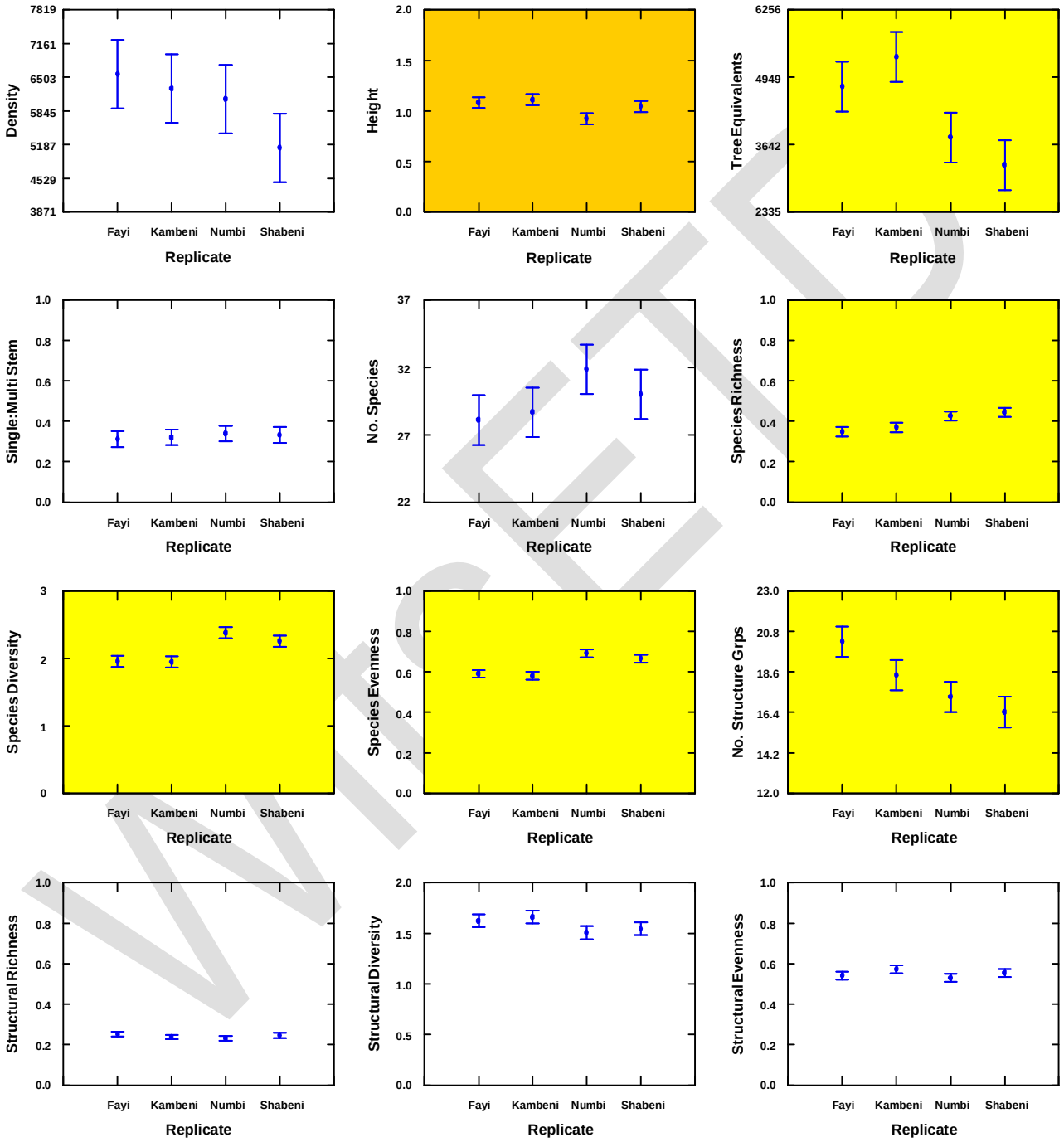


Figure 6-9: The least squares means and standard errors of the vegetation indices from the ANOVA analyses on the 1996 data testing for post treatment differences between the four replicates in the Pretoriuskop region. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.2.10 Differences in structural richness between replicates

The structural richness was very similar between the Pretoriuskop EBP replicates in 1954 and in 1996 and there was no statistical significant difference between replicates in 1954 and 1996 (Table 6-4). The Kambeni replicate had the highest structural richness in 1954 (0.364), and the Shabeni replicate had the lowest structural richness (0.319) (Table 13-2 and Figure 6-8). The Fayi replicate had the highest structural richness in 1996 (0.251), and the Numbi replicate had the lowest structural richness (0.231) (Table 13-3 and Figure 6-9). The structural richness decreased on all the Pretoriuskop EBP replicates between 1954 and 1996.

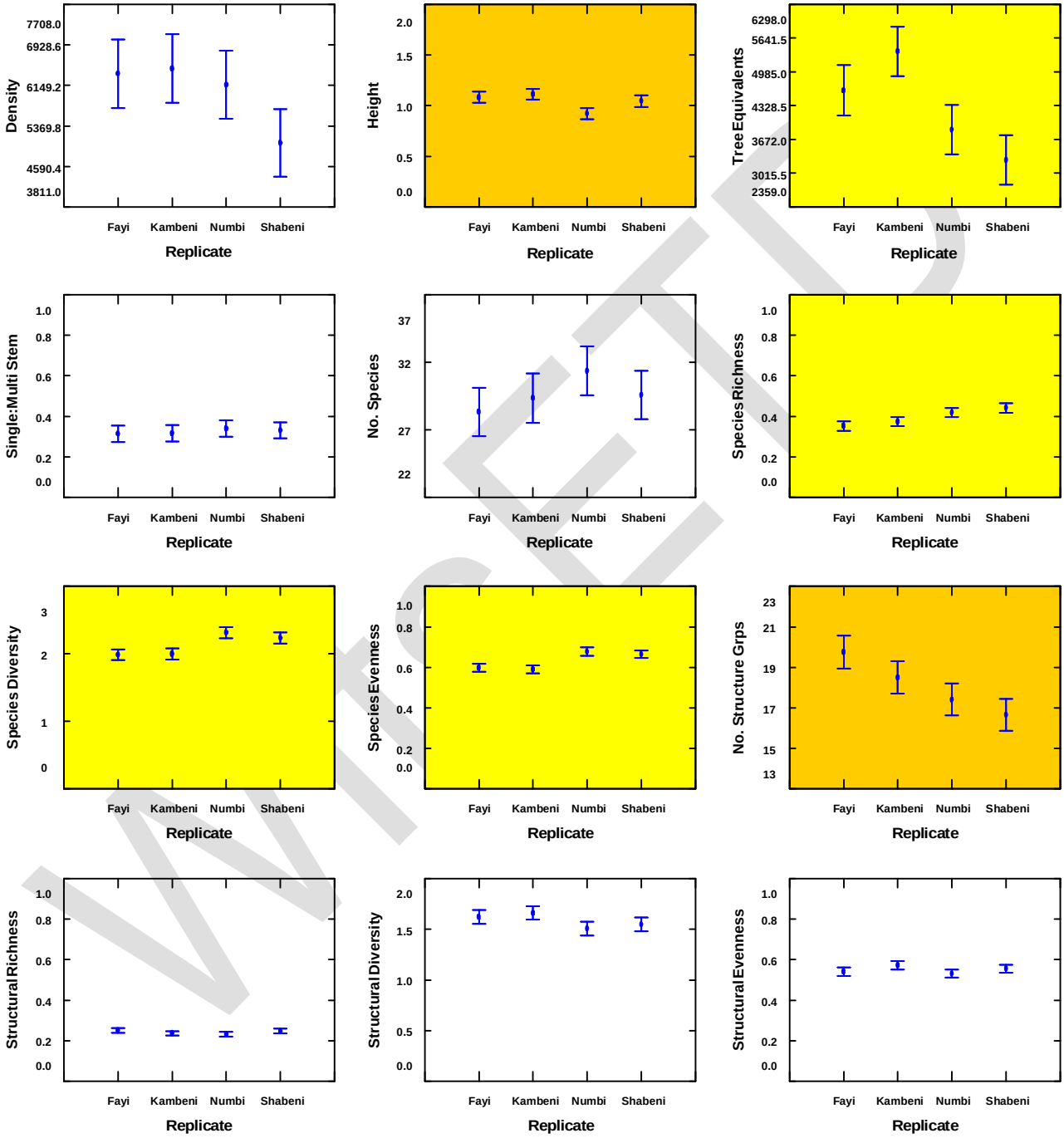


Figure 6-10: The least squares means and standard errors of the vegetation indices from the ANCOVA analyses on the 1996 data (with the 1954 data as covariates) testing for post treatment differences between the four replicates in the Pretoriuskop region taking into account the state of the plots before the treatments began. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.2.11 Differences in structural diversity between replicates

In 1954, there was a significant difference in structural diversity between the Pretoriuskop EBP replicates (p = 0.099) (Table 6-4). Tukey Studentized *post hoc* analyses show no significant differences in 1954 (Table 14-1). The Fayi replicate had the highest structural diversity in 1954 (1.826), and the Shabeni replicate had the lowest structural diversity (1.647) (Table 13-2 and Figure 6-8). There was no significant difference between the replicates in 1996 (Table 6-4). The Kambeni replicate had the highest structural diversity in 1996 (1.660), and the Numbi replicate had the lowest structural diversity (1.504) (Table 13-3 and Figure 6-9). The structural diversity decreased on all the Pretoriuskop EBP replicates between 1954 and 1996.

6.2.2.2.12 Differences in structural evenness between replicates

The structural evenness was very similar between the Pretoriuskop EBP replicates in 1954 and in 1996 and there was no statistical significant between the replicates in 1954 and 1996 (Table 6-4). In 1954, the Kambeni replicate had the highest structural evenness (0.654), and the Shabeni replicate had the lowest structural evenness (0.626) (Table 13-2 and Figure 6-8). The structural evenness was very similar between the replicates in 1954. In 1996, the Kambeni replicate had the highest structural evenness (0.573), and the Numbi replicate had the lowest structural evenness (0.530) (Table 13-3 and Figure 6-9). The Kambeni replicate had the highest structural evenness in 1954 and in 1996. The structural evenness decreased on all the Pretoriuskop EBP replicates between 1954 and 1996.

6.2.2.3 Testing for differences in the woody vegetation density, structure and composition between Pretoriuskop EBPs burnt at different frequencies (Annual, Biennial, Triennial and no burn)

The results of the Analysis of Variance and Analysis of Covariance testing for differences in woody vegetation between the frequencies of the fire treatments (annual, biennial, triennial, and no burn) on the Pretoriuskop EBPs using the No-August-Annual data grouping are presented in Table 6-5 (p. 76), Figure 6-11, Figure 6-12, and Figure 6-13. The results of the ANOVA and ANCOVA analyses using the August-Control data grouping are presented in Table 6-6 (p. 77), Figure 6-14, Figure 6-15, and Figure 6-16. The results of the Tukey *post hoc* analyses using the No-August-Annual grouping are presented in Appendix 6 Table 14-4 (p. 239), Table 14-5 (p. 240), and Table 14-6 (p. 241). The results of the Tukey *post hoc* analyses using the August-Control grouping are presented in Table 14-7 (p. 242), Table 14-8 (p. 243), and Table 14-9 (p. 244) in Appendix 6. Summaries of the 1954 and 1996 data used in the No-August-Annual analyses are presented in Appendix 5 in Table 13-4 (p. 226) and Table 13-5 (p. 226) respectively. Summaries of the 1954 and 1996 data used in the August-Control analyses are presented in Appendix 5 in Table 13-6 (p. 227) and Table 13-7 (p. 228) respectively.

For each vegetation index, the results of the No-August-Annual and August-Control ANOVA and ANCOVA analyses on the vegetation indices are presented separately. The general patterns and relationships between the vegetation index and fire frequency from these analyses are presented in a separate summary. Many of the results and patterns from the No-August-Annual and August-Control ANOVA and ANCOVA analyses are similar.

6.2.2.3.1 Differences in woody plant density between plots burnt at different frequencies

6.2.2.3.1.1 ANOVA and ANCOVA analyses on the woody plant density using the No-August-Annual data grouping

In 1954, the woody plant density was not significant difference between the treatments burnt at different frequencies (Table 6-5). The woody plant density (plants/Ha) was highest on the biennial treatments (2209.9) and lowest in the control treatments (1721.5) in 1954 (Table 13-4). In 1996, the woody plant density was highest on the control treatments (8696.0) and lowest on the triennial treatments (5376.0) (Table 13-5). In 1996, the woody plant density was significantly different between the fire frequency treatments (ANOVA p = 0.035, ANCOVA p = 0.018) (Table 6-5). Tukey Studentized *post hoc* analyses show that density was significantly higher on the control treatments than on the biennial (ANCOVA: p = 0.044) and triennial

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(ANOVA: p = 0.028, ANCOVA: p = 0.013) treatments (Table 14-5 and Table 14-6). Woody plant density increased on all the Pretoriuskop EBP frequency treatments between 1954 and 1996.

6.2.2.3.1.2 ANOVA and ANCOVA analyses on the woody plant density using the August-Control data grouping

There was no significant difference in the woody plant density between the treatments burnt at different frequencies in 1954 and 1996 (Table 6-6). In 1954, the woody plant density was highest on the biennial treatments (2433.5) and lowest on the control treatments (1721.5) (Table 13-6). In 1996, woody plant density was highest on the control treatments (8696.0) and lowest on the triennial treatments (5217.3) (Table 13-7). Woody plant density increased on all the Pretoriuskop EBP frequency treatments between 1954 and 1996.

Table 6-5: Results of the ANOVA and ANCOVA analyses on the vegetation indices calculated to test the frequency effects of the fire treatments. The August annual treatments were not included in these analyses (No-August-Annual data grouping).

						Taxonomic diversity				Structural diversity			
Year	Statistic	Density	Mean height	Tree equivalents	Single:Multi stem	Number of species	Species Richness	Species diversity	Species evenness	Number of structural groups	Structure richness	Structure diversity	Structure evenness
1954 (ANOVA)	df	2	2	2	2	2	2	2	2	2	2	2	2
	df error	41	41	41	41	41	41	41	41	41	41	41	41
	F-ratio	0.653	0.497	0.325	26.126	2.338	3.829	0.444	0.138	2.010	3.246	1.201	0.933
	p value	0.526	0.612	0.725	< 0.001	0.109	0.030	0.644	0.872	0.147	0.049	0.311	0.402
1996 (ANOVA)	df	2	2	2	2	2	2	2	2	2	2	2	2
	df error	41	41	41	41	41	41	41	41	41	41	41	41
	F-ratio	3.631	1.809	5.162	8.907	3.400	0.593	2.264	0.993	1.737	0.434	10.667	6.779
	p value	0.035	0.177	0.010	0.001	0.043	0.558	0.117	0.379	0.189	0.651	< 0.001	0.003
1996:1954 (ANCOVA)	df	2	2	2	2	2	2	2	2	2	2	2	2
	df error	40	40	40	40	40	40	40	40	40	40	40	40
	F-ratio	4.430	1.788	6.487	8.688	4.589	0.221	2.965	0.838	1.500	0.569	9.149	6.293
	p value	0.018	0.180	0.004	0.001	0.016	0.802	0.063	0.440	0.235	0.570	0.001	0.004

Note: The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.3.1.3 Summary of the general relationship between woody plant density and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

Generally, the least squared means and standard errors of the woody plant density on the treatments burnt at different frequencies, relative to one another, were similar in the No-August-Annual and August-Control ANOVA and ANCOVA analyses on the Pretoriuskop EBPs in 1954 and 1996 (Figure 6-11 to Figure 6-16). In 1954, the biennial treatments had the highest density and the control treatments had the lowest density, the annual treatments had the second highest density and the triennial treatments had the second lowest density. In 1996, the control treatments had the highest density, and the triennial treatment had the lowest density, the annual treatment had the second highest density and the biennial treatment had the second lowest. Over time, the woody plant density increased on all the fire frequency treatments. Generally, as the inter-fire period increases from 1 year to 3 years, there is a decrease in woody plant density, and then as the inter-fire period increases beyond 3 years to 42 years there is an increase in the woody plant density.

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6.2.2.3.2 Differences in woody plant height between plots burnt at different frequencies

6.2.2.3.2.1 ANOVA and ANCOVA analyses on the mean woody plant height using the No-August-Annual data grouping

In 1954 and 1996, the mean woody plant height was not significantly different between the treatments burnt at different frequencies (Table 6-5). In 1954, the control treatments had the tallest mean plant height (1.116m), and the triennial treatments had the shortest mean plant height (1.038m) (Table 13-4). In 1996, the control treatments had the tallest mean plant height (1.202m) and the biennial treatments had the shortest mean plant height (1.013m) (Table 13-5). Between 1954 and 1996, the mean plant height increased on the control and triennial treatments and decreased on the biennial treatments.

Table 6-6: Results of the ANOVA and ANCOVA analyses on the vegetation indices calculated to test the frequency effects of the fire treatments. Only the Control treatments and August annual, biennial, and triennial treatments were used in these analyses (August-Control data grouping).

						Taxonomic diversity				Structural diversity			
Year	Statistic	Density	Mean height	Tree equivalents	Single:Multi stem	Number of species	Species Richness	Species diversity	Species evenness	Number of structural groups	Structure richness	Structure diversity	Structure evenness
1954 (ANOVA)	df	3	3	3	3	3	3	3	3	3	3	3	3
	df error	12	12	12	12	12	12	12	12	12	12	12	12
	F-ratio	0.821	0.987	0.867	4.155	0.093	0.840	0.300	0.689	4.731	9.300	1.011	0.252
	p value	0.507	0.432	0.485	0.031	0.963	0.498	0.825	0.576	0.021	0.002	0.422	0.858
1996 (ANOVA)	df	3	3	3	3	3	3	3	3	3	3	3	3
	df error	12	12	12	12	12	12	12	12	12	12	12	12
	F-ratio	1.730	3.833	2.725	15.161	4.197	0.472	3.104	1.161	2.333	0.200	11.585	9.868
	p value	0.214	0.039	0.091	< 0.001	0.030	0.708	0.067	0.365	0.126	0.894	0.001	0.001
1996:1954 (ANCOVA)	df	3	3	3	3	3	3	3	3	3	3	3	3
	df error	11	11	11	11	11	11	11	11	11	11	11	11
	F-ratio	1.932	3.650	3.253	13.635	4.036	0.659	2.831	0.867	3.147	1.349	12.095	8.948
	p value	0.183	0.048	0.064	0.001	0.037	0.594	0.088	0.487	0.069	0.309	0.001	0.003

Note: The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.3.2.2 ANOVA and ANCOVA analyses on the mean woody plant height using the August-Control data grouping

In 1954, the mean woody plant height was not significantly different between the treatments burnt at different frequencies (Table 6-6). The control treatments had the tallest mean plant height (1.116m), and the triennial treatments had the shortest mean plant height (0.882m) (Table 13-6). In 1996, the control treatments had the tallest mean plant height (1.202m), and the annual treatments had the shortest mean plant height (0.859m) (Table 13-7). The mean plant heights were significantly different between the frequency treatments in 1996 (ANOVA: p = 0.039, ANCOVA: p = 0.048) (Table 6-6). Tukey Studentized *post hoc* analyses show that the mean woody plant height was significantly shorter on the annual treatments than on the control treatments in 1996 (ANOVA: p = 0.035, ANCOVA: p = 0.048) (Table 14-8 and Table 14-9). Between 1954 and 1996, the mean plant height increased on the control, biennial, and triennial treatments and decreased on the annual treatments.

6.2.2.3.2.3 Summary of the general relationship between woody plant height and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

Generally, the least squared means and standard errors of the mean woody plant height on the treatments burnt at different frequencies, relative to one another, were similar in the No-August-Annual and August-Control ANOVA and ANCOVA analyses on the Pretoriuskop EBPs in 1954 and 1996 (Figure 6-11 to Figure 6-16). In 1954, the woody vegetation on the control treatments was the tallest and on the triennial treatments was the shortest, the woody vegetation on the annual treatments was the second tallest and on the biennial treatments was the second shortest. In 1996, the woody vegetation on the control treatments was the tallest and on the annual treatments was the shortest. In the No-August-Annual grouping in 1996, the woody vegetation was second tallest on the triennial treatments and second shortest on the biennial treatments. In the August-Control grouping in 1996, the woody vegetation was second tallest on the biennial treatments and second shortest on the triennial treatments. Generally, as inter-fire period increases from 1 year to beyond 3 years and up to 42 years the mean height of the woody vegetation increases.

6.2.2.3.3 Differences in the number of tree equivalents between plots burnt at different frequencies

6.2.2.3.3.1 ANOVA and ANCOVA analyses on the number of tree equivalents using the No-August-Annual data grouping

In 1954, the mean number of tree equivalents was not significantly different between the treatments burnt at different frequencies (Table 6-5). In 1954, the mean number of tree equivalents (tree equivalents/Ha) was highest on the biennial treatments (1603.5) and was lowest on the control treatments (1315.3) (Table 13-4). In 1996, the control treatments had the highest number of tree equivalents (6963.3), and the biennial treatments had the lowest number of tree equivalents (4109.4) (Table 13-5).In 1996, the mean number of tree equivalents was significantly different between the treatments burnt at different frequencies (ANOVA: $p = 0.010$, ANCOVA: $p = 0.004$) (Table 6-5). Tukey Studentized *post hoc* analyses show that the control treatments had a significantly higher number of tree equivalents than the biennial (ANOVA: $p = 0.009$, ANCOVA: $p = 0.003$) and triennial (ANOVA: $p = 0.011$, ANCOVA: $p = 0.005$) treatments in 1996 (Table 14-5 and Table 14-6). Between 1954 and 1996, the mean number of tree equivalents increased on all the fire frequency treatments

6.2.2.3.3.2 ANOVA and ANCOVA analyses on the number of tree equivalents using the August-Control data grouping

In 1954, the mean number of tree equivalents was not significantly different between the treatments burnt at different frequencies (Table 6-6). In 1954, the mean number of tree equivalents was highest on the annual treatments (1854.8), and was lowest on the control treatments (1315.3) (Table 13-6). In 1996, the mean number of tree equivalents was highest on the control treatments (6963.250) and lowest on the annual treatments (3051.5) (Table 13-7). The mean number of tree equivalents was significantly different between the treatments burnt at different frequencies in 1996 (ANOVA: $p = 0.091$, ANCOVA: $p = 0.064$) (Table 6-6). Tukey Studentized *post hoc* analyses show that the mean number of tree equivalents in 1996 was significantly higher on the control treatments than on the annual treatments in 1996 (ANOVA: $p = 0.071$, ANCOVA: $p = 0.048$) (Table 14-8, and Table 14-9). Between 1954 and 1996, the mean number of tree equivalents increased on all of the fire frequency treatments.

6.2.2.3.3.3 Summary of the general relationship between the number of tree equivalents and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

In 1954 and 1996, the relationship between the mean number of tree equivalents and fire frequency on the Pretoriuskop EBPs was similar in the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). In 1954, the number of tree equivalents was highest in the annual treatments and lowest on the control treatments, the biennial treatments had the second highest number of tree equivalents and the triennial treatments had the second lowest. In 1996, the control treatments had the highest number of tree equivalents and the annual treatments had the lowest, the triennial treatments had the second highest

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number of tree equivalents and the biennial had the second lowest. Generally, as the period between fires increases from 1 year to beyond 3 years, the number of tree equivalents increases. Tree equivalents are an estimate of the phytomass (plant mass) of the woody vegetation, and as the period between fire events increases the woody plant phytomass increases.

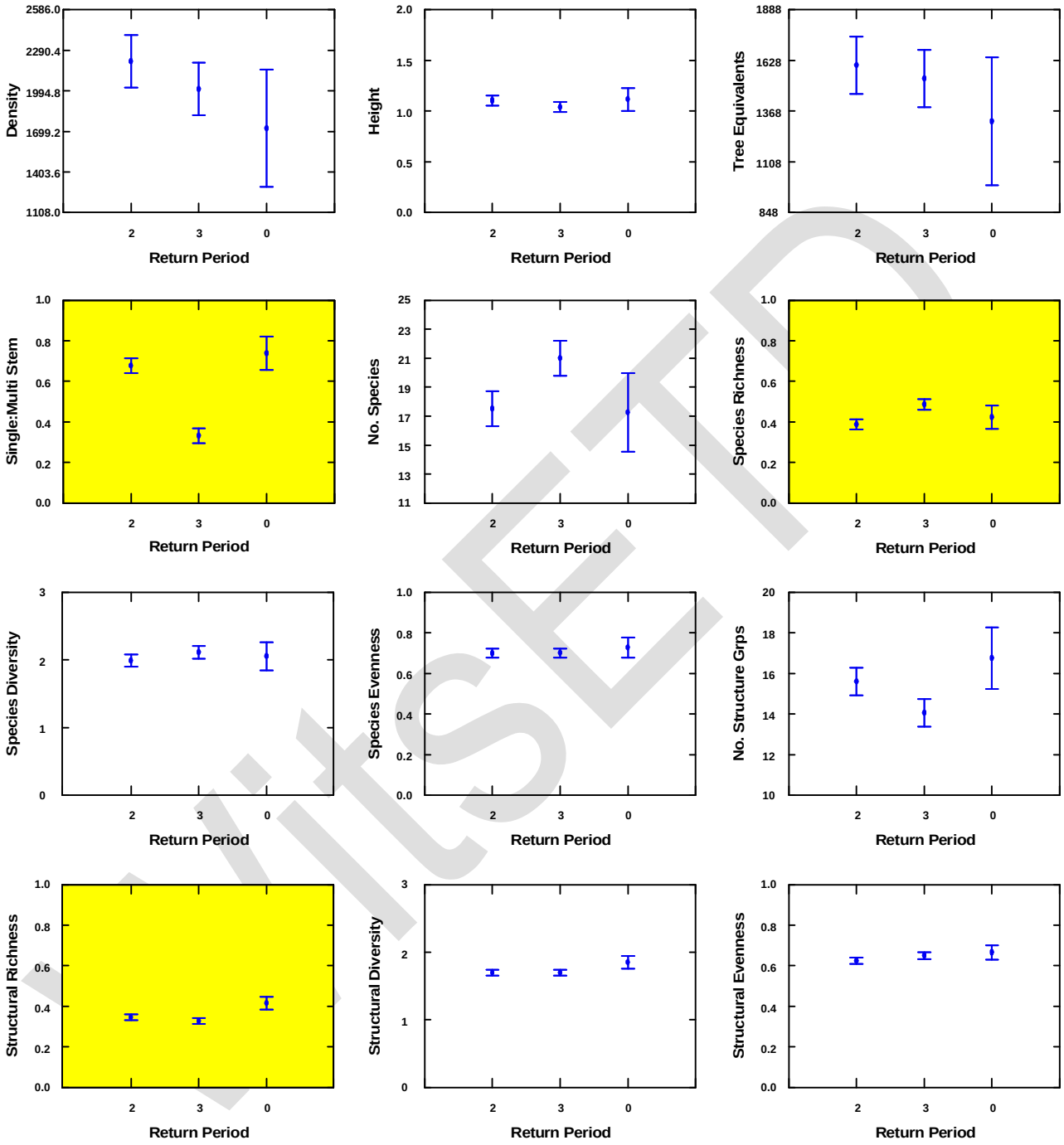


Figure 6-11: The least squares means and standard errors of the vegetation indices from the ANOVA analyses on the 1954 data testing for pre-treatment differences between the plots to be burnt at different frequencies using the No-August-Annual data grouping. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

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6.2.2.3.4 Differences in the single-stem to multi-stem index between plots burnt at different frequencies

6.2.2.3.4.1 ANOVA and ANCOVA analyses on the single-stem to multi-stem index using the No-August-Annual data grouping

In 1954, the single-stem to multi-stem index was highest on the control treatments (0.738) and lowest on the triennial treatments (0.332) (Table 13-4). The single-stem to multi-stem index was significantly different between the treatments burnt at different frequencies in 1954 ($p < 0.001$) (Table 6-5). Tukey Studentized *post hoc* analyses show that the single-stem to multi-stem index was significantly lower on the triennial treatments than on the on the biennial ($p < 0.001$) and control ($p < 0.001$) treatments in 1954 (Table 14-4). In 1996, the single-stem to multi-stem index was highest on the control treatments (0.539) and lowest on the biennial treatments (0.303) (Table 13-5). The single-stem to multi-stem index was significantly different between the treatments burnt at different frequencies in 1996 (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$) (Table 6-5). Tukey Studentized *post hoc* analyses show that the single-stem to multi-stem index on the control treatments was significantly higher than on the biennial (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$) and triennial (ANOVA: $p = 0.003$, ANCOVA: $p = 0.041$) treatments in 1996 (Table 14-5, and Table 14-6). Between 1954 and 1996, the single-stem to multi-stem index decreased on the control and biennial treatments and increased slightly on the triennial treatments.

6.2.2.3.4.2 ANOVA and ANCOVA analyses on the single-stem to multi-stem index using the August-Control data grouping

In 1954, the single-stem to multi-stem index was highest on the control treatments (0.738) and lowest on the triennial treatments (0.408) (Table 13-6). The single-stem to multi-stem index was significantly different between the treatments burnt at different frequencies in 1954 ($p = 0.031$) (Table 6-6). Tukey Studentized *post hoc* analyses show that the single-stem to multi-stem index on the triennial treatments was significantly lower than on the annual ($p = 0.061$) and control treatments ($p = 0.037$) in 1954 (Table 14-7). In 1996, the single-stem to multi-stem index was highest on the control treatments (0.539) and lowest on the annual treatments (0.126) (Table 13-7). The single-stem to multi-stem index was significantly different between the treatments burnt at different frequencies in 1996 (ANOVA: $p < 0.001$, ANCOVA: $p = 0.001$) (Table 6-6). Tukey Studentized *post hoc* analyses show that the single-stem to multi-stem index was significantly higher on the control treatments than on the annual (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$), biennial (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$), and triennial (ANOVA: $p = 0.005$, ANCOVA: $p = 0.073$) treatments in 1996 (Table 14-8, and Table 14-9). Between 1954 and 1996, the single-stem to multi-stem index decreased on all the frequency treatments. The most marked decreases were on the annual and biennial treatments (0.708 to 0.126 and 0.662 to 0.155 respectively).

6.2.2.3.4.3 Summary of the general relationship between the single-stem to multi-stem index and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

In 1954 and 1996, the relationship between the mean single-stem to multi-stem index and fire frequency on the Pretoriuskop EBPs was similar in both the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). In 1954, the single-stem to multi-stem index was highest on the control treatments and lowest on the triennial treatments, the annual treatments had the second highest single-stem to multi-stem index and the biennial treatments had the second lowest. In 1996, the single-stem to multi-stem index was highest on the control treatments and lowest on the annual treatments, the triennial treatments had the second highest single-stem to multi-stem index and the biennial treatments had the lowest. Over time, generally there was a decrease in the single-stem to multi-stem index on all the fire frequency treatments. Generally, as the inter-fire period increases from 1 year to beyond 3 years the single-stem to multi-stem index increases. Therefore as the period between fires increases the number of single-stem individuals relative to multi-stem individuals increases.

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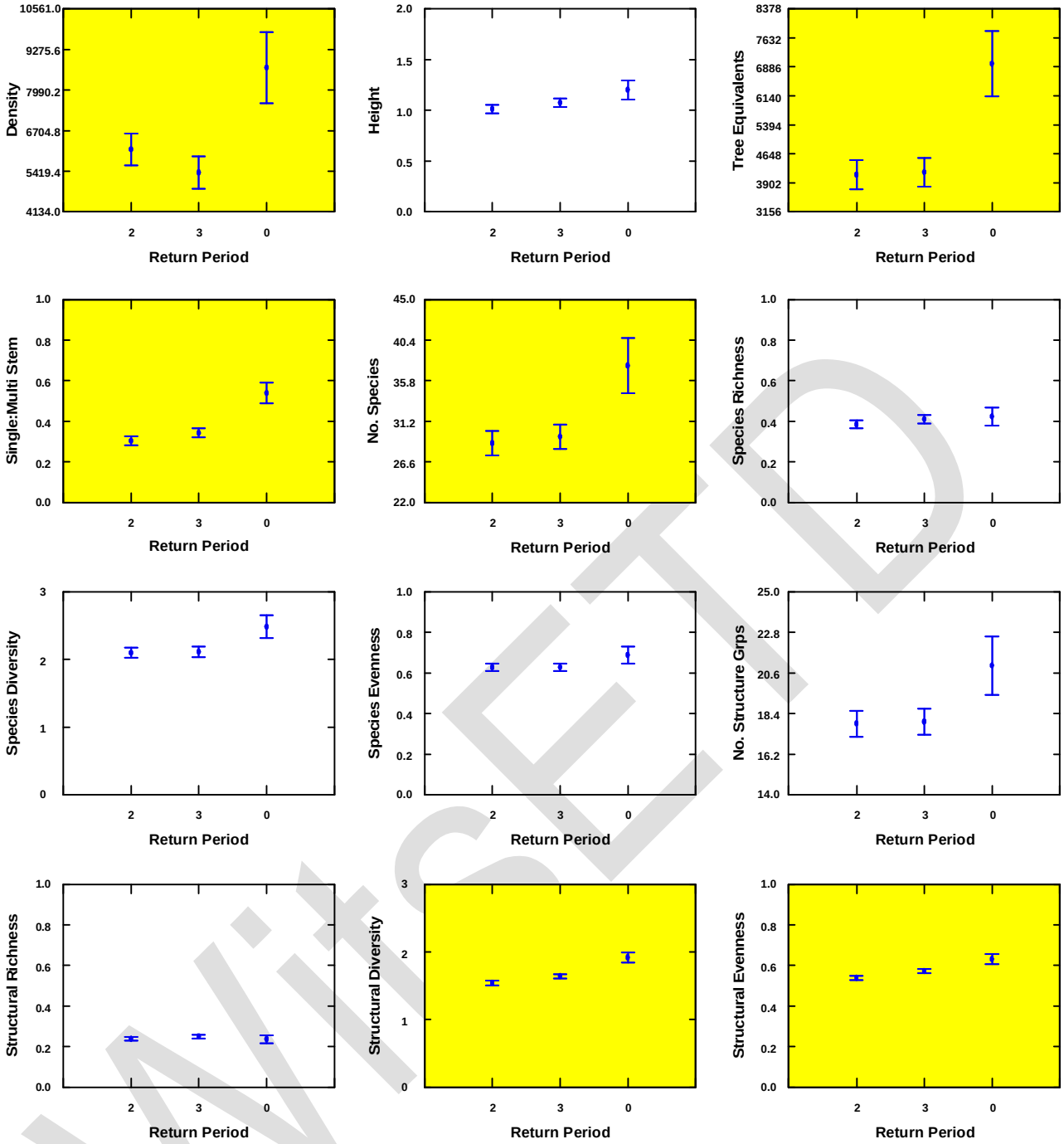


Figure 6-12: The least squares means and standard errors of the vegetation indices from the ANOVA analyses on the 1996 data testing for the treatment effects between plots burnt at different frequencies using the No-August-Annual data grouping. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.3.5 Differences in the number of species between plots burnt at different frequencies

6.2.2.3.5.1 ANOVA and ANCOVA analyses on the number of species using the No-August-Annual data grouping

In 1954, the number of species was not significantly different between the treatments burnt at different frequencies (Table 6-5). The mean number of species was highest on the triennial treatments (21.0) and the lowest on the control treatments in 1954 (17.3) (Table 13-4). In 1996, the mean number of species was highest on the control treatments (37.5) and lowest on the biennial treatments (28.7) (Table 13-5). The number of species was significantly different between the treatments burnt at different frequencies in 1996 (ANOVA: p = 0.043, ANCOVA: p = 0.016) (Table 6-5). Tukey Studentized *post hoc* analyses show that

number of species was significantly higher on the control treatments than on the biennial (ANOVA: p = 0.035, ANCOVA: p = 0.022) and triennial (ANOVA: p = 0.059, ANCOVA: 0.014) treatments in 1996 (Table 14-5, and Table 14-6). The number of species increased on all the fire frequency treatments between 1954 and 1996.

6.2.2.3.5.2 ANOVA and ANCOVA analyses on the number of species using the August-Control data grouping

In 1954, the number of species was not significantly different between the treatments burnt at different frequencies (Table 6-6). The mean number of species was highest on the annual treatments (18.0) and lowest on the biennial treatments (16.3) (Table 13-6). In 1996, the mean number of species was highest on the control treatments (37.5) and lowest on the biennial (26.3) and triennial treatments (26.3) (Table 13-7). The mean number of species was significantly different between the treatments burnt at different frequencies in 1996 (ANOVA: p = 0.030, ANCOVA: p = 0.037) (Table 6-6). Tukey Studentized *post hoc* analyses show that the number of species on the control treatments was significantly higher than the annual (ANOVA: p = 0.085, ANCOVA: p = 0.084), biennial (ANOVA: p = 0.048, ANCOVA: p = 0.060), and triennial (ANOVA: p = 0.048, ANCOVA: 0.060) treatments in 1996 (Table 14-8, and Table 14-9). The number of species increased on all the fire frequency treatments between 1954 and 1996.

6.2.2.3.5.3 Summary of the general relationship between the number of species and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

In 1954, the relationship between the number of species and fire frequency on the Pretoriuskop EBPs was not similar in both the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). In 1996 however, the relationship between the number of species and fire frequency was similar in both the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). In 1996, the number of species was highest on the control treatments and lowest on the biennial treatments, the triennial treatment had the second highest number of species and the annual treatment had the second lowest. Over time, the number of species increased on all the fire frequency treatments. Generally, as the inter-fire period increases from 1 year to 2 years the number of species decreases, then as the inter-fire period increases from 2 years to beyond 3 years, the number of species increases.

6.2.2.3.6 Differences in species richness between plots burnt at different frequencies

6.2.2.3.6.1 ANOVA and ANCOVA analyses on the species richness using the No-August-Annual data grouping

In 1954, the species richness was highest on the triennial treatments (0.486) and lowest on the biennial treatments (0.388) (Table 13-4). The species richness was significantly different between the treatments burnt at different frequencies in 1954(p = 0.030) (Table 6-5). Tukey Studentized *post hoc* analyses show that the species richness on the triennial treatments was significantly higher than on the biennial treatments (p = 0.023) (Table 14-4). In 1996, the species richness was not significantly different between the treatments burnt at different frequencies (Table 6-5). The species richness was highest on the control treatments (0.424) and lowest on the biennial treatments (0.384) in 1996 (Table 13-5). Between 1954 and 1996, species richness decreased on the triennial treatments and slightly on the biennial treatments, and increased slightly on the control treatments.

6.2.2.3.6.2 ANOVA and ANCOVA analyses on the species richness using the August-Control data grouping

In 1954, the species richness was not significantly different between the treatments burnt at different frequencies (Table 6-6). The species richness was highest on the control treatments (0.423) and lowest on the biennial treatments (0.329) (Table 13-6). In 1996, the number of species was not significantly different between the treatments burnt at different frequencies (Table 6-6). The species richness was highest on the control treatments (0.424) and lowest on the annual treatments (0.358) (Table 13-6). Between 1954 and

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1996, the species richness increased on the biennial and triennial treatments and slightly on the control treatments, and decreased on the annual treatments.

6.2.2.3.6.3 Summary of the general relationship between the species richness and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

In 1954 and 1996, the relationship between the species richness and fire frequency on the Pretoriuskop EBPs was not similar in the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). There is no clear trend in species richness on the fire frequency treatments. Generally, the species richness appears to increase as the inter-fire period increases, however this trend is tenuous.

6.2.2.3.7 Differences in species diversity between plots burnt at different frequencies

6.2.2.3.7.1 ANOVA and ANCOVA analyses on the species diversity using the No-August-Annual data grouping

The species diversity was not significantly different between the treatments burnt at different frequencies in 1954 (Table 6-5). The species diversity was highest on the triennial treatments (2.113) and lowest on the biennial treatments (1.988) in 1954 (Table 13-4). In 1996, the species diversity was highest on the control treatments (2.482) and lowest on the biennial treatments (2.098) (Table 13-5). The species diversity was significantly different between the treatments burnt at different frequencies in 1996 (ANCOVA: $p = 0.063$) (Table 6-5). Tukey Studentized *post hoc* analyses show that the species diversity is significantly higher on the control treatments than on the biennial (ANCOVA: $p = 0.087$) and triennial (ANCOVA: $p = 0.052$) treatments in 1996 (Table 14-5, and Table 14-6). Between 1954 and 1996, species diversity decreased slightly on the triennial treatments, and increased on the control and biennial treatments.

6.2.2.3.7.2 ANOVA and ANCOVA analyses on the species diversity using the August-Control data grouping

The species diversity was not significantly different between the treatments burnt at different frequencies in 1954 (Table 6-6). The species diversity was highest on the control treatments (2.054) and was lowest on the biennial treatments (1.740) in 1954 (Table 13-6). In 1996, the species diversity was highest on the control treatments (2.482) and lowest on the biennial treatments (1.892) (Table 13-7). The species diversity was significantly different between the treatments burnt at different frequencies in 1996 (ANOVA: $p = 0.067$, ANCOVA: $p = 0.088$) (Table 6-6). Tukey Studentized *post hoc* analyses show that the species diversity is significantly higher on the control treatments than the biennial (ANOVA: $p = 0.080$) and triennial (ANOVA: $p = 0.096$, ANCOVA: 0.091) treatments in 1996 (Table 14-8, and Table 14-9). Between 1954 and 1996, the species diversity increased slightly on the triennial treatments, and increased on the annual, biennial, and triennial treatments.

6.2.2.3.7.3 Summary of the general relationship between the species diversity and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

In 1954 and 1996, the relationship between the species diversity and fire frequency on the Pretoriuskop EBPs was not similar in the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). Over time, the species diversity has increased on all the fire frequency treatments with the exception of the triennial treatments, which have remained the same. Generally, as the inter-fire period increases from 1 year to 2 years the species diversity decreases, the species diversity then remains constant between inter-fire periods of 2 years and 3 years, and then the species diversity increases as the inter-fire period increases beyond 3 years.

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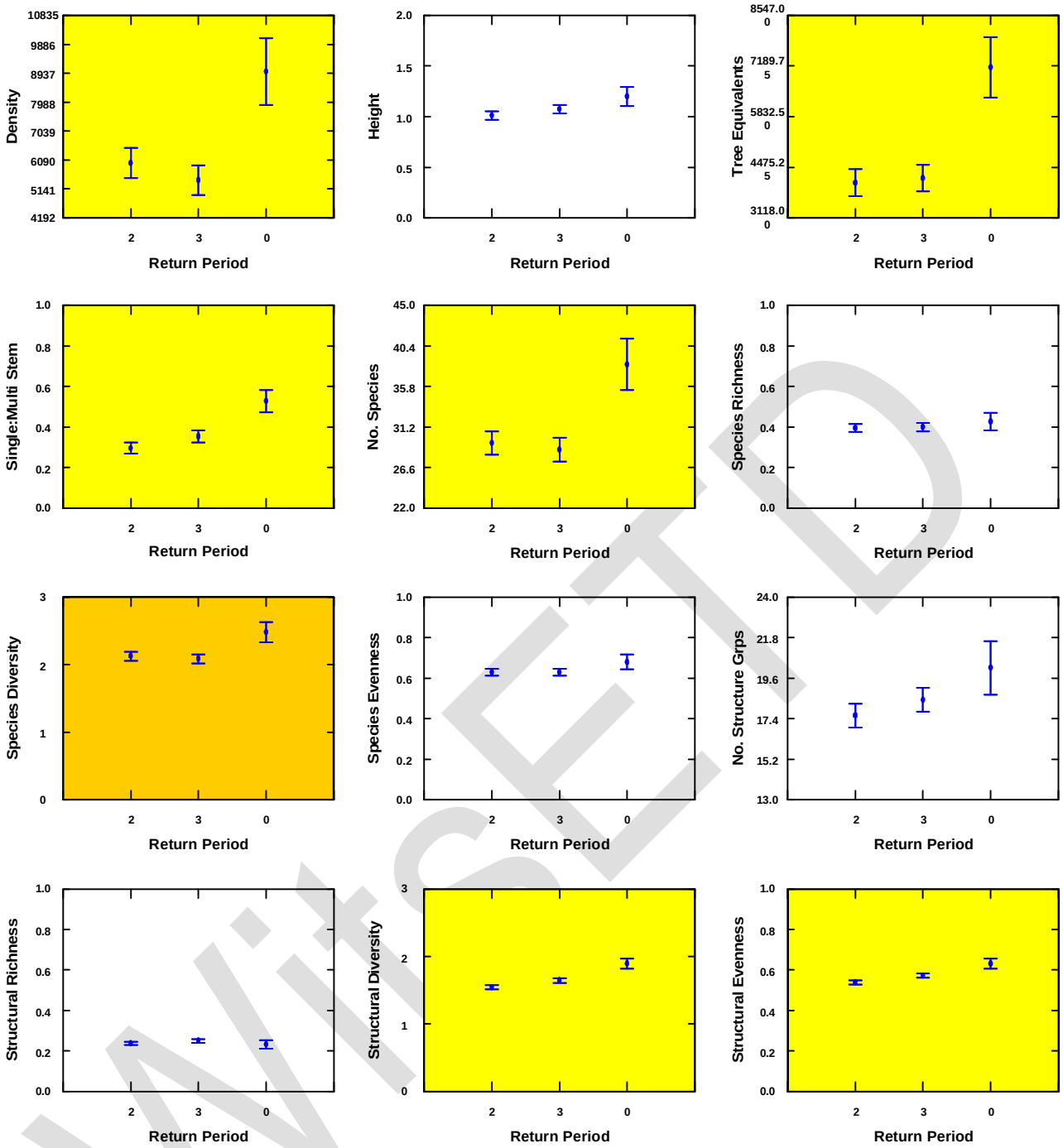


Figure 6-13: The least squares means and standard errors of the vegetation indices from the ANCOVA analyses on the 1996 data (with the 1954 data as covariates) testing for the treatment effects between plots burnt at different frequencies taking into account the state of the plots before the treatments began. The No-August-Annual data grouping was used in these analyses. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.3.8 Differences in species evenness between plots burnt at different frequencies

6.2.2.3.8.1 ANOVA and ANCOVA analyses on the species evenness using the No-August-Annual data grouping

The species evenness was not significantly different between the treatments burnt at different frequencies in 1954 (Table 6-5). The species evenness was highest on the control treatments (0.727) and lowest on the biennial treatments (0.698) in 1954 (Table 13-4). In 1996, the species evenness was highest on the control treatments (0.688) and lowest on the biennial treatments (0.627) (Table 13-5). The species evenness was

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not significantly different between the treatments burnt at different frequencies in 1996 (Table 6-5). Between 1954 and 1996, the species evenness decreased on all the treatments burnt at different frequencies.

6.2.2.3.8.2 ANOVA and ANCOVA analyses on the species evenness using the August-Control data grouping

The species evenness was not significantly different between the treatments burnt at different frequencies in 1954 (Table 6-6). The species evenness was highest on the control treatments (0.727) and was lowest on the biennial treatments (0.623) in 1954 (Table 13-6). In 1996, the species evenness was highest on the control treatments (0.688) and lowest on the biennial treatments (0.579) (Table 13-7). The species evenness was not significantly different between the treatments burnt at different frequencies in 1996 (Table 6-6). Between 1954 and 1996, the species evenness decreased on all the treatments burnt at different frequencies.

6.2.2.3.8.3 Summary of the general relationship between the species evenness and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

In 1954 and 1996, the relationship between the species evenness and fire frequency on the Pretoriuskop EBPs was similar in the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). In 1954, the species evenness was highest on the control treatments and lowest on the biennial treatments, the triennial treatments had the second highest species evenness, and the annual treatments had the lowest. In 1996, the species evenness was highest on the control treatments and lowest on the biennial treatments, the triennial treatments had the second highest species evenness and the annual treatments had the second lowest. Over time, the species evenness has decreased on all the fire frequency treatments. Generally, as the inter-fire period increases from 1 year to 2 years, the species evenness decreases, and then as the inter-fire period increases from 2 years to 3 years and up to 42 years the species evenness increases.

6.2.2.3.9 Differences in the number of structural groups between plots burnt at different frequencies

6.2.2.3.9.1 ANOVA and ANCOVA analyses on the number of structural groups using the No-August-Annual data grouping

The number of structural groups was not significantly different between the treatments burnt at different frequencies in 1954 (Table 6-5). The mean number of structural groups was highest on the control treatments (16.8) and lowest on the triennial treatments (14.1) in 1954 (Table 13-4). In 1996, the mean number of structural groups was highest on the control treatments (21.0) and lowest on the biennial treatments (17.850) (Table 13-5). The number of structural groups was not significantly different between the treatments burnt at different frequencies in 1996 (Table 6-5). Between 1954 and 1996, the number of structural groups increased on all the treatments burnt at different frequencies.

6.2.2.3.9.2 ANOVA and ANCOVA analyses on the number of structural groups using the August-Control data grouping

In 1954, the mean number of structural groups was highest on the annual treatments (18.3) and was lowest on the triennial treatments (11.5) (Table 13-6). The number of structural groups was significantly different between the treatments burnt at different frequencies in 1954 ($p = 0.021$) (Table 6-6). Tukey Studentized *post hoc* analyses show that the number of structural groups on the triennial treatments was significantly lower than on the control (0.073), annual (0.019), and biennial (0.091) treatments (Table 14-7). In 1996, the mean number of structural groups was highest on the control treatments (21.0) and lowest on the triennial treatments (16.500) (Table 13-7). The number of structural groups was significantly different between the treatments burnt at different frequencies in 1996 (ANCOVA: $p = 0.069$) (Table 6-6). Tukey Studentized *post hoc* analyses show that the number of structural groups was significantly higher on the control treatments than the annual treatments (ANCOVA: $p = 0.059$) (Table 14-9). Between 1954 and 1996, the number of structural groups increased on the control, biennial, and triennial treatments, and decreased on the annual treatments.

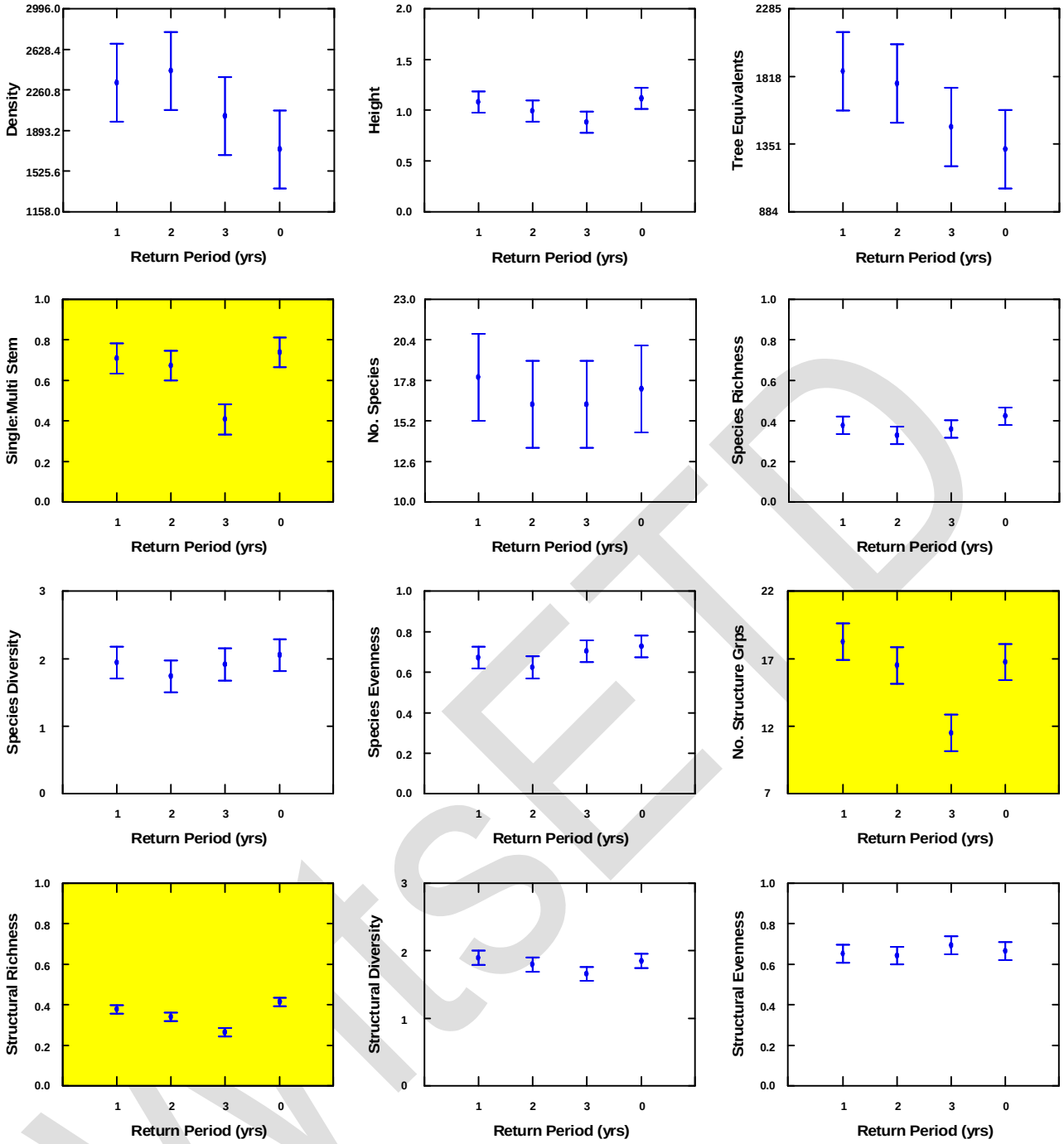


Figure 6-14: The least squares means and standard errors of the vegetation indices from the ANOVA analyses on the 1954 data testing for pre-treatment differences between the plots to be burnt at different frequencies using the August-Control data grouping. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.3.9.3 Summary of the general relationship between the number of structural groups and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

In 1954 and 1996, the relationship between the number of structural groups and fire frequency on the Pretoriuskop EBPs was similar in the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). In 1954, the number of structural groups was highest on the annual treatments and lowest on the triennia treatments, the control treatment had the second highest number of structural groups and the biennial treatments the lowest. In 1996, the control treatments had the highest number of structural groups and the triennial treatments had the lowest, the biennial treatment had the second highest number of

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structural groups and the annual had the second lowest. Generally, as the inter-fire period increases from 1 year to beyond 3 years the number of structural groups increases.

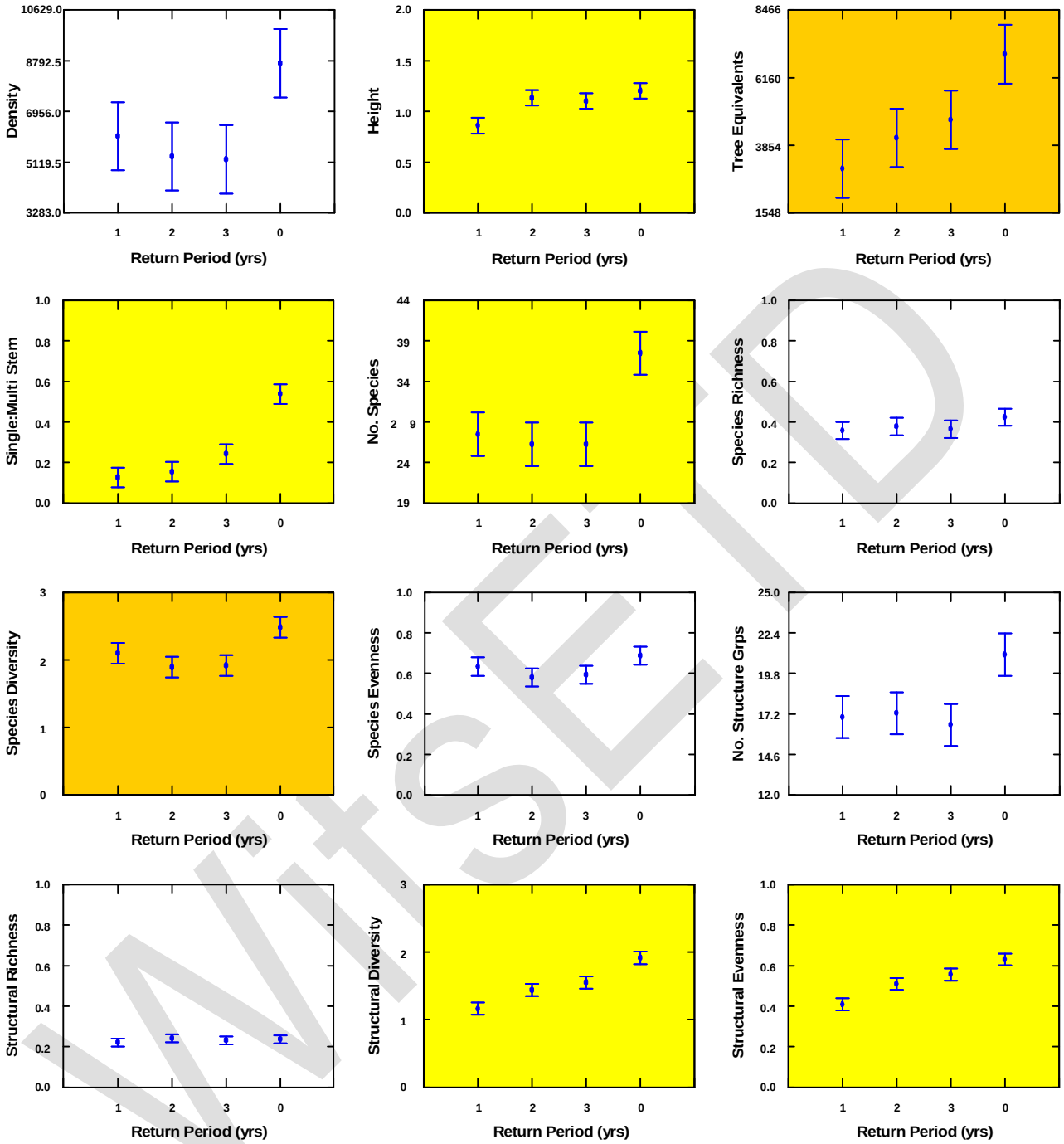


Figure 6-15: The least squares means and standard errors of the vegetation indices from the ANOVA analyses on the 1996 data testing for the treatment effects between plots burnt at different frequencies using the August-Control data grouping. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.3.10 Differences in structural richness between plots burnt at different frequencies

6.2.2.3.10.1 ANOVA and ANCOVA analyses on the structural richness using the No-August-Annual data grouping

In 1954, the mean structural richness was highest on the control treatments (0.451) and lowest on the triennial treatments (0.327) (Table 13-4). The structural richness was significantly different between the treatments burnt at different frequencies in 1954 (p = 0.049) (Table 6-5). Tukey Studentized *post hoc*

analyses show the structural richness on the control treatments was significantly higher than on the triennial treatments (p = 0.039) (Table 14-4). In 1996, the mean structural richness was highest on the triennial treatments (0.249) and lowest on the control treatments (0.237) (Table 13-5). The structural richness was not significantly different between the treatments burnt at different frequencies in 1996 (Table 6-5). Between 1954 and 1996, the structural richness decreased on all the treatments burnt at different frequencies.

6.2.2.3.10.2 ANOVA and ANCOVA analyses on the structural richness using the August-Control data grouping

In 1954, the mean structural richness was highest on the control treatments (0.415) and was lowest on the triennial treatments (0.265) (Table 13-6). The structural richness was significantly different between the treatments burnt at different frequencies in 1954 (p = 0.002) (Table 6-6). Tukey Studentized *post hoc* analyses show that the structural richness on the triennial treatments was significantly lower than on the control (0.001) and annual (0.012) treatments (Table 14-7). In 1996, the mean structural richness was highest on the biennial treatments (0.242) and lowest on the annual treatments (0.221) (Table 13-7). The structural richness was not significantly different between the treatments burnt at different frequencies in 1996 (Table 6-6). Between 1954 and 1996, the structural richness decreased on all the treatments burnt at different frequencies.

6.2.2.3.10.3 Summary of the general relationship between the structural richness and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

In 1954 and 1996, the relationship between the structural richness and fire frequency on the Pretoriuskop EBPs was not similar in the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). Over time, the structural richness has decreased on all the frequency treatments. There is no clear trend in structural richness on the fire frequency treatments. Generally, the structural richness appears to increase as the inter-fire period increases from 1 year to 3 years, and then as the inter-fire period increases beyond 3 years up to 42 years, the structural richness decreases. However, this trend is weak.

6.2.2.3.11 Differences in structural diversity between plots burnt at different frequencies

6.2.2.3.11.1 ANOVA and ANCOVA analyses on the structural diversity using the No-August-Annual data grouping

In 1954, the structural diversity was not significantly different between the treatments burnt at different frequencies (Table 6-5). The mean structural diversity was highest on the control treatments (1.850) and lowest on the biennial treatments (1.697) in 1954 (Table 13-4). In 1996, the mean structural diversity was highest on the control treatments (1.918) and lowest on the biennial treatments (1.540) (Table 13-5). The structural diversity was significantly different between the treatments burnt at different frequencies in 1996 (ANOVA: p < 0.001, ANCOVA: p = 0.001) (Table 6-5). Tukey Studentized *post hoc* analyses show that the structural diversity was significantly higher on the control treatments than on the biennial (ANOVA: p = 0.001, ANCOVA: p = 0.001) and triennial (ANOVA: p = 0.005, ANCOVA: p = 0.014) treatments in 1996 (Table 14-8, and Table 14-9). The *post hoc* analyses also show that the structural diversity was significantly higher on the triennial treatments than on the biennial treatments in 1996 (ANOVA: p = 0.098, ANCOVA: p = 0.094) (Table 14-8, and Table 14-9). Between 1954 and 1996, the structural diversity increased on the control treatments and decreased on the biennial and triennial treatments.

6.2.2.3.11.2 ANOVA and ANCOVA analyses on the structural diversity using the August-Control data grouping

In 1954, the mean structural diversity was highest on the annual treatments (1.897) and was lowest on the triennial treatments (1.658) (Table 13-6). The structural diversity was not significantly different between the treatments burnt at different frequencies in 1954 (Table 6-6). In 1996, the mean structural diversity was highest on the control treatments (1.918) and lowest on the annual treatments (1.162) (Table 13-7). The structural diversity was significantly different between the treatments burnt at different frequencies in 1996 (ANOVA: p = 0.001, ANCOVA: p = 0.001) (Table 6-6). Tukey Studentized *post hoc* analyses show that the

structural diversity on the control treatments was significantly higher than the annual (ANOVA: $p < 0.001$, ANCOVA: $p = 0.001$), biennial (ANOVA $p = 0.014$, ANCOVA: $p = 0.019$), and triennial (ANOVA: $p = 0.065$) treatments in 1996 (Table 14-8, and Table 14-9). The *post hoc* analyses also show that the structural diversity was significantly higher on the triennial treatments than on the annual treatments in 1996 (ANOVA: $p = 0.048$, ANCOVA: $p = 0.037$) (Table 14-8, and Table 14-9). Between 1954 and 1996, the structural diversity increased on the control treatment, and decreased on the annual, biennial, and triennial treatments.

6.2.2.3.11.3 Summary of the general relationship between the structural diversity and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

In 1954 and 1996, the relationship between the structural diversity and fire frequency on the Pretoriuskop EBPs was similar in the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). In 1954, the structural diversity was highest on the annual treatments and lowest on the triennial treatments, the control treatments had the second highest structural diversity and the biennial had the second lowest. In 1996, the structural diversity was highest on the control treatments and lowest on the annual treatments, the triennial treatments had the second highest structural diversity and the biennial treatments had the second lowest. Over time, the structural diversity increased on the control treatments and decreased on the annual, biennial, and triennial treatments. Generally, as the inter-fire period increases from 1 year to beyond 3 years the structural diversity increases.

6.2.2.3.12 Differences in structural evenness between plots burnt at different frequencies

6.2.2.3.12.1 ANOVA and ANCOVA analyses on the structural evenness using the No-August-Annual data grouping

In 1954, the structural evenness was not significantly different between the treatments burnt at different frequencies (Table 6-5). The mean structural evenness was highest on the control treatments (0.666) and lowest on the biennial treatments (0.624) in 1954 (Table 13-4). In 1996, the mean structural evenness was highest on the control treatments (0.631) and lowest on the biennial treatments (0.539) (Table 13-5). The structural evenness was significantly different between the treatments burnt at different frequencies in 1996 (ANOVA: $p = 0.003$, ANCOVA: $p = 0.004$) (Table 6-5). Tukey Studentized *post hoc* analyses show that the structural evenness was significantly higher on the control treatments than on the biennial (ANOVA: $p = 0.003$, ANCOVA: $p = 0.005$) and triennial (ANOVA: $p = 0.080$, ANCOVA: $p = 0.086$) treatments in 1996 (Table 14-8, and Table 14-9). The *post hoc* analyses also show that the structural evenness was significantly higher on the triennial treatments than on the biennial treatments in 1996 (ANOVA: $p = 0.088$) (Table 14-8, and Table 14-9). Between 1954 and 1996, the structural evenness decreased on all the treatments burnt at different frequencies.

6.2.2.3.12.2 ANOVA and ANCOVA analyses on the structural evenness using the August-Control data grouping

In 1954, the mean structural evenness was highest on the triennial treatments (0.694) and was lowest on the biennial treatments (0.643) (Table 13-6). The structural evenness was not significantly different between the treatments burnt at different frequencies in 1954 (Table 6-6). In 1996, the mean structural evenness was highest on the control treatments (0.631) and lowest on the annual treatments (0.409) (Table 13-7). The structural evenness was significantly different between the treatments burnt at different frequencies in 1996 (ANOVA: $p = 0.001$, ANCOVA: $p = 0.003$) (Table 6-6). Tukey Studentized *post hoc* analyses show that the structural evenness on the control treatments was significantly higher than the annual (ANOVA: $p = 0.001$, ANCOVA: $p = 0.002$) and biennial (ANOVA $p = 0{,}056$, ANCOVA: $p = 0.078$) treatments in 1996 (Table 14-8, and Table 14-9). The *post hoc* analyses also show that the structural evenness was significantly higher on the triennial treatments than on the annual treatments in 1996 (ANOVA: $p = 0.019$, ANCOVA: $p = 0.033$) (Table 14-8, and Table 14-9). Between 1954 and 1996, the structural evenness decreased on all the treatments burnt at different frequencies.

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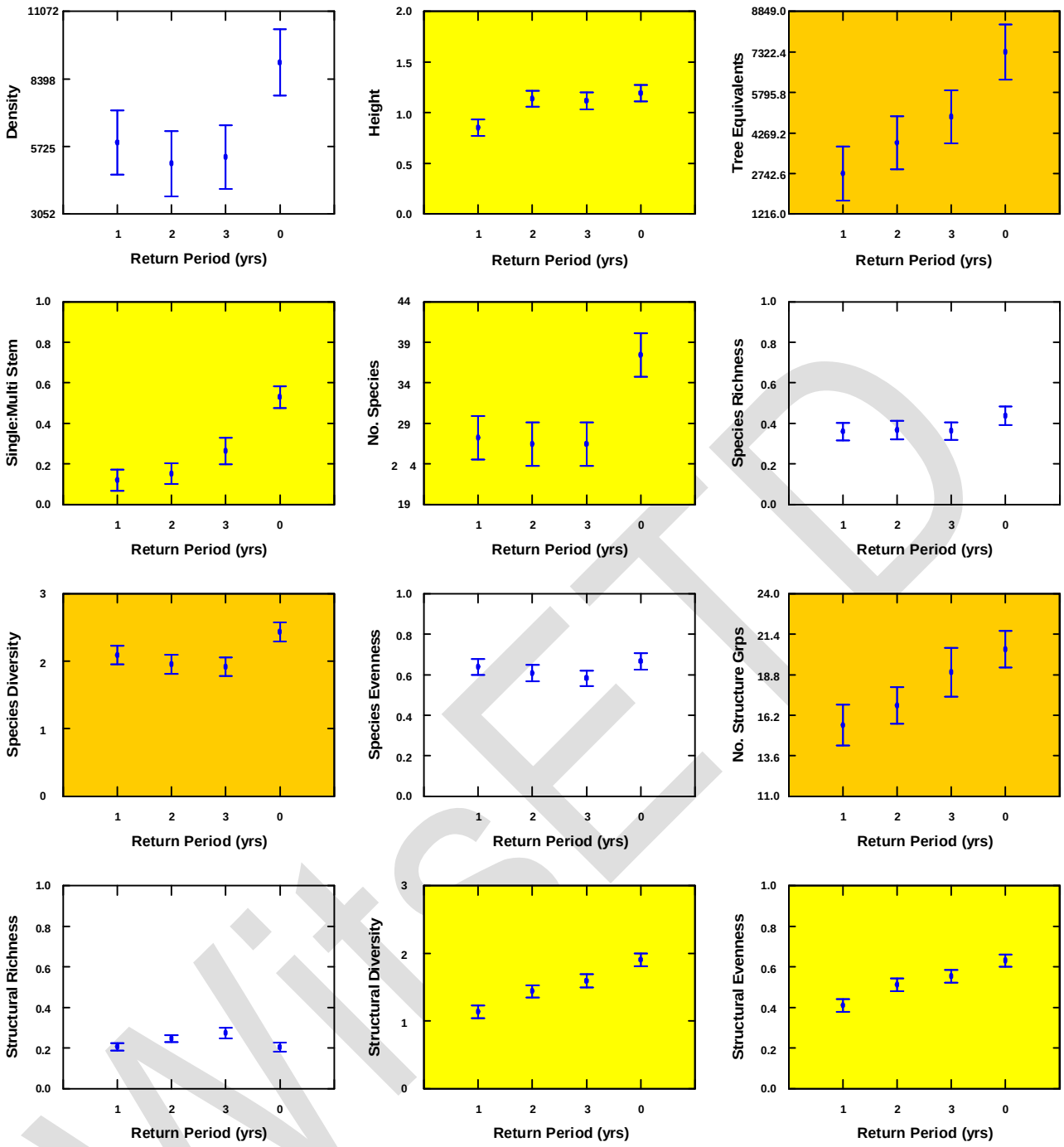


Figure 6-16: The least squares means and standard errors of the vegetation indices from the ANCOVA analyses on the 1996 data (with the 1954 data as covariates) testing for the treatment effects between plots burnt at different frequencies taking into account the state of the plots before the treatments began. The August-Control data grouping was used in these analyses. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.3.12.3 Summary of the general relationship between the structural evenness and fire frequency based on the No-August-Annual and August-Control ANOVA and ANCOVA analyses

In 1954, the relationship between the structural evenness and fire frequency on the Pretoriuskop EBPs was not similar in the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). In 1996, the relationship between the structural evenness and fire frequency on the Pretoriuskop EBPs was similar in the No-August-Annual and August-Control analyses (Figure 6-11 to Figure 6-16). In 1996, the structural evenness was highest on the control treatments and lowest on the annual treatments, the triennial treatments had the second highest structural evenness and the biennial treatments had the second lowest.

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Over time, the structural evenness decreased on the treatments burnt at different frequencies. Generally, as inter-fire period increases from 1 year to beyond 3 years the structural evenness increases.

6.2.2.4 Testing for differences in the woody vegetation density, structure and composition between the Pretoriuskop EBPs burnt at different times of the year (February, April, August, October, and December)

The results of the Analysis of Variance and Analysis of Covariance testing for differences in woody vegetation between the fire timing treatments (February, April, August, October and December) on the Pretoriuskop EBPs are presented in Table 6-7 (p. 91) (Figure 6-17 (p. 93), Figure 6-18 (p. 95), and Figure 6-19 (p. 97)). Results of *post hoc* analyses performed where significant differences were found between the fire timing treatments are presented in Table 14-10 (p. 245), Table 14-11 (p. 246), and Table 14-12 (p. 248). Summaries of the 1954 and 1996 data used in these analyses are presented in Appendix 5 in Table 13-8 (p. 229) and Table 13-9 (p. 230) respectively.

Table 6-7: Results of the ANOVA and ANCOVA analyses on the vegetation indices calculated to test the timing effects of the fire treatments (the August annual treatments were not included in these analyses).

						Taxonomic diversity				Structural diversity			
Year	Statistic	Density	Mean height	Tree equivalents	Single:Multi stem	Number of species	Species Richness	Species diversity	Species evenness	Number of structural groups	Structure richness	Structure diversity	Structure evenness
1954 (ANOVA)	df	5	5	5	5	5	5	5	5	5	5	5	5
	df error	38	38	38	38	38	38	38	38	38	38	38	38
	F-ratio	0.705	1.038	0.615	0.900	0.926	2.133	1.484	1.189	0.731	3.274	1.507	0.970
	p value	0.624	0.410	0.689	0.491	0.475	0.082	0.218	0.333	0.604	0.015	0.210	0.448
1996 (ANOVA)	df	5	5	5	5	5	5	5	5	5	5	5	5
	df error	38	38	38	38	38	38	38	38	38	38	38	38
	F-ratio	1.648	2.767	2.031	2.941	11.798	0.840	2.426	1.711	1.863	0.170	4.329	3.989
	p value	0.171	0.032	0.096	0.024	0.001	0.530	0.053	0.156	0.124	0.972	0.003	0.005
1996:1954 (ANCOVA)	df	5	5	5	5	5	5	5	5	5	5	5	5
	df error	37	37	37	37	37	37	37	37	37	37	37	37
	F-ratio	1.845	2.974	2.500	3.906	11.436	1.163	3.705	1.814	2.170	0.214	3.973	3.898
	p value	0.128	0.024	0.048	0.006	0.001	0.346	0.008	0.134	0.079	0.954	0.006	0.006

Note: The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.4.1 Differences in woody plant density between plots burnt at different times of the year

In 1954 and 1996, the woody plant density was not significantly different between the treatments burnt at different times of the year (Table 6-7). The rank order of the fire timing treatments from highest to lowest density (plants/Ha) in 1954 was February (2473.8), August (2228.5), April (2057.5), December (1979.4), October (1803.9), and Control (1721.5) (Table 13-8). In 1996, the rank order of the fire timing treatments from highest to lowest density was Control (8696.0), February (6765.3), December (5716.8), April (5703.1), August (5267.0), and October (5248.9) (Table 13-9). Between 1954 and 1996, the woody plant density increased on all fire treatments.

The intensity of fires varies from cool to extremely hot at different times of the year. Treatments with more intense fires (August and October) have lower woody plant densities than treatments with less intense fires

(February and December). This may be because some individuals cannot survive the more intense fires in August and October while they are able to survive the less intense fires in February and December. Furthermore, the carbohydrate storage phenology of woody plants is also a determinant in their post-fire survival, because woody plants are less likely to recover from fire damage when their carbohydrate reserves are depleted. Carbohydrate reserves are highest at the end of summer in February and April and lowest at the end of winter and the onset of spring in August and October. Therefore, some individuals may not survive fires in August and October because their carbohydrate reserves are low, and they do not have the energy reserves to recover from being burnt.

6.2.2.4.2 Differences in woody plant height between plots burnt at different times of the year

In 1954, the woody plant height was not significantly different between the treatments to be burnt at different times of the year (Table 6-7). The rank order of the fire timing treatments from tallest to shortest height (m) in 1954 was February (1.184), Control (1.116), December (1.089), October (1.078), April (1.067), and August (0.938) (Table 13-8). In 1996, the rank order of the timing treatments from tallest to shortest height was Control (1.202), October (1.157), August (1.117), December (1.057), April (0.978), and February (0.907) (Table 13-9). The woody plant height was significantly different between the treatments burnt at different times of the year in 1996 (ANOVA: p = 0.032, ANCOVA: p = 0.024) (Table 6-7). Tukey Studentized post hoc analyses show that the woody plant height on the February treatments was significantly shorter than the Control (ANOVA: p = 0.087, ANCOVA: 0.073) and October (ANOVA: p = 0.068, ANCOVA: 0.051) treatments (Table 14-11, and Table 14-12). Between 1954 and 1996, woody plant height decreased on the February, April, and December treatments, and increased on the August, October, and Control treatments.

The August and October treatments have taller plant heights than the February and April treatments. The August and October treatments are also expected to have more intense fires than the February and April treatments.

6.2.2.4.3 Differences in the number of tree equivalents between plots burnt at different times of the year

In 1954, the number of tree equivalents was not significantly different between the treatments to be burnt at different times of the year (Table 6-7). The rank order of the fire timing treatments from highest to lowest number of tree equivalents (tree equivalents/Ha) in 1954 was February (1851.5), August (1618.9), April (1541.1), December (1489.3), October (1344.6), and Control (1315.3) (Table 13-8). In 1996, the rank order of the timing treatments from highest to lowest number of tree equivalents was Control (6963.3), August (4406.8), April (4249.3), February (4191.1), October (3992.6), and December (3868.3) (Table 13-9). The number of tree equivalents was significantly different between the treatments burnt at different times of the year in 1996 (ANOVA: p = 0.096, ANCOVA: p = 0.048) (Table 6-7). Tukey Studentized post hoc analyses show that the number of tree equivalents was significantly higher on the Control treatments than on the February (ANCOVA: p = 0.038), April (ANCOVA: p = 0.070), August (ANCOVA: p = 0.087), October (ANOVA: p = 0.079, ANCOVA: p = 0.056), and December (ANOVA: p = 0.060, ANCOVA: p = 0.032) treatments in 1996 (Table 14-11, and Table 14-12). Between 1954 and 1996, the number of tree equivalents increased on all the treatments burnt at different times of the year.

6.2.2.4.4 Differences in the single-stem to multi-stem index between plots burnt at different times of the year

In 1954, the single-stem to multi-stem index was not significantly different between the treatments to be burnt at different times of the year (Table 6-7). The rank order of the fire timing treatments from highest to lowest single-stem to multi-stem index in 1954 was Control (0.738), December (0.550), August (0.540), April (0.522), October (0.463), and February (0.446) (Table 13-8). In 1996, the rank order of the timing treatments from highest to lowest single-stem to multi-stem index was Control (0.539), February (0.383), December (0.380), April (0.364), October (0.288), and August (0.199) (Table 13-9). The single-stem to multi-stem index was significantly different between the treatments burnt at different times of the year in 1996 (ANOVA: p = 0.024, ANCOVA: p = 0.006) (Table 6-7). Tukey Studentized post hoc analyses show that the single-stem to

multi-stem index was significantly higher on the Control treatments than on the February (ANOVA: p = 0.031, ANCOVA: p = 0.036), April (ANOVA: p = 0.011, ANCOVA: p = 0.012), August (ANOVA: p = 0.001, ANCOVA: p = 0.001), October (ANOVA: p = 0.001, ANCOVA: p < 0.001), and December (ANOVA: p = 0.026, ANCOVA: p = 0.028) treatments in 1996 (Table 14-11, and Table 14-12). The single-stem to multi-stem index was also significantly lower on the August treatments than on the February (ANOVA: p = 0.001, ANCOVA: p = 0.001), April (ANOVA: p = 0.002, ANCOVA: p = 0.003), and December (ANOVA: p = 0.001, ANCOVA: p = 0.001) treatments in 1996. Between 1954 and 1996, the single-stem to multi-stem index decreased on all the treatments burnt at different times of the year.

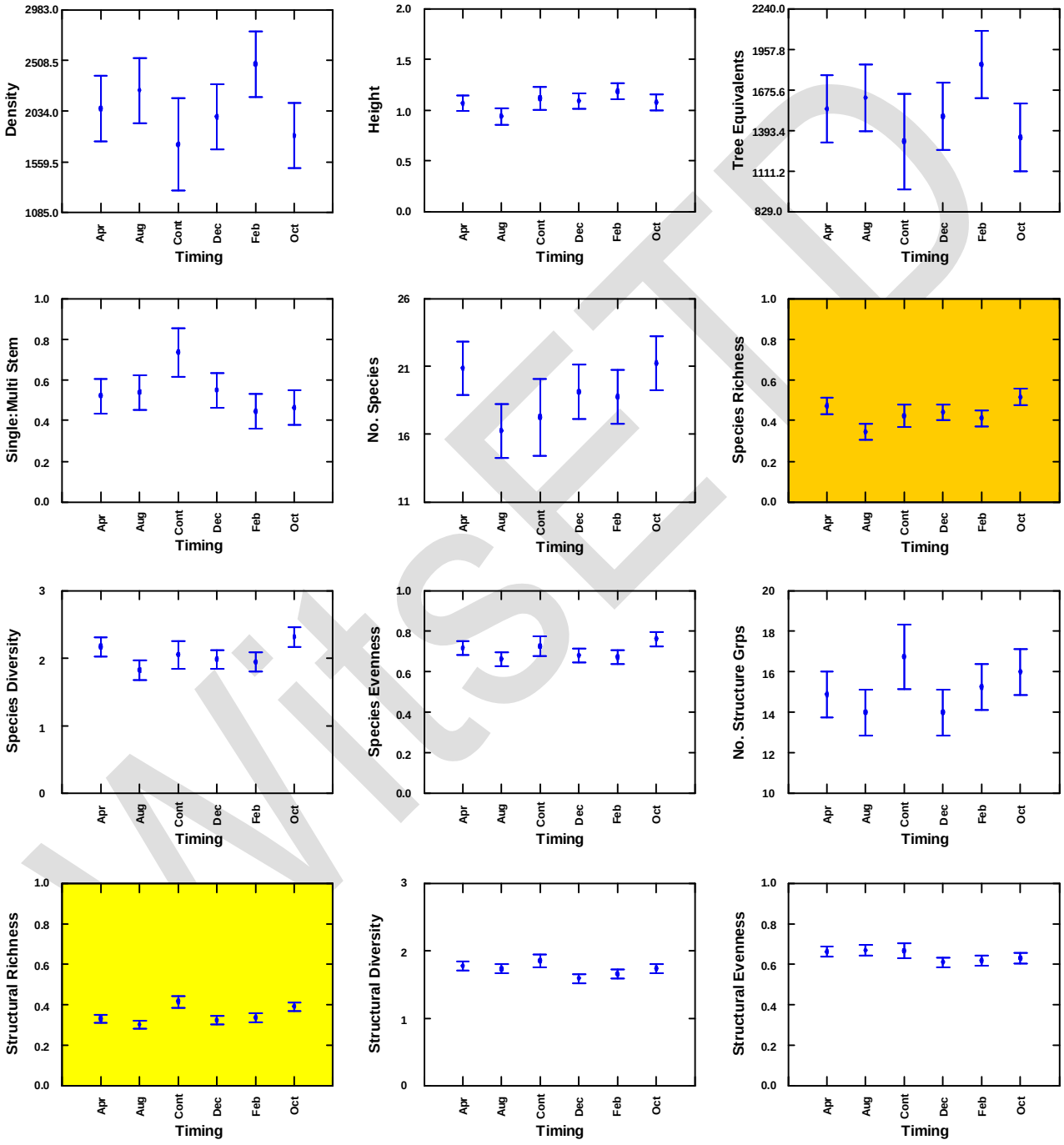


Figure 6-17: The least squares means and standard errors of the vegetation indices from the ANOVA analyses on the 1954 data testing for pre-treatment differences between the plots to be burnt at different times of the year. The August annual treatments were excluded from these analyses. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

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Generally, treatments that burn more intensely (August and October) tend to have more multi-stem individuals relative to single-stem individuals than treatments that burn less intensely (February and December).

6.2.2.4.5 Differences in the number of species between plots burnt at different times of the year

In 1954, the number of species was not significantly different between the treatments to be burnt at different times of the year (Table 6-7). The rank order of the fire timing treatments from highest to lowest number of species in 1954 was October (21.250), April (20.875), December (19.125), February (18.750), Control (17.250), and August (16.250) (Table 13-8). In 1996, the rank order of the timing treatments from highest to lowest number of species was Control (37.500), December (32.375), February (31.250), April (29.375), August (26.250), and October (26.125) (Table 13-9). The number of species was significantly different between the treatments burnt at different times of the year in 1996 (ANOVA: p = 0.001, ANCOVA: p = 0 001) (Table 6-7). Tukey Studentized post hoc analyses show that the number of species was significantly higher on the Control treatment than on the April (ANCOVA: p = 0.067), August (ANOVA: p = 0.040, ANCOVA: p = 0.029), and October (ANOVA: p = 0.036, ANCOVA: p = 0.005) treatments in 1996 (Table 14-11, and Table 14-12). Between 1954 and 1996, the number of species increased on all the treatments burnt at different times of the year.

Generally, treatments that burn less intensely (February and December) have higher number of species than treatments that burn more intensely (August and October). This may be because some species can survive the less intense fires in February and December while they are not able to survive the more intense August and October fires. Furthermore, some species may not be able to survive fires in August and October because these fire events occur at the end of the dry season when carbohydrate reserves have been depleted, and these species do not have enough energy reserves to recover from being burnt.

6.2.2.4.6 Differences in species richness between plots burnt at different times of the year

In 1954, the rank order of the fire timing treatments from highest to lowest species richness in 1954 was October (0.516), April (0.472), December (0.441), Control (0.423), February (0.411), and August (0.344) (Table 13-8). In 1954, the species richness was significantly different between the treatments to be burnt at different times of the year (p = 0.082) (Table 6-7). Tukey Studentized post hoc analyses show that the species richness was significantly higher on the treatments to be burnt in October than on the treatments to be burnt in August (p = 0.044) in 1954 (Table 14-11, and Table 14-12). In 1996, the rank order of the timing treatments from highest to lowest species richness was December (0.448), Control (0.424), February (0.402), April (0.391), October (0.373), and August (0.372) (Table 13-9). The species richness was not significantly different between the treatments burnt at different times of the year in 1996 (Table 6-7). Between 1954 and 1996, the species richness decreased on all the treatments burnt at different times of the year. As explained above (p. 66) this decrease in species richness may be an artefact of the calculation of species richness, which is the number of species observed relative to the sample size.

Generally, treatments that burn less intensely (February and December) have higher species richness than treatments that burn more intensely (August and October). However, the species richness between the treatments burnt at different times does not vary much (ranging from 0.372 to 0.448).

6.2.2.4.7 Differences in species diversity between plots burnt at different times of the year

In 1954, the species diversity was not significantly different between the treatments to be burnt at different times of the year (Table 6-7). The rank order of the fire timing treatments from highest to lowest species diversity in 1954 was October (2.317), April (2.173), Control (2.054), December (1.988), February (1.947), and August (1.827) (Table 13-8). In 1996, the rank order of the timing treatments from highest to lowest species diversity was Control (2.482), February (2.271), December (2.213), October (2.137), April (1.991) and August (1.904), (Table 13-9). The species diversity was significantly different between the treatments burnt at different times of the year in 1996 (ANOVA: p = 0.053, ANCOVA: p = 0.008) (Table 6-7). Tukey Studentized post hoc analyses show that the species diversity was significantly higher on the Control

treatments than on the April (ANCOVA: p = 0.027), August (ANOVA: p = 0.061, ANCOVA: p = 0.075), and October (ANCOVA: p = 0.092) treatments in 1996 (Table 14-11, and Table 14-12). Post hoc analyses also show that the February treatments had significantly higher species diversity than the April treatments in 1996 (ANCOVA: p = 0.088). Between 1954 and 1996, the species diversity increased on the February, August, December, Control treatments, and decreased on the April and October treatments.

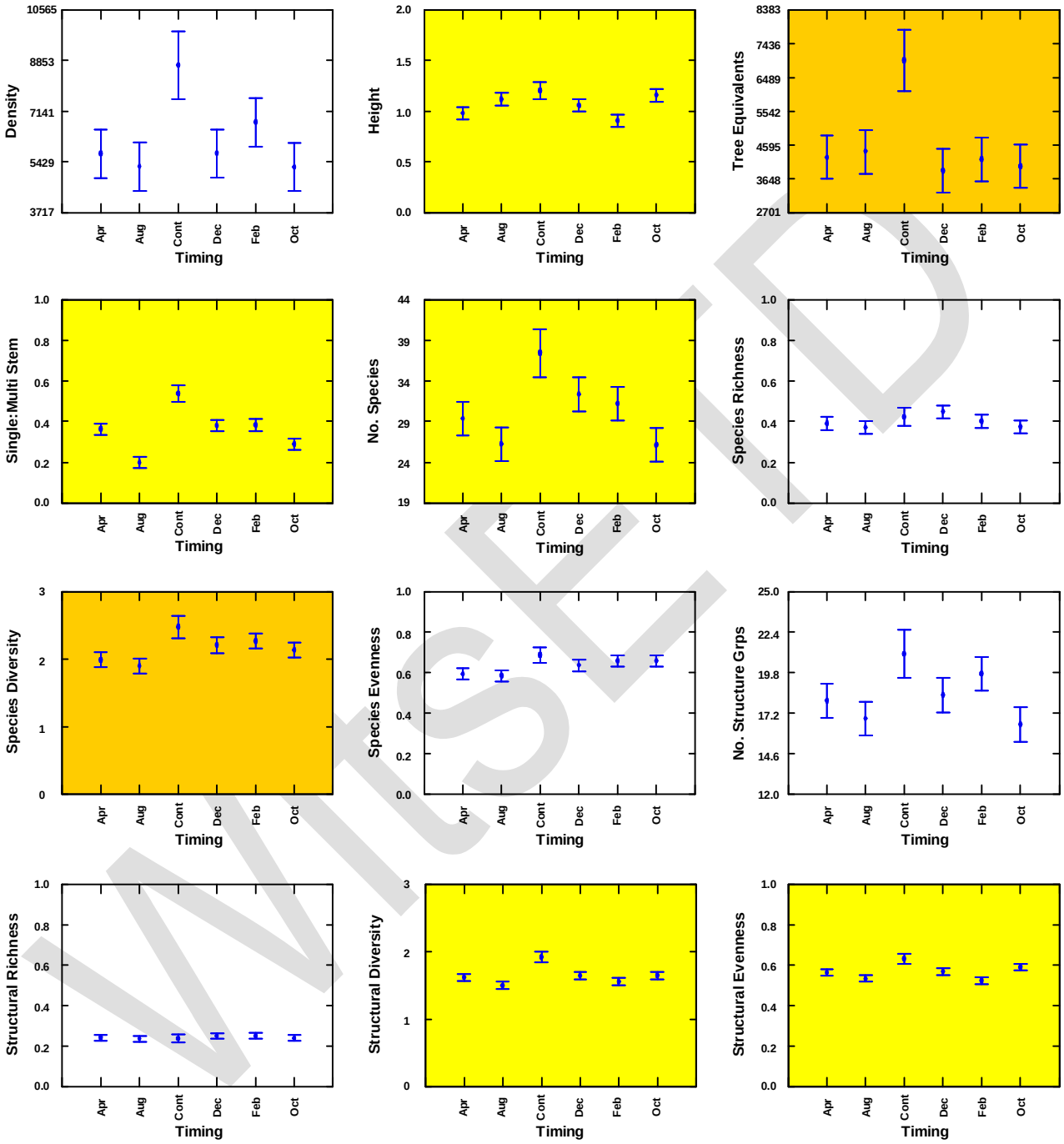


Figure 6-18: The least squares means and standard errors of the vegetation indices from the ANOVA analyses on the 1996 data testing for the treatment effects between plots burnt at different times of the year. The August annual treatments were excluded from these analyses. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

The April, August, and October treatments had the lowest species diversity. Some species may not be able to survive fires in August and October because fires at this time of the year are very intense and most often cause total top kill of saplings and shrubs. Furthermore, August and October fires occur at a time when many

species carbohydrate reserves are depleted and these species are unable to recover from fire damage. This may explain why the species diversity was low on the August and October treatments. The April treatments appear anomalous because fires are less intense in April than they are in August and October, nor are species carbohydrate reserves depleted in April, and yet the species diversity on the April treatments was low. However, Shannon's species diversity is a measure of both the number of species and the relative abundances of the species present. The April treatments did not have the lowest number of species or species richness, however they did have the second lowest species evenness. Species evenness is a measure of how evenly proportioned species abundances are. The species diversity is low on the April treatments because the abundances of the species present are not evenly proportioned.

6.2.2.4.8 Differences in species evenness between plots burnt at different times of the year

In 1954 and 1996, the species evenness was not significantly different between the treatments burnt at different times of the year (Table 6-7). The rank order of the fire timing treatments from highest to lowest species evenness in 1954 was October (0.763), Control (0.727), April (0.717), December (0.681), February (0.673), and August (0.663) (Table 13-8). In 1996, the rank order of the timing treatments from highest to lowest species evenness was Control (0.688), February (0.660), October (0.659), December (0.636), April (0.594), and August (0.586) (Table 13-9). Between 1954 and 1996, the species evenness decreased on all treatments burnt at different frequencies.

6.2.2.4.9 Differences in the number of structural groups between plots burnt at different times of the year

In 1954, the number of structural groups was not significantly different between the treatments to be burnt at different times of the year (Table 6-7). The rank order of the fire timing treatments from highest to lowest mean number of structural groups in 1954 was Control (16.750), October (16.000), February (15.250), April (14.875), August (14.000), and December (14.000) (Table 13-8). In 1996, the rank order of the timing treatments from highest to lowest mean number of structural groups was Control (21.000), February (19.750), December (18.375), April (18.000), August (16.875), and October (16.500) (Table 13-9). In 1996, the number of structural groups was significantly different between the treatments burnt at different times of the year (ANCOVA: $p = 0.079$) (Table 6-7). However, Tukey Studentized post hoc analyses do not show any significant differences in the number of structural groups (Table 14-12). Between 1954 and 1996, the number of structural groups increased on all treatments burnt at different frequencies.

Generally, treatments that burn less intensely (February and December) have a higher number of structural groups than treatments that burn more intensely (August and October). The structural classification comprises single-stem and multi-stem basal size classes and height classes, and the February and December treatments had more single stem individuals relative to multi-stem individuals than the August and October treatments. This partly explains why the February and December treatments have a higher number of structural groups than the August and October treatments. Furthermore, top kill of woody plants is higher on the treatments that burn more intensely (August and October) than on plots that burn less intensely (February and December). The result is that proportionately more woody plants are burnt back and coppice from the base on the August and October treatments than on the February and December treatments.

6.2.2.4.10 Differences in structural richness between plots burnt at different times of the year

In 1954, the rank order of the fire timing treatments from highest to lowest structural richness in 1954 was Control (0.415), October (0.391), February (0.336), December (0.322), April (0.330), and August (0.303) (Table 13-8). In 1954, the structural richness was significantly different between the treatments to be burnt at different times of the year ($p = 0.015$) (Table 6-7). Tukey Studentized post hoc analyses show that the structural richness was significantly lower on the August treatment than on the Control (0.039) and October (0.051) treatments in 1954 (Table 14-10). In 1996, the rank order of the timing treatments from highest to lowest structural richness was February (0.251), December (0.250), April (0.241), October (0.239), Control (0.237), and August (0.237) (Table 13-9). In 1996, the structural richness was not significantly different

between the treatments burnt at different times of the year (Table 6-7). Between 1954 and 1996, the structural richness decreased on all treatments burnt at different frequencies.

Generally, the structural richness in 1996 (ranging from 0.237 to 0.251) was very similar between the treatments that were burnt at different times of the year between 1954 and 1996.

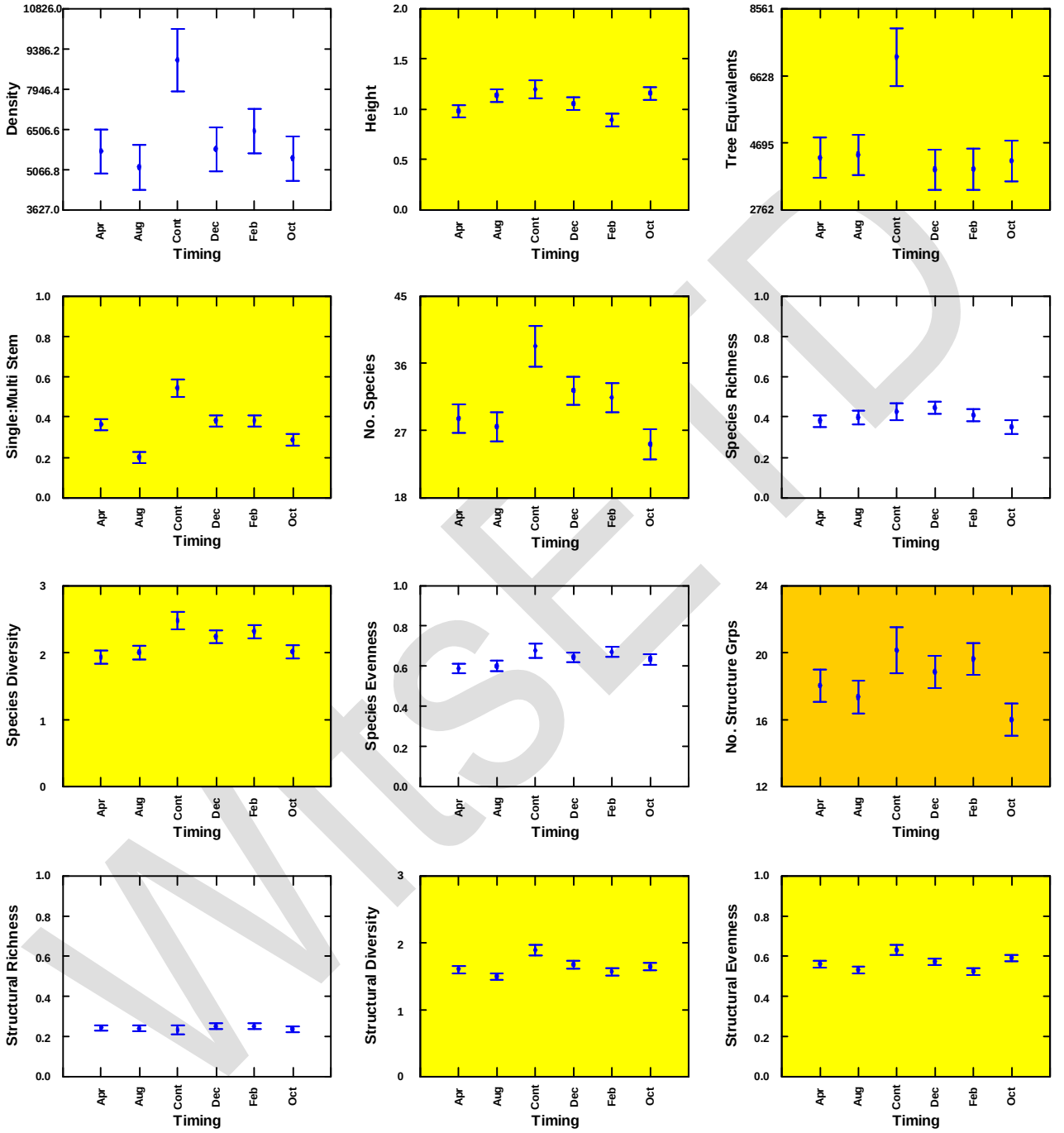


Figure 6-19: The least squares means and standard errors of the vegetation indices from the ANCOVA analyses on the 1996 data (with the 1954 data as covariates) testing for the treatment effects between plots burnt at different times of the year taking into account the state of the plots before the treatments began The August annual treatments were excluded from these analyses. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

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6.2.2.4.11 Differences in structural diversity between plots burnt at different times of the year

In 1954, the structural diversity was not significantly different between the treatments to be burnt at different times of the year (Table 6-7). The rank order of the fire timing treatments from highest to lowest structural diversity in 1954 was Control (1.850), April (1.774), October (1.735), August (1.728), February (1.654), and December (1.591) (Table 13-8). In 1996, the rank order of the timing treatments from highest to lowest structural diversity was Control (1.918), October (1.645), December (1.644), April (1.615), February (1.555), and August (1.496) (Table 13-9). In 1996, the structural diversity was significantly different between the treatments burnt at different times of the year (ANOVA: p = 0.003, ANCOVA: p = 0.006) (Table 6-7). Tukey Studentized post hoc analyses show structural diversity was significantly higher on the Control treatments than on the February (ANOVA: p = 0.006, ANCOVA: p = 0.023), April (ANOVA: p = 0.032, ANCOVA: p = 0.044), August (ANOVA: p = 0.001, ANCOVA: p = 0.002), October (ANOVA: p = 0.068), and December (ANOVA: p = 0.066) treatments in 1996 (Table 14-11, and Table 14-12). Between 1954 and 1996, the structural diversity decreased on the February, April, and August treatments and increased on the December and Control treatments.

6.2.2.4.12 Differences in structural evenness between plots burnt at different times of the year

In 1954, the structural evenness was not significantly different between the treatments to be burnt at different times of the year (Table 6-7). The rank order of the fire timing treatments from highest to lowest structural evenness in 1954 was August (0.669), Control (0.666), April (0.661), October (0.629), February (0.618), and December (0.609) (Table 13-8). In 1996, the rank order of the timing treatments from highest to lowest structural evenness was Control (0.631), October (0.589), December (0.568), April (0.563), August (0.533), and February (0.522) (Table 13-9). In 1996, the structural evenness was significantly different between the treatments burnt at different times of the year (ANOVA: p = 0.005, ANCOVA: p = 0.006) (Table 6-7). Tukey Studentized post hoc analyses show structural evenness was significantly higher on the Control treatments than on the February (ANOVA: p = 0.007, ANCOVA: p = 0.012) and August (ANOVA: p = 0.019, ANCOVA: p = 0.020) treatments in 1996 (Table 14-11, and Table 14-12). Post hoc analyses also show that the structural evenness on the October treatment was significantly higher than on the February treatment (ANCOVA: p = 0.086). Between 1954 and 1996, the structural evenness increased on all the treatments burnt at different times of the year.

6.2.2.5 Testing for differences in the woody vegetation density, structure and composition between the Pretoriuskop EBPs burnt at different frequencies and at different times of the year (i.e. between the EBP treatments)

The results of the Analyses of Variance and Analyses of Covariance analyses testing for differences in the woody vegetation between the fire treatments on the Pretoriuskop EBPs are presented in Table 6-8 (p. 100), Figure 6-21 (p. 103), Figure 6-22 (p. 107), and Figure 6-23 (p. 111). Results of the post hoc analyses performed where significant differences were found between the fire treatments are presented in Table 14-13 (p. 250), Table 14-14 (p. 251), and Table 14-15 (p. 253). Summaries of the 1954 and 1996 data used in these analyses are presented in Appendix 5 in Table 13-10 (p. 231), and Table 13-11 (p. 233) respectively. Descriptions of the treatment codes are presented in Table 3-1 (p. 15).

The mean and standard error of the means from the ANOVA and ANCOVA analyses on the 1996 data are similar when there was little covariance in the data between the EBP treatments in 1954 and 1996 (Figure 6-22 and Figure 6-23). At times, the standard error of the means from the ANOVA and ANCOVA analyses on the 1996 data are not similar showing that there was covariance in the data between the EBP treatments in 1954 and 1996 (Figure 6-22 and Figure 6-23). For example, the rank order from tallest to shortest mean treatment plant height was similar between the ANOVA and ANCOVA analyses on the 1996 data, and the rank order from most dense to least dense treatment was not similar between the ANOVA and ANCOVA analyses on the 1996.

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6.2.2.5.1 Differences in woody plant density between plots burnt at different frequencies and at different times of the year

In 1954 and 1996, the woody plant density was not significantly different between the different EBP treatments in the Pretoriuskop region (Table 6-8). The treatment with the highest woody plant density (plants/Ha) in 1954, was Feb3 (2540.750) and the Oct3 (1317.000) treatment had the lowest woody plant density (Figure 6-21 and Table 13-10). In 1996, the Con0 treatment had the highest woody plant density (8696.000) and the Dec3 treatment had the lowest woody plant density (4912.750) (Figure 6-22and Table 13-11). Between 1954 and 1996, the woody plant density increased on all the Pretoriuskop EBP treatments.

The rank order of the treatments based on the density of the woody vegetation per treatment was not the same for the ANOVA and ANCOVA analyses on the 1996 data (Figure 6-22 and Figure 6-23). The results from the ANOVA and ANCOVA analyses on the density of the woody vegetation in 1996 differed in the relative placement of the Aug3 and Oct3 treatments. In the ANOVA analysis, the Aug3 treatment had a higher density than the Aug2 treatment and the Oct3 treatment had a higher density than the Oct2 treatment (Figure 6-22). In the ANCOVA analysis, which accounts for the covariance between the 1954 and 1996 data, the Aug2 treatment had a higher density than the Aug3 treatment, and the Oct2 treatment had a higher density than the Oct3 treatment (Figure 6-23). Looking at the ANCOVA analyses, the density on the Biennial treatments was lower than on the Triennial treatments at the same time of the year on the April, August, and October treatments. The density on the Biennial treatments was higher than the Triennial treatments at the same time of the year for the February and December treatments (Figure 6-23). The Feb2 (7937.500) and Dec2 (6520.750) treatments had the second and third highest woody plant density in 1996 (Figure 6-22 and Table 13-11).

Generally, there is a large difference in the density of the woody vegetation (plants/Ha) between the biennial and triennial treatments burnt during the wet season and towards the end of the wet season in February (2344.500), April (904.750), and December (1608.000). The difference in the woody vegetation density between treatments burnt during and towards the end of the dry season in August (99.500) and October (495.250) is smaller.

6.2.2.5.2 Differences in the mean woody plant height between plots burnt at different frequencies and at different times of the year

In 1954, the mean woody plant height was not significantly different between the EBP treatments in the Pretoriuskop region (Table 6-8). The mean woody plant height was highest on the Feb2 treatment (1.279m) and lowest on the Aug3 treatment (0.882m) in 1954 (Table 13-10). In 1996, the treatment (1.202m) had the highest mean woody plant height and the Feb2 treatment (0.846m) had the lowest mean woody plant height (Table 13-11). The mean woody plant height was significantly different between the EBP treatments in 1996 (ANOVA: $p = 0.015$, ANCOVA: $p = 0.015$) (Table 6-8). Tukey Studentized post hoc analyses do not show where the differences lie (Table 14-14 and Table 14-15). Between 1954 and 1996, the mean woody plant height decreased on the Apr2, Apr3, Aug1, Dec2, Feb2, and Feb3 treatments, and increased on the Aug2, Aug3, Control, Dec3, Oct2, and Oct3 treatments.

In 1996, the mean woody plant height on the Biennial treatments was lower than on the Triennial treatments at the same time of the year on the February, October, and December treatments (Figure 6-22 and Figure 6-23). The mean woody plant height on the Biennial treatments was higher than the Triennial treatments at the same time of the year for the April and August treatments.

6.2.2.5.3 Differences in the number of tree equivalents between plots burnt at different frequencies and at different times of the year

In 1954 and 1996, the number of tree equivalents was not significantly different between the EBP treatments in the Pretoriuskop region (Table 6-8). The number of tree equivalents (tree equivalents/Ha) was highest on the Feb3 treatment (1982.500) and lowest on the Oct3 treatment (1068.500) in 1954 (Figure 6-21 and Table 13-10). In 1996, the number of tree equivalents was highest on the Con0 treatment (6963.250) and lowest

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on the Aug1 treatment (3051.500) (Figure 6-22, Figure 6-23 and Table 13-11). Between 1954 and 1996, the number of tree equivalents increased on all the Pretoriuskop EBP treatments.

Table 6-8: Results of the ANOVA and ANCOVA analyses on the vegetation indices calculated to test the combined effects of timing and frequency of the fire treatments.

						Taxonomic diversity				Structural diversity			
Year	Statistic	Density	Mean height	Tree equivalents	Single:Multi stem	Number of species	Species Richness	Species diversity	Species evenness	Number of structural groups	Structure richness	Structure diversity	Structure evenness
1954 (ANOVA)	df	11	11	11	11	11	11	11	11	11	11	11	11
	df error	36	36	36	36	36	36	36	36	36	36	36	36
	F-ratio	0.812	0.895	0.833	5.212	1.056	2.851	0.916	1.161	1.701	2.691	1.363	0.746
	p value	0.628	0.554	0.609	0.001	0.422	0.009	0.536	0.347	0.113	0.012	0.232	0.688
1996 (ANOVA)	df	11	11	11	11	11	11	11	11	11	11	11	11
	df error	36	36	36	36	36	36	36	36	36	36	36	36
	F-ratio	1.081	2.594	1.160	9.003	2.207	0.756	1.340	0.860	1.026	0.812	5.916	7.021
	p value	0.403	0.015	0.348	0.001	0.036	0.679	0.243	0.585	0.445	0.628	0.001	0.001
1996:1954 (ANCOVA)	df	11	11	11	11	11	11	11	11	11	11	11	11
	df error	35	35	35	35	35	35	35	35	35	35	35	35
	F-ratio	1.386	2.603	1.645	8.974	2.570	0.750	2.138	1.521	1.839	1.021	6.604	6.915
	p value	0.223	0.015	0.129	0.001	0.017	0.685	0.043	0.168	0.084	0.449	0.001	0.001

Note: The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

The rank order of the treatments based the mean number of tree equivalents per treatment was not the same for the ANOVA and ANCOVA analyses on the 1996 data (Figure 6-22 and Figure 6-23). The results from the ANOVA and ANCOVA analyses on the number of tree equivalents in 1996 differed in the relative placement of the Dec3 and Oct3 treatments. In the ANOVA analysis, the Dec3 treatment had a higher number of tree equivalents than the Dec2 treatment, and the Oct3 treatment had a lower number of tree equivalents than the Feb2 treatment (Figure 6-22). In the ANCOVA analysis, which accounts for the covariance between the 1954 and 1996 data, the Dec3 treatment had a lower number of tree equivalents than the Dec2 treatment, and the Oct3 treatment had a higher number of tree equivalents than the Feb2 treatment (Figure 6-23). Looking at the ANCOVA analyses, the number of tree equivalents on the Biennial treatments was lower than on the Triennial treatments at the same time of the year on the April, August, and October treatments in 1996. The number of tree equivalents on the Biennial treatments was higher than the Triennial treatments at the same time of the year for the February and December treatments in 1996.

6.2.2.5.4 Differences in the single-stem to multi-stem index between plots burnt at different frequencies and at different times of the year

In 1954, the single-stem to multi-stem index was highest on the Dec2 treatment (0.774) lowest on the Feb3 treatment (0.289) (Figure 6-21 and Table 13-10). The single-stem to multi-stem index was significantly different between the Pretoriuskop EBP treatments in 1954 (p = 0.001) (Table 6-8). Tukey Studentized post hoc analyses show the Apr2 treatment had a significantly higher single-stem to multi-stem index than the Feb3 (p = 0.049) and Oct3 (p = 0.057) treatments in 1954 (Table 14-13). The Aug1 treatment had a significantly higher single-stem to multi-stem index than the Dec3 (p = 0.095), Feb3 (p = 0.046), and Oct3 (p = 0.053) treatments in 1954. The single-stem to multi-stem index on the Aug2 was significantly higher than on the Feb3 treatment (p = 0.093) in 1954. The single-stem to multi-stem index on the Con0 treatment was

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significantly higher than on the Apr3 (p = 0.068), Dec3 (p = 0.053), Feb3 (p = 0.024), and Oct3 (p = 0.029) treatments in 1954. The Dec2 treatment had a significantly higher single-stem to multi-stem index than the Apr3 (p = 0.033), Dec3 (p = 0.025), Feb3 (p = 0.011), and the Oct3 (p = 0.013) treatments in 1954. In 1996, the single-stem to multi-stem index was highest on the Con0 treatment (0.539) and lowest on the Aug1 treatment (0.126) (Figure 6-22, Figure 6-23 and Table 13-11). The single-stem to multi-stem index was significantly different between treatments in 1996 (ANOVA: p = 0.036, ANCOVA: p = 0.017) (Table 6-8). Tukey Studentized post hoc analyses show that in 1996 the Aug1 treatment had a significantly lower single-stem to multi-stem index than the Apr2 (ANOVA: p = 0.003, ANCOVA: p = 0.003), Apr3 (ANOVA: p = 0.007, ANCOVA: p = 0.010), Dec2 (ANOVA: p = 0.003, ANCOVA: p = 0.004), Dec3 (ANOVA: p = 0.001, ANCOVA: p = 0.008), Feb2 (ANOVA: p = 0.020, ANCOVA: p = 0.017), and Feb3 (ANOVA: p = 0.001, ANCOVA: p = 0.001) treatments (Table 14-14 and Table 14-15). The Aug2 treatment had a significantly lower single-stem to multi-stem index than the Apr2 (ANOVA: p = 0.013, ANCOVA: p = 0.016), Apr3 (ANOVA: p = 0.027, ANCOVA: p = 0.029), Dec2 (ANOVA: p = 0.012, ANCOVA: p = 0.020), Dec3 (ANOVA: p = 0.006, ANCOVA: p = 0.008), Feb2 (ANOVA: p = 0.071, ANCOVA: p = 0.064), and Feb3 (ANOVA: p = 0.001, ANCOVA: p = 0.001) treatments in 1996. The Aug3 treatment had a significantly lower single-stem to multi-stem index than the Feb3 treatment (ANOVA: p = 0.050, ANCOVA: p = 0.043) in 1996. The Con0 treatment had a significantly higher single-stem to multi-stem index than the Apr3 (ANOVA: p = 0.066), Aug1 (ANOVA: p = 0.001, ANCOVA: p = 0.001), Aug2 (ANOVA: p = 0.001, ANCOVA: p = 0.001), Aug3 (ANOVA: p = 0.001, ANCOVA: p = 0.003), Feb2 (ANOVA: p = 0.025, ANCOVA: p = 0.046), Oct2 (ANOVA: p = 0.002, ANCOVA: p = 0.003), and Oct3 (ANOVA: p = 0.003, ANCOVA: p = 0.063) treatments in 1996. Between 1954 and 1996, the single-stem to multi-stem index decreased on the Apr2, Aug1, Aug2, Aug3, Con0, Dec2, Feb2, Oct2, and Oct3 treatments and increased on the Apr3, Dec3, and Feb3 treatments.

The rank order of the treatments based the single-stem to multi-stem index per treatment was not the same for the ANOVA and ANCOVA analyses on the 1996 data (Figure 6-22 and Figure 6-23). The results from the ANOVA and ANCOVA analyses on the single-stem to multi-stem index in 1996 differed in the relative placement of the Apr3 treatment. In the ANOVA analyses, the Apr3 treatment had a lower single-stem to multi-stem index than the Apr2 treatment (Figure 6-22). In the ANCOVA analyses, the Apr3 treatment had a higher single-stem to multi-stem index than the Apr2 treatment (Figure 6-23). Looking at the ANCOVA analyses, the single-stem to multi-stem index was lower on the biennial treatments than on the triennial treatments at the same time of the year for all the treatments.

Generally, regarding the frequency of the treatments, the more frequent the fires the less single-stem individuals relative to multi-stem individuals there tend to be (i.e. the single-stem to multi-stem index decreases). Regarding the timing of the treatments, the August treatments have the lowest number of single-stem individuals relative to multi-stem individuals followed by the October treatments having the second lowest single-stem to multi-stem index. The February, April, and December treatments have similar number of single-stem individuals relative to multi-stem individuals and the Control treatment has the highest number of single-stem individuals relative to multi-stem individuals.

6.2.2.5.5 Differences in the number of species between plots burnt at different frequencies and at different times of the year

In 1954, the number of species was not significantly different between the EBP treatments in the Pretoriuskop region (Table 6-8). In 1954, the Apr3 treatment (24.500) had the highest mean number of species and the Aug3, Aug2, and Dec2 treatments (16.250) had the lowest mean number of species (Figure 6-21 and Table 13-10). In 1996, the Con0 treatment (37.500) had the highest mean number of species and the Apr2 treatment (24.500) had the lowest mean number of species (Figure 6-22 and Table 13-11). The number of species was significantly different between treatments in 1996 (ANOVA: p = 0.036, ANCOVA: p = 0.017) (Table 6-8). Tukey Studentized post hoc analyses show that Con0 treatment had a significantly higher number of species than the Apr2 (ANOVA: p = 0.080, ANCOVA: p = 0.045), Oct2 (ANCOVA: p = 0.075), and Oct3 (ANCOVA: p = 0.034) treatments (Table 14-14 and Table 14-15). Between 1954 and 1996, the number of species increased on all the Pretoriuskop EBP treatments.

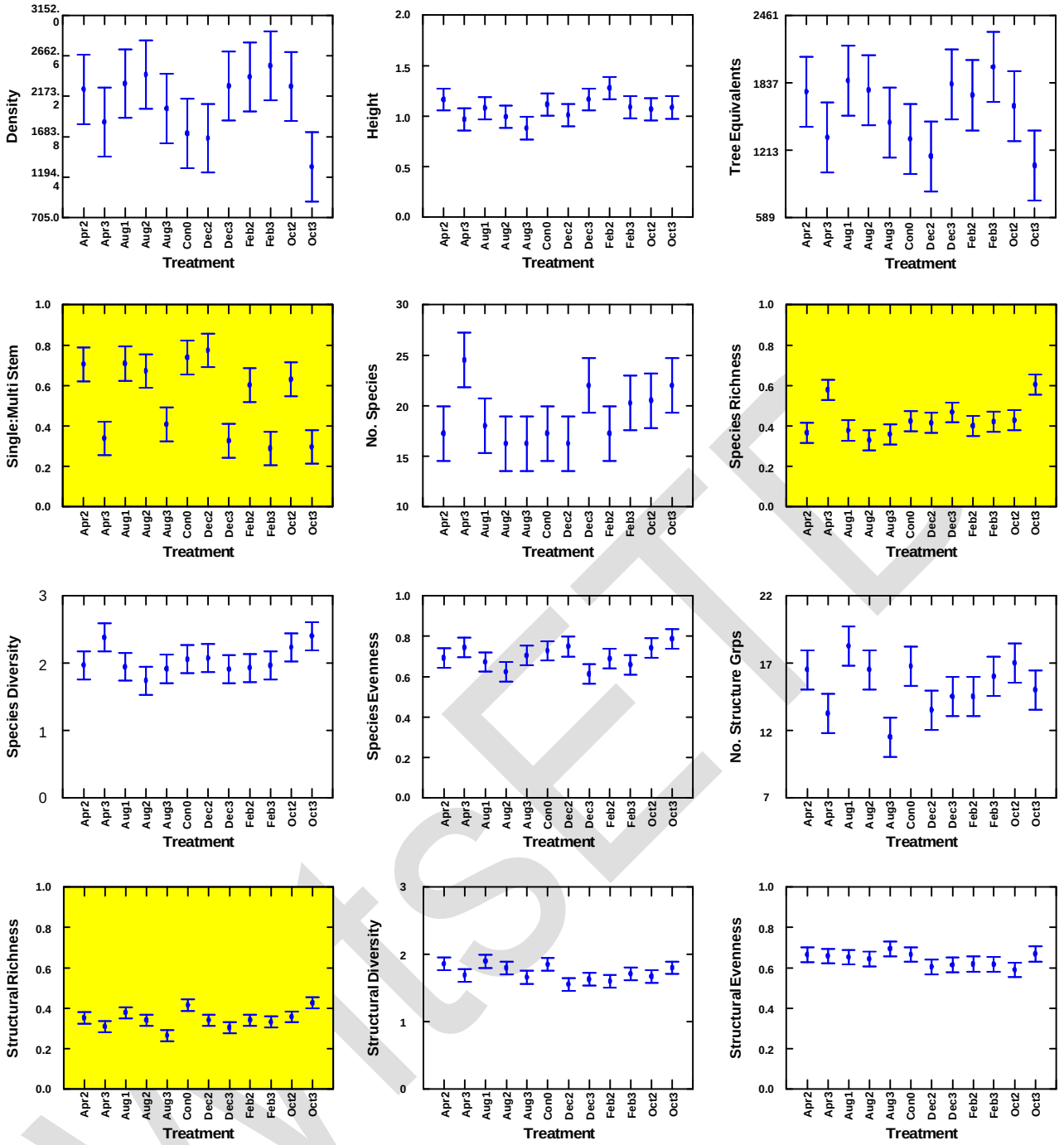


Figure 6-20: The least squares means and standard errors of the vegetation indices from the ANOVA analyses on the 1954 data testing for pre-treatment differences between the plots assigned the different treatments. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

The rank order of the treatments based on the number of species was not the same for the ANOVA and ANCOVA analyses on the 1996 data (Figure 6-22 and Figure 6-23). The results from the ANOVA and ANCOVA analyses on the number of species in 1996 differed in the relative placement of the Apr3 and Oct3 treatments. In the ANOVA analysis, the Apr3 treatment had the second highest number of species and the Oct3 treatment had the second lowest number of species (Figure 6-22). In the ANCOVA analysis, the Apr3 treatment had the fourth highest number of species and the Oct3 treatment had the lowest number of species (Figure 6-23). Looking at the ANCOVA analysis, the number of species on the biennial treatments was higher than the triennial treatments at the same time of the year for the February, October, and December treatments in 1996. The number of species on the august annual and biennial treatments was the

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same, and the number of species on the April biennial treatment was lower than the April triennial treatment in 1996.

Generally, regarding the timing of the treatments, the dry season treatments in August and October have the lower number of species than the wet season treatments in February and December. The April treatment is unusual because the Apr3 treatment is grouped with the wet season treatments and the Apr2 treatment is grouped with the dry season treatments. Regarding the frequency of the treatments, biennial treatments tend to have a higher number of species than triennial treatments excepting for the April treatments. The no burn (Con0) treatment had the highest number of species.

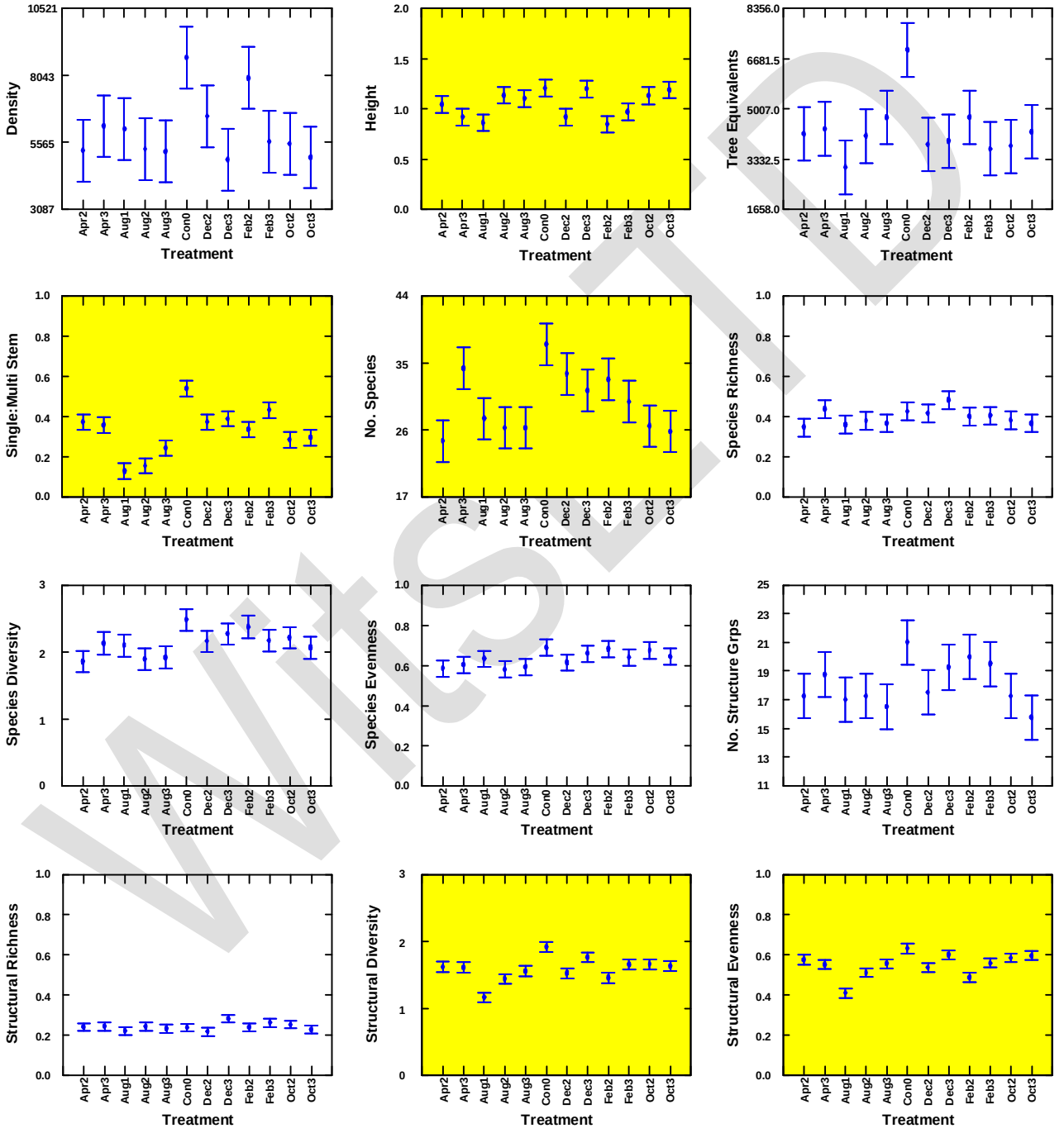


Figure 6-21: The least squares means and standard errors of the vegetation indices from the ANOVA analyses on the 1996 data testing the effect of the different treatments assigned to plots. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

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6.2.2.5.6 Differences in species richness between plots burnt at different frequencies and at different times of the year

In 1954, the species richness was highest on the Oct3 treatment (0.605) and lowest on the Aug2 treatment (0.329) (Table 13-10). The species richness was significantly different between the Pretoriuskop EBP treatments in 1954 (p = 0.009) (Table 6-8). Tukey Studentized post hoc analyses show that the species richness on the Apr3 treatment was significantly higher than on the Aug2 treatment (p = 0.043) in 1954 (Table 14-13). Post hoc analyses also show that the Oct3 treatment had a significantly higher species richness than the Apr2 (p = 0.062), Aug1 (p = 0.091), Aug2 (p = 0.016), and Aug3 (p = 0.049) treatments in 1954. In 1996, the species richness was not significantly different between the Pretoriuskop EBP treatments (Table 6-8). In 1996, the Dec3 treatment (0.481) had the highest species richness and the Apr2 treatment (0.346) had the lowest species richness (Table 13-11). Between 1954 and 1996, the species richness decreased on the Apr2, Apr3, Aug1, Feb2, Feb3, Oct2, and Oct3 treatments and increased on the Aug2, Aug3, Con0, Dec2, and Dec3 treatments.

The rank order of the treatments based on the species richness was not the same for the ANOVA and ANCOVA analyses on the 1996 data (Figure 6-22 and Figure 6-23). The results of the ANOVA and ANCOVA analyses on the species richness in 1996 differed in the relative placement of the Apr3 and Oct3 treatments. In the ANOVA analysis, the Apr3 treatment had the second highest species richness and the Oct3 treatment had the third lowest species richness (Figure 6-22). In the ANCOVA analysis, the Apr3 treatment had the seventh highest species richness and the Oct3 treatment had the lowest species richness (Figure 6-23). Looking at the ANCOVA analysis, the species richness on the biennial treatments was higher than the triennial treatments at the same time of the year for the dry season treatments in August and October in 1996. The species richness in 1996, on the biennial treatments was lower than the triennial treatments at the same time of the year for the wet season treatments in April and December, and the species richness on the February biennial and triennial treatments was similar.

Generally, fires burnt biennially in the dry season tend to have higher species richness than fires burnt triennially in the dry season. Fires burnt biennially in the wet season tend to have lower species richness than fires burnt triennially in the dry season. The no burn (Con0) treatment had the third highest species richness after the Apr3 and Dec3 treatments.

6.2.2.5.7 Differences in species diversity between plots burnt at different frequencies and at different times of the year

In 1954, the species diversity was not significantly different between the Pretoriuskop EBP treatments (Table 6-8). The Oct3 treatment (2.402) had the highest species diversity in 1954, and the Aug2 treatment (1.740) had the lowest species diversity (Table 13-10). In 1996, the Con0 treatment (2.482) had the highest species diversity and the Apr2 treatment (1.855) had the lowest species diversity (Table 13-11). The species diversity was significantly different between the EBP treatments in the Pretoriuskop region (ANCOVA: p = 0.043) (Table 6-8). Tukey Studentized post hoc analyses do not show where the significant differences lie (Table 14-15). Between 1954 and 1996, the species diversity decreased on the Apr2, Apr3, Oct2, and 0ct3 treatments, and increased on the Aug1, Aug2, Aug3, Con0, Dec2, Dec3, Feb2, and Feb3 treatments.

The rank order of the treatments based on species diversity was not the same for the ANOVA and ANCOVA analyses on the 1996 data (Figure 6-22 and Figure 6-23). The results of the ANOVA and ANCOVA analyses on the species diversity in 1996 differed in the relative placement of the Apr3, Aug2, Oct2, and Oct3 treatments. In the ANOVA analysis, the species diversity on the Apr3 treatment was higher than the Aug1 treatment, the species diversity on the Aug2 treatment was lower than the Aug3 treatment, the species diversity on the Oct2 treatment was higher than the Feb3 treatment, and the Oct3 treatment had the fourth lowest species diversity. In the ANCOVA analysis, the species diversity on the Apr3 treatment was lower than the Aug1 treatment, the species diversity on the Aug2 treatment was higher than the Aug3 treatment, the species diversity on the Oct2 treatment was lower than the Feb3 treatment, and the Oct3 treatment had the lowest species diversity. Looking at the ANCOVA analysis, the species diversity on the biennial

treatments is higher than on the triennial treatments at the same time of the year on the February, August, and October treatments in 1996. The species diversity in 1996, on the biennial treatments was lower than on the triennial treatments at the same time of the year on the April and December treatments.

Generally, treatments burnt in the wet season (February and December) tend to have higher species diversity than treatments burnt in the dry season (August and October). The April treatments tend to have the lowest species diversity and the no burn (Con0) treatments have the highest species diversity.

6.2.2.5.8 Differences in species evenness between plots burnt at different frequencies and at different times of the year

In 1954 and 1996, the species evenness was not significantly different between the Pretoriuskop EBP treatments (Table 6-8). The Oct3 treatment (0.786) had the highest species evenness in 1954, and the Dec3 treatment (0.613) had the lowest species evenness (Table 13-10). In 1996, the Con0 treatment (0.688) had the highest species evenness and the Aug2 treatment (0.579) had the second lowest species evenness (Table 13-11). Between 1954 and 1996, the species evenness decreased on the Apr2, Apr3, Aug1, Aug2, Aug3, Con0, Dec2, Feb2, Feb3, Oct2, and Oct3 treatment, and the species evenness increased on the Dec3 treatment.

The rank order of the treatments based on the species evenness was not the same for the ANOVA and ANCOVA analyses on the 1996 data (Figure 6-22 and Figure 6-23). The results of the ANOVA and ANCOVA analyses on the species evenness in the 1996 differed in the relative placement of the Apr3, Aug2, Dec2, Dec3, Feb2, and Feb3 treatments. In the ANOVA analysis on the species evenness, the Apr3 treatment was higher than the Apr2 treatment, the Aug2 treatment was lower than the Aug3 treatment, the Dec2 treatment was higher than the Aug3 treatment, the Dec3 treatment was lower than on the Dec2 treatment, the Feb2 treatment was the same as the Oct2 treatment, and the Feb3 treatment was lower than the Oct2 treatment. In the ANCOVA analysis on the species evenness, the Apr3 treatment was lower than the Apr2 treatment, the Aug2 treatment was higher than the Aug3 treatment, the Dec2 treatment was the same as the Aug3 treatment, the Dec3 treatment was higher than on the Dec2 treatment, the Feb2 treatment was higher than the Oct2 treatment, and the Feb3 treatment was the same as Oct2 treatment. Looking at the ANCOVA analysis, the species evenness in 1996 on the biennial treatments is higher than the triennial treatments at the same time of the year on the February, April, August, and October treatments. The species evenness in 1996 was lower on the biennial treatment in December than the triennial treatment in December.

6.2.2.5.9 Differences in the number of structural groups between plots burnt at different frequencies and at different times of the year

In 1954, the number of structural groups was not significantly different between the Pretoriuskop EBP treatments (Table 6-8). The Aug1 treatment (18.250) had the highest mean number of structural groups in 1954, and the Aug3 treatment (11.500) had the lowest mean number of structural groups (Table 13-10). In 1996, the Con0 treatment (21.000) had the highest mean number of structural groups, and the Oct3 treatment (15.750) had lowest mean number of structural groups (Table 13-11). The number of structural groups was significantly different between the Pretoriuskop EBP treatment in 1996 (ANCOVA: $p = 0.084$) (Table 6-8). Tukey Studentized post hoc analyses do not show where the significant differences lie (Table 14-15). Between 1954 and 1996, the number of structural groups increased on the Apr2, Apr3, Aug2, Aug3, Con0, Dec2, Dec3, Feb2, Feb3, Oct2, and Oct3 treatments and decreased on the Aug1 treatment.

The rank order of the treatments based on the number of structural groups was not the same for the ANOVA and ANCOVA analyses on the 1996 data (Figure 6-22 and Figure 6-23). The results of the ANOVA and ANCOVA analyses on the number of structural groups in 1996 differed in the relative placement of the Apr3, Aug1, Aug3, Feb2, and Oct3 treatments. In the ANOVA analysis on the number of structural groups, the Apr3 treatment had the fifth highest number of structural groups, the Aug1 treatment had the third lowest number of structural groups, the Aug3 treatment was lower than the Aug2 treatment, the Feb2 treatment was lower than the Con0 treatment, and the Oct3 treatment had the lowest number of structural groups. In the

ANCOVA analysis on the number of structural groups, the Apr3 treatment had the third highest number of structural groups, the Aug1 treatment had the lowest number of structural groups, the Aug3 treatment was higher than the Aug2 treatment, the Feb2 treatment was higher than the Con0 treatment, and the Oct3 treatment had the second lowest number of structural groups. Looking at the ANCOVA analysis, the biennial treatment had lower number of structural groups in 1996 than the triennial treatments at the same time of the year on the April, August, and December treatments. The number of structural groups in 1996 was higher on the biennial treatments than on the triennial treatments at the same time of the year on the October and December treatments.

Generally, the treatments burnt in the dry season (August and October) tend to have a lower number of structural groups than treatments burnt in the wet season (February and December). The no burn (Con0) treatment had the highest number of structural groups in 1996.

6.2.2.5.10 Differences in structural richness between plots burnt at different frequencies and at different times of the year

In 1954, the structural richness was highest on the Oct3 treatment (0.426) and lowest on the Aug3 treatment (0.265) (Table 13-10 and Figure 6-21). The structural richness was significantly different between the Pretoriuskop EBP treatments in 1954 ($p = 0.012$) (Table 6-8). Tukey Studentized post hoc analyses show that the Aug3 treatment had a significantly lower structural richness than the Con0 (0.020) and Oct3 (0.009) treatments (Table 14-13). In 1996, the structural richness was not significantly different between the Pretoriuskop EBP treatments (Table 6-8). The Dec3 treatment (0.282) had the highest structural richness in 1996 and the Dec2 treatment (0.218) had the lowest (Table 13-11 and Figure 6-22). Between 1954 and 1996, the structural richness decreased on all Pretoriuskop EBP treatments.

The rank order of the treatments based on the structural richness was not the same for the ANOVA and ANCOVA analyses on the 1996 data (Figure 6-22 and Figure 6-23). The results of the ANOVA and ANCOVA analyses on the structural richness in 1996 differed in the relative placement of the Aug3 treatment. In the ANOVA analysis, the structural richness on the Aug3 treatment was lower than on the Aug2 treatment. In the ANCOVA analysis, the structural richness on the Aug3 treatment was higher than on the Aug2 treatment. Looking at the ANCOVA analysis, the biennial treatments had higher structural richness than the triennial treatments at the same time of the year on the October treatments (Figure 6-23). The structural richness was lower on the biennial treatments in 1996 than on the triennial treatments at the same time of the year on the February, April, August, and December treatments. The no burn (Con0) treatment had the fifth lowest structural richness in 1996.

Pattern in the structural richness between the different treatments is subtle, generally looking at the ANCOVA analysis the structural richness increases as the inter-fire period increases from 1 year to 3 years at the same time of the year. However, this trend does not continue as the inter-fire period increases beyond 3 years, because the structural richness decreases at some point between 3 years and 42 years.

6.2.2.5.11 Differences in structural diversity between plots burnt at different frequencies and at different times of the year

In 1954, the structural diversity between the Pretoriuskop EBP treatments was not significantly different (Table 6-8). The structural diversity was highest on the Aug1 treatment (1.897) and lowest on the Dec2 treatment (1.554) in 1954 (Table 13-10 and Figure 6-21). In 1996, the structural diversity was highest on the Con0 treatment (1.918) and lowest on the Aug1 treatment (1.162) (Table 13-11 and Figure 6-22). The structural diversity was significantly different between the Pretoriuskop treatments in 1996 (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$) (Table 6-8). Tukey Studentized post hoc analyses show that the structural diversity on the Aug1 treatment was significantly lower than on the Apr2 (ANOVA: $p = 0.007$, ANCOVA: $p = 0.004$), Apr3 (ANOVA: $p = 0.009$, ANCOVA: $p = 0.002$), Aug3 (ANOVA: $p = 0.037$, ANCOVA: $p = 0.009$), Dec2 (ANOVA: $p = 0.066$, ANCOVA: $p = 0.015$), Dec3 (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$), Feb2 (ANCOVA: $p = 0.007$), Feb3 (ANOVA: $p = 0.003$, ANCOVA: $p = 0.001$), Oct2 (ANOVA: $p = 0.003$, ANCOVA:

p = 0.001), and Oct3 (ANOVA: p = 0.005, ANCOVA: p = 0.002) treatments in 1996 (Table 14-14 and Table 14-15). Post hoc analyses show that the structural diversity on the Con0 treatment was significantly higher than the Aug1 (ANOVA: p = 0.001, ANCOVA: p = 0.001), Aug2 (ANOVA: p = 0.004, ANCOVA: p = 0.004), Aug3 (ANOVA: p = 0.063), Dec2 (ANOVA: p = 0.035), and Feb2 (ANOVA: p = 0.006, ANCOVA: p = 0.031) treatments in 1996. Post hoc analyses also show that the structural diversity on the Dec3 treatment was significantly higher than on the Aug2 treatment in 1996 (ANCOVA: p = 0.057). Between 1954 and 1996, the structural diversity decreased on the Apr2, Apr3, Aug1, Aug2, Aug3, Dec2, Feb2, Feb3, Oct2, and Oct3 treatments and increased on the Con0 and Dec3 treatments.

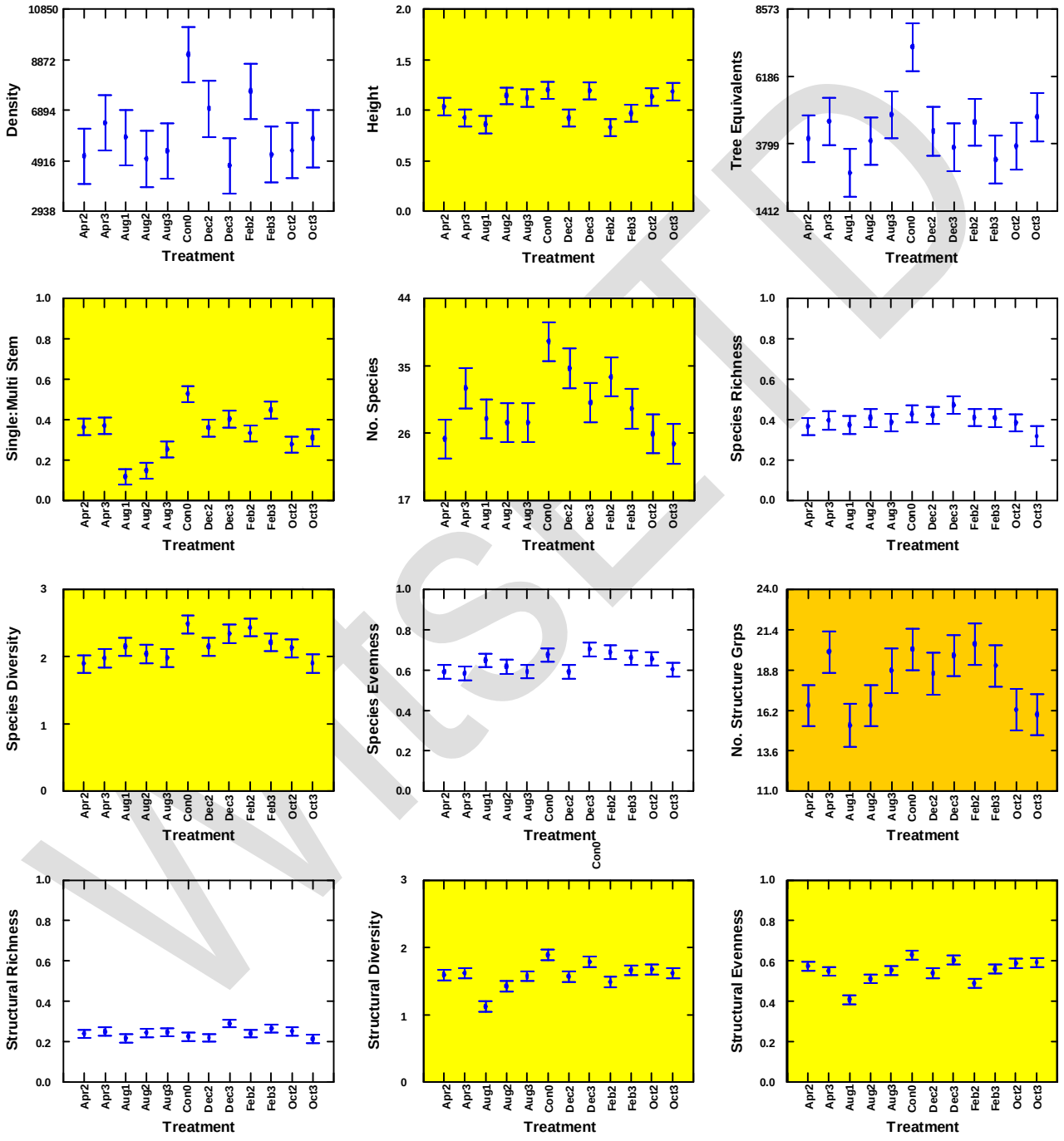


Figure 6-22: The least squares means and standard errors of the vegetation indices from the ANCOVA analyses on the 1996 data (with the 1954 data as covariates) testing the effect of the different treatments assigned to plots taking into account the state of the plots before the treatments began. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

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The rank order of the treatments based on the structural diversity was not the same for the ANOVA and ANCOVA analyses on the 1996 data (Figure 6-22 and Figure 6-23). The results of the ANOVA and ANCOVA analyses on the structural diversity in 1996 differ in the relative placement of the Apr3 and Oct2 treatments. In the ANOVA analysis, the structural diversity on the Apr3 treatment was lower than on the Apr2 treatment, and the structural diversity on the Oct2 treatment was lower than on the Feb3 treatment. In the ANCOVA analysis, the structural diversity on the Apr3 treatment was higher than on the Apr2 treatment, and the structural diversity on the Oct2 treatment was higher than on the Feb3 treatment. Looking at the ANCOVA analysis, the biennial treatments tend to have lower structural diversities than the triennial treatments at the same time of the year on the February, April, August and December treatments in 1996. The biennial October treatment had a higher structural diversity than the triennial October treatment in 1996. Generally regarding to the fire frequency, the structural diversity increases as the inter-fire period increases from 1 year to 3 years, and beyond 3 years at the same time of the year. Regarding the fire timing, the structural diversity is lowest on treatments burnt in August, December biennially, and February biennially, the structural diversity is highest on the treatments not burnt and those burnt in December triennially.

6.2.2.5.12 Differences in structural evenness between plots burnt at different frequencies and at different times of the year

In 1954, the structural evenness between the Pretoriuskop EBP treatments was not significantly different (Table 6-8). The structural evenness was highest on the Aug3 treatment (0.694) and was lowest on the Oct2 treatment (0.590) in 1954 (Table 13-10 and Figure 6-21). In 1996, the structural evenness was highest on the Con0 treatment (0.631) and lowest on the Aug1 treatment (0.409) (Table 13-11 and Figure 6-22). The structural evenness was significantly different between the Pretoriuskop EBP treatment in 1996 (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$) (Table 6-8). Tukey Studentized post hoc analyses show that the structural evenness was significantly higher on the Con0 treatment than on the Aug1 (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$), Aug2 (ANOVA: $p = 0.021$, ANCOVA: $p = 0.027$), and Feb2 (ANOVA: $p = 0.003$, ANCOVA: $p = 0.005$) treatments in 1996 (Table 14-14 and Table 14-15). Post hoc analyses show that the structural evenness was significantly lower on the Aug1 treatment than on the Apr2 (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$), Apr3 (ANOVA: $p = 0.004$anc 0.005), Aug3 (ANOVA: $p = 0.002$, ANCOVA: $p = 0.004$), Dec2 (ANOVA: $p = 0.001$, ANCOVA: $p = 0.012$), Dec3 (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$), Feb3 (ANOVA: $p = 0.002$, ANCOVA: $p = 0.002$), Oct2 (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$), and Oct3 (ANOVA: $p = 0.001$, ANCOVA: $p = 0.001$) treatment in 1996. Post hoc analyses also show that the Feb2 treatment had a significantly lower structural evenness than the Dec3 (ANOVA: $p = 0.039$, ANCOVA: $p = 0.040$) and Oct3 (ANOVA: $p = 0.062$, ANCOVA: $p = 0.096$) treatments in 1996. Between 1954 and 1996, the structural evenness decreased on all the Pretoriuskop EBP treatments.

The biennial treatments had a lower structural evenness than the triennial treatments at the same time of the year on the February, August, October and December treatments in 1996. The April biennial treatment had a higher structural evenness than the April triennial treatment in 1996.

Generally regarding to the fire frequency, the structural evenness increases as inter-fire period increases from 1 year to 3 years and beyond 3 years at the same time of the year. Regarding the fire timing, the structural evenness is lowest on treatments burnt in August, December biennially, and February biennially, and the structural evenness is highest on the treatments not burnt and those burnt in December triennially.

6.2.2.6 Testing for differences in the woody vegetation density, structure and composition on the Pretoriuskop EBP Control (no burn) plots between 1954, 1959 and 1996

The results from the Analyses of Variance used to test differences in the woody vegetation between the surveys on the Control treatments in 1954, 1959, and 1996 of the Pretoriuskop EBPs are presented in Table 6-9 (p. 109) and Figure 6-22 (p. 107). The results of the post hoc analyses performed where significant differences were found between the surveys are presented in Table 14-16 (p. 255), and summaries of the data used in these analyses are presented in Appendix 5 in Table 13-12 (p. 235).

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6.2.2.6.1 Differences in woody plant density on the Control treatment between 1954, 1959, and 1996

The density of the woody vegetation (plants/Ha) was lowest in 1954 (1721.5), second highest in 1959 (2396.5), and highest in 1996 (8696.0) (Table 13-12 and Figure 6-22). There was a significant difference in the woody plant density on the Control treatment between 1954, 1959, and 1996 (p = 0.006) (Table 6-9). Tukey Studentized post hoc analyses show that the woody plant density was significantly higher in 1996 than in 1959 (p = 0.015) and 1954 (0.008) (Table 14-16).

The general trend is that as the post fire period increased, the woody plant density increased. The rate of increase in woody plant density (plants/Ha/year) between 1954 and 1959 was 135.0, the rate of increase in density between 1959 and 1996 was 170.3, and the overall rate of increase between 1954 and 1996 was 166.1.

6.2.2.6.2 Differences in the mean woody plant height on the Control treatment between 1954, 1959, and 1996

The mean woody plant height was lowest in 1959 (0.792m), second highest in 1954 (1.116m), and highest in 1996 (1.202m) (Table 13-12 and Figure 6-22). There was a significant difference in the mean woody plant height on the Control treatment between 1954, 1959, and 1996 (p = 0.008) (Table 6-9). Tukey Studentized post hoc analyses show that the mean woody plant height was significantly lower in 1959 than in 1954 (0.030) and 1996 (0.009) (Table 14-16).

The mean woody plant height decreased initially as the inter-fire period increased between 1954 and 1959, and then the mean woody plant height increased as the inter-fire period increased between 1959 and 1996. This result is consistent with the findings on the August treatments in which the mean woody plant height decreased as the inter-fire period increased from 1 year to 3 years, and then the mean woody plant height increased as the inter-fire period increased from 3 years to 42 years.

Table 6-9: Results of the ANOVA analyses on the vegetation indices calculated to test the effects of not burning between 1954 and 1996.

					Taxonomic diversity				Structural diversity			
Statistic	Density	Mean height	Tree equivalents	Single:Multi stem	Number of species	Species Richness	Species diversity	Species evenness	Number of structural groups	Structure richness	Structure diversity	Structure evenness
df	2	2	2	2	2	2	2	2	2	2	2	2
df error	9	9	9	9	9	9	9	9	9	9	9	9
F-ratio	9.602	8.644	18.29	5.12	12.562	0.044	2.282	0.292	3.237	6.066	0.372	0.272
p value	0.006	0.008	0.001	0.033	0.002	0.958	0.158	0.754	0.087	0.021	0.7	0.768

Note: The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

6.2.2.6.3 Differences in the number of tree equivalents on the Control treatment between 1954, 1959, and 1996

The number of tree equivalents (tree equivalents/Ha) was lowest in 1954 (1315.3), second highest in 1959 (1650.3), and highest in 1996 (6963.3) (Table 13-12 and Figure 6-22). There was a significant difference in the number of tree equivalents on the Control treatment between 1954, 1959, and 1996 (p = 0.001) (Table 6-9). Tukey Studentized post hoc analyses show that the number of tree equivalents was significantly higher in 1996 than in 1959 (p = 0.002) and 1954 (p = 0.001) (Table 14-16).

Generally, as the inter-fire period increased, the number of tree equivalents increased. The rate of increase in the number of tree equivalents (tree equivalents/Ha/year) between 1954 and 1959 was 67.0 and the rate of increase in tree equivalents between 1959 and 1996 was 143.6, which was almost double the rate of increase from 1954 to 1959. The overall rate of increase of number of tree equivalents between 1954 and 1996 was 134.5.

6.2.2.6.4 Differences in the single-stem to multi-stem index on the Control treatment between 1954, 1959, and 1996

The single-stem to multi-stem index was lowest in 1996 (0.539), second highest in 1959 (0.548), and highest in 1954 (0.738) (Table 13-12 and Figure 6-22). There was a significant difference in the single-stem to multi-stem index on the Control treatment between 1954, 1959, and 1996 ($p = 0.002$) (Table 6-9). Tukey Studentized post hoc analyses show that the single-stem to multi-stem index was significantly higher in 1954 than in 1959 ($p = 0.057$) and 1996 ($p = 0.047$) (Table 14-16).

Generally, as the inter-fire period increased, the single-stem to multi-stem index decreased. That is the number of single-stem individuals relative to multi-stem individuals decreased at first rapidly and then less so as the inter-fire period increased.

6.2.2.6.5 Differences in the number of species on the Control treatment between 1954, 1959, and 1996

The mean number of species was lowest in 1954 (17.3), second highest in 1959 (20.0), and highest in 1996 (37.5) (Table 13-12and Figure 6-22). There was a significantly difference in the number of species on the Control treatment between 1954, 1959, and 1996 ($p = 0.033$) (Table 6-9). Tukey Studentized post hoc analyses show that the number of species was significantly higher in 1996 than in 1959 ($p = 0.003$) and 1954 ($p = 0.008$) (Table 14-16).

Generally, as the inter-fire period increased, the number of species increased. The rate of increase in number of species (number of species/year) between 1954 and 1959 was 0.55, the rate of increase in number of species between 1959 and 1996 was 0.47, and the overall rate of increase in number of species between 1954 and 1996 was 0.48.

6.2.2.6.6 Differences in species richness on the Control treatment between 1954, 1959, and 1996

Species richness was lowest in 1959 (0.410), second highest in 1954 (0.423), and highest in 1996 (0.424) (Table 13-12and Figure 6-22). There was no significant difference in the species richness on the Control treatment between 1954, 1959, and 1996 (Table 6-9).

6.2.2.6.7 Differences in species diversity on the Control treatment between 1954, 1959, and 1996

Species diversity was lowest in 1954 (2.054), second highest in 1959 (2.058), and highest in 1996 (2.482) (Table 13-12and Figure 6-22). There was no significant difference in species diversity on the Control treatment between 1954, 1959 and 1996 (Table 6-9).

Generally, as the inter-fire period increased the species diversity increased. The rate of increase in species diversity on the Control treatment between 1954 and 1959 was 0.001, the rate of increase in species diversity between 1959 and 1996 was 0.011, and the overall rate of increase in species diversity between 1954 and 1996 was 0.010.

6.2.2.6.8 Differences in species evenness on the Control treatment between 1954, 1959, and 1996

Species evenness was lowest in 1996 (0.688), second highest in 1959 (0.696), and highest in 1954 (0.727) (Table 13-12and Figure 6-22). There was no significant difference in the species evenness on the Control treatment between 1954, 1959, and 1996 (Table 6-9). Generally, as the inter-fire period increased the species evenness decreased.

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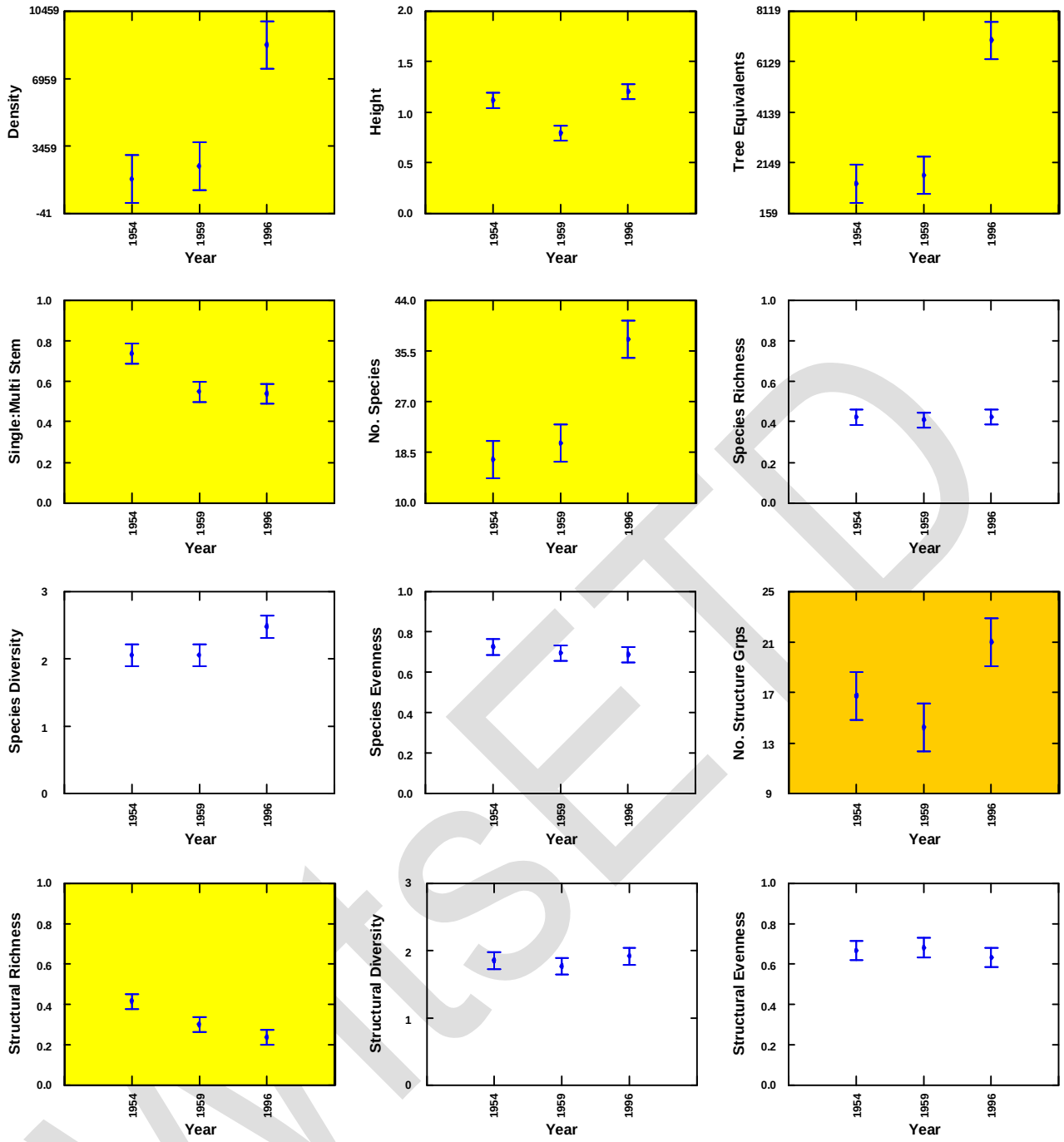


Figure 6-23: The least squares means and standard errors of the vegetation indices from the ANOVA analyses on the 1954, 1959, and 1996 control plot data testing for the effects of not burning. The colour coding shows the level of the test significance (yellow: α=0.05, and orange: α = 0.10).

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6.2.2.6.9 Differences in the number of structural groups on the Control treatment between 1954, 1959, and 1996

The number of structural groups was lowest in 1959 (14.3), second highest in 1954 (16.8), and highest in 1996 (21.0) (Table 13-12and Figure 6-22). There was a significant difference in the number of structural groups on the Control treatment between 1954, 1959, and 1996 (p = 0.087) (Table 6-9). Tukey Studentized post hoc analyses show that the number of structural groups was significantly higher in 1996 than in 1959 (p = 0.077) (Table 14-16).

Generally, with the increase in inter-fire period between 1954 and 1959 the number of structural groups decreased at a rate of 0.5 structures per year. The as the inter-fire period increased between 1959 and 1996

the number of structural groups increased at a rate of 0.18 structures per year. The overall rate of increase in the number of structural groups between 1954 and 1996 was 0.10 structures per year.

6.2.2.6.10 Differences in structural richness on the Control treatment between 1954, 1959, and 1996

The structural richness was lowest in 1996 (0.237), second highest in 1959 (0.300), and highest in 1954 (0.415) (Table 13-12and Figure 6-22). There was a significant difference in the structural richness on the Control treatment between 1954, 1959, and 1996 ($p = 0.021$) (Table 6-9). Tukey Studentized post hoc analyses show that the structural richness was significantly lower in 1996 than in 1954 ($p = 0.018$) (Table 14-16). Generally, as the inter-fire period increased the structural richness decreased.

6.2.2.6.11 Differences in structural diversity on the Control treatment between 1954, 1959, and 1996

The structural diversity was lowest in 1959 (1.765), second highest in 1954 (1.850), and highest in 1996 (1.918) (Table 13-12and Figure 6-22). There was no significant difference in the structural diversity on the Control treatment between 1954, 1959, and 1996 (Table 6-9).

6.2.2.6.12 Differences in structural evenness on the Control treatment between 1954, 1959, and 1996

The structural evenness was lowest in 1996 (0.631), second highest in 1954 (0.666), and highest in 1959 (0.680) (Table 13-12and Figure 6-22). There was no significant difference in structural evenness on the Control treatment between 1954, 1959, and 1996 (Table 6-9).

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6.2.3 Analyses of species composition and structure composition on the Pretoriuskop EBPs using Horn's index of similarity

The hierarchical cluster trees derived from the Pearson-Ward cluster analyses are presented in Figure 6-24 (p. 114), Figure 6-26 (p. 117), Figure 6-28 (p. 120), and Figure 6-30 (p. 123). The distances at which the plot clusters were grouped are shown by two vertical dashed lines on the cluster trees. The distance at which 10 to 12 plot clusters are formed is referred to as "distance 1", and the plot clusters are referred to as the "cluster group 1". The distance at which four clusters are formed is referred to as "distance 2" and the plot clusters are referred to as the "cluster group 2". In the cluster tree figures, the plot clusters in the cluster group 1 are denoted by clear boxes, and each cluster is identified by a number on the left hand side. The plot clusters in cluster group 2 are denoted by coloured boxes, and each cluster is identified by a letter on the left hand side.

Each Pearson-Ward cluster tree has a corresponding map showing the layout of the Pretoriuskop EBPs with the plots colour coded according to the cluster grouping at distance 2 in Figure 6-25 (p. 115), Figure 6-27 (p. 118), Figure 6-29 (p. 121), and Figure 6-31 (p. 124). The colours of the Pretoriuskop EBPs (red, green, , and yellow) on the maps correspond to the colours used for the clusters at distance 2 on the Pearson-Ward cluster trees.

6.2.3.1 Pearson-Ward cluster analysis on the similarity of species between EBPs in 1954

In 1954, the first cluster grouping at distance 1 showed that cluster 11 comprised only Numbi replicate plots (Figure 6-24). Looking at Figure 6-25, the Oct2, Dec2, and Dec3 plots in cluster 11 were adjacent to one another, and the Aug3, Aug2, and Apr2 plots in cluster 11 were adjacent to one another (Figure 6-25). Cluster 3 comprised mainly Fayi replicate plots, and all the plots in cluster 3 were adjacent to one another. Cluster 4 comprised mainly Kambeni plots, and all the plots in cluster 4 were adjacent to one another on this replicate. Cluster 10 comprised mainly Shabeni replicate plots. The Shabeni Control, Dec2, and Oct2 plots in cluster 10 were adjacent to one another, and that the Shabeni Apr3 and Dec3 plots in cluster 10 were adjacent to one another.

In 1954, the second cluster grouping up the hierarchy at distance 2 showed that the plots on the Fayi replicate were found in both clusters A and B, the plots on the Numbi and Shabeni replicates were found in clusters C and D, and the plots on the Kambeni replicate were found in clusters A, B, C, and D (Figure 6-24). The Pearson-Ward cluster tree showed that species composition of the plots in clusters A and B were most similar. The map of the EBPs with the SADF vegetation classification showed that the plots in clusters A and B were found in the closed *Terminalia sericea* - *Combretum* woodlands of the Pretoriuskop region (Figure 6-25). The cluster tree showed that the species composition of the plots in cluster C was similar to that of the plots in clusters A and B, and looking at the layout of the plots, the plots in cluster C were found in the open *Terminalia sericea* - *Combretum* woodlands of the Pretoriuskop region. The cluster tree also showed that the species composition of plots in cluster D was least similar to that of clusters A, B and C. Looking at the layout of the plots in Pretoriuskop, the plots in cluster D were found in the open *Terminalia sericea* - *Combretum* woodlands of the Pretoriuskop region.

In 1954, the species composition was similar between plots that were in close proximity for example occurring adjacent to one another or in the same replicate. Furthermore, species composition was also similar between plots that occurred in the same vegetation type for example the open or closed *Terminalia sericea* - *Combretum* woodlands. For example, the dominant vegetation type on the Fayi replicate was *Terminalia sericea* - *Combretum* closed woodland, the dominant vegetation type on the Numbi and Shabeni replicates was *Terminalia sericea* - *Combretum* open woodland, and that of the Kambeni replicate was a transition between the open and closed *Terminalia sericea* - *Combretum* woodlands (Figure 6-25)..

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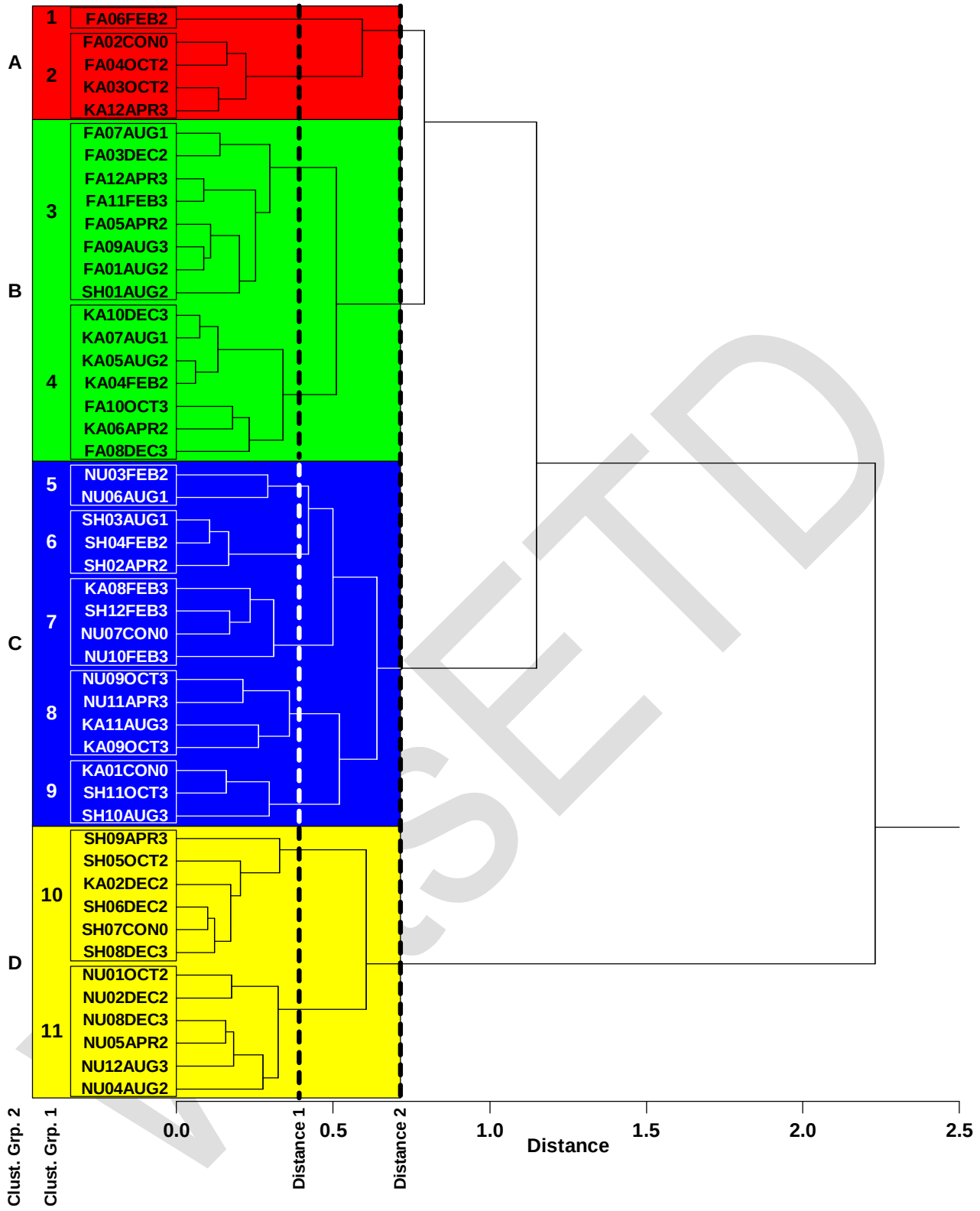


Figure 6-24: Hierarchical cluster tree from a Pearson-Ward cluster analysis on Horn's indices of similarity in species between Pretoriuskop EBPs in 1954. The codes for the treatment plots are defined in Table 10-1 (p. 214).

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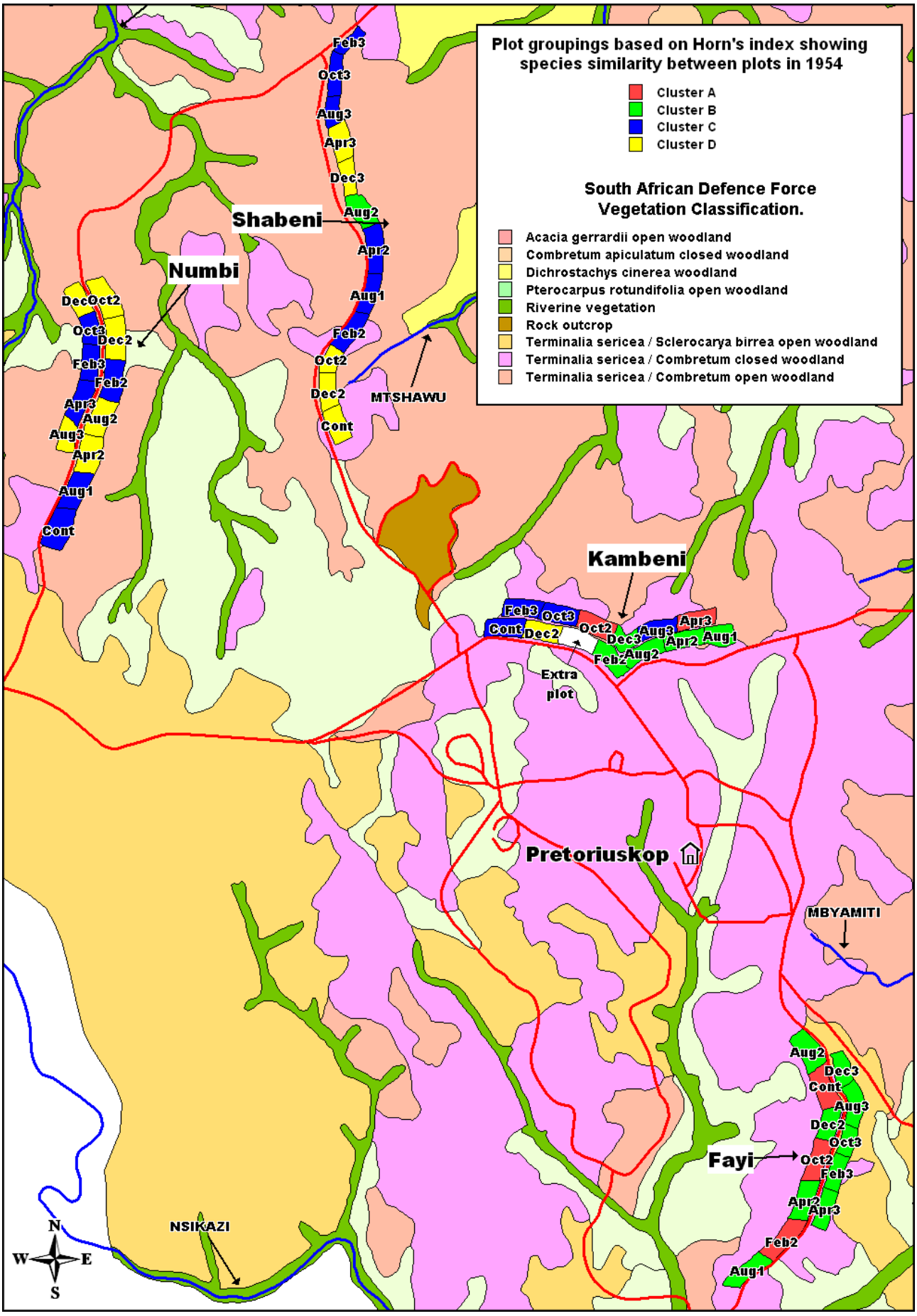


Figure 6-25: Map showing the clustering of the Pretoriuskop EBPs at distance 2 from the Pearson-Ward cluster analysis on Horn's indices of similarity in species between plots in 1954 shown in Figure 6-24.

6.2.3.2 Pearson-Ward cluster analysis on the similarity of species between EBPs in 1996

In 1996, the first cluster grouping at distance 1 showed that cluster 1 comprised only Shabeni replicate plots (Figure 6-26). The map of the Pretoriuskop EBPs showed that the Apr2 and Aug2 plots of cluster 1 were adjacent to one another, and the Apr3 and Feb3 plots were not (Figure 6-27). Cluster 3 comprised only Numbi replicate plots, and the map showed that the Feb3, Oct2, Oct3, and Dec2 plots of cluster 3 were adjacent to one another while Apr2 was not. Cluster 8 comprised two Numbi replicate plots, Feb2 and Apr3, which were adjacent to one another on the replicate. Cluster 7 comprised mainly Kambeni replicate plots, and the map showed that the Feb2, Apr2, Apr3, Aug1, Aug2, Oct2, and Dec3 plots of cluster 7 were adjacent to one another while Feb3 was not. The Fayi plots Feb3, Apr2, Apr3, Aug2, Aug3, and Oct3 were grouped together in cluster 7 and the map showed that they were all adjacent to one another excepting the Aug2 plot. Cluster 10 comprised the Control plots for all the replicates and the Dec3 plot from the Fayi replicate.

In 1996, the second cluster grouping up the hierarchy at distance 2 showed that most plots on the Fayi and Kambeni replicates were found in cluster C, and most plots on the Numbi and Shabeni replicates were found in clusters A and B (Figure 6-26, Figure 6-27). The control plots on all the replicates were found in cluster D along with the Dec3 plot from the Fayi replicate.

Generally, the plots that were not burnt between 1954 and 1996 had species compositions that were more similar to one another than with the plots that were burnt between 1954 and 1996. However, as was the case in 1954 the species composition on plots that were burnt between 1954 and 1996 was similar between plots that were in close proximity for example occurring adjacent to one another or in the same replicate. Furthermore, species composition was also similar between plots that occurred in the same vegetation type for example the open or closed *Terminalia sericea* - *Combretum* woodlands.

In a number of cases, plots that were clustered together at distance 1 in 1954 were clustered together in 1996. In other words, there were plots that were similar in species composition in 1954 that were similar in species composition in 1996 regardless of the fire treatment applied. Five of the Fayi plots in cluster 3 in 1954 were clustered together in cluster 6 in 1996. Five of the Kambeni plots in cluster 4 in 1954 were clustered together in cluster 7 in 1996. Three of the Numbi plots in cluster 11 in 1954 were clustered together in cluster 3 in 1996. Three of the four plots clustered together in cluster 2 in 1954 were clustered together in cluster 7 in 1996. There was no clear pattern regarding the fire treatment effects on the similarity of species between the Pretoriuskop EBPs because, many of the plots remained similar in species composition between 1954 and 1996.

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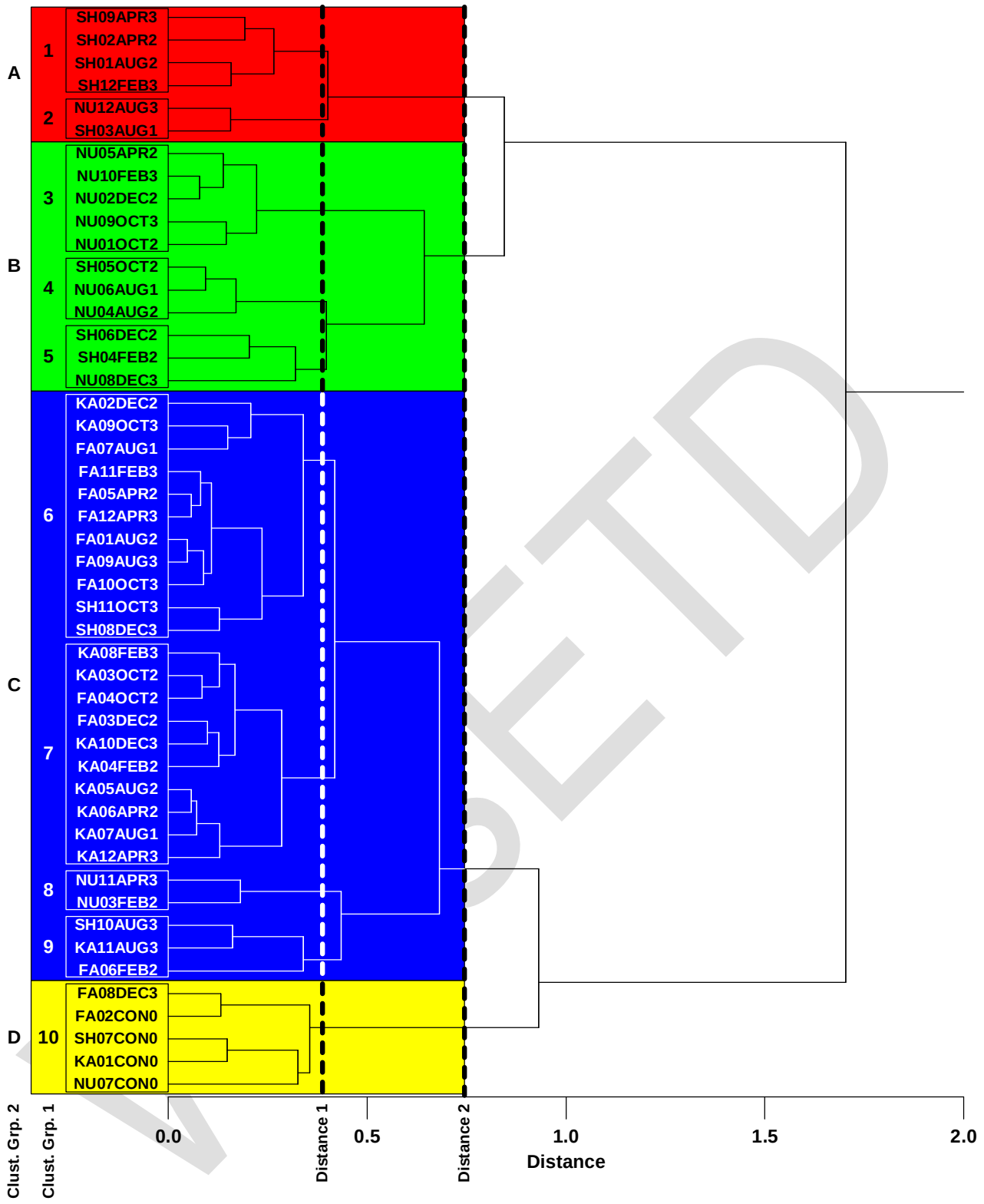


Figure 6-26: Hierarchical cluster tree from a Pearson-Ward cluster analysis on Horn's indices of similarity in species between Pretoriuskop EBPs in 1996. The codes for the treatment plots are defined in Table 10-1 (p. 214)

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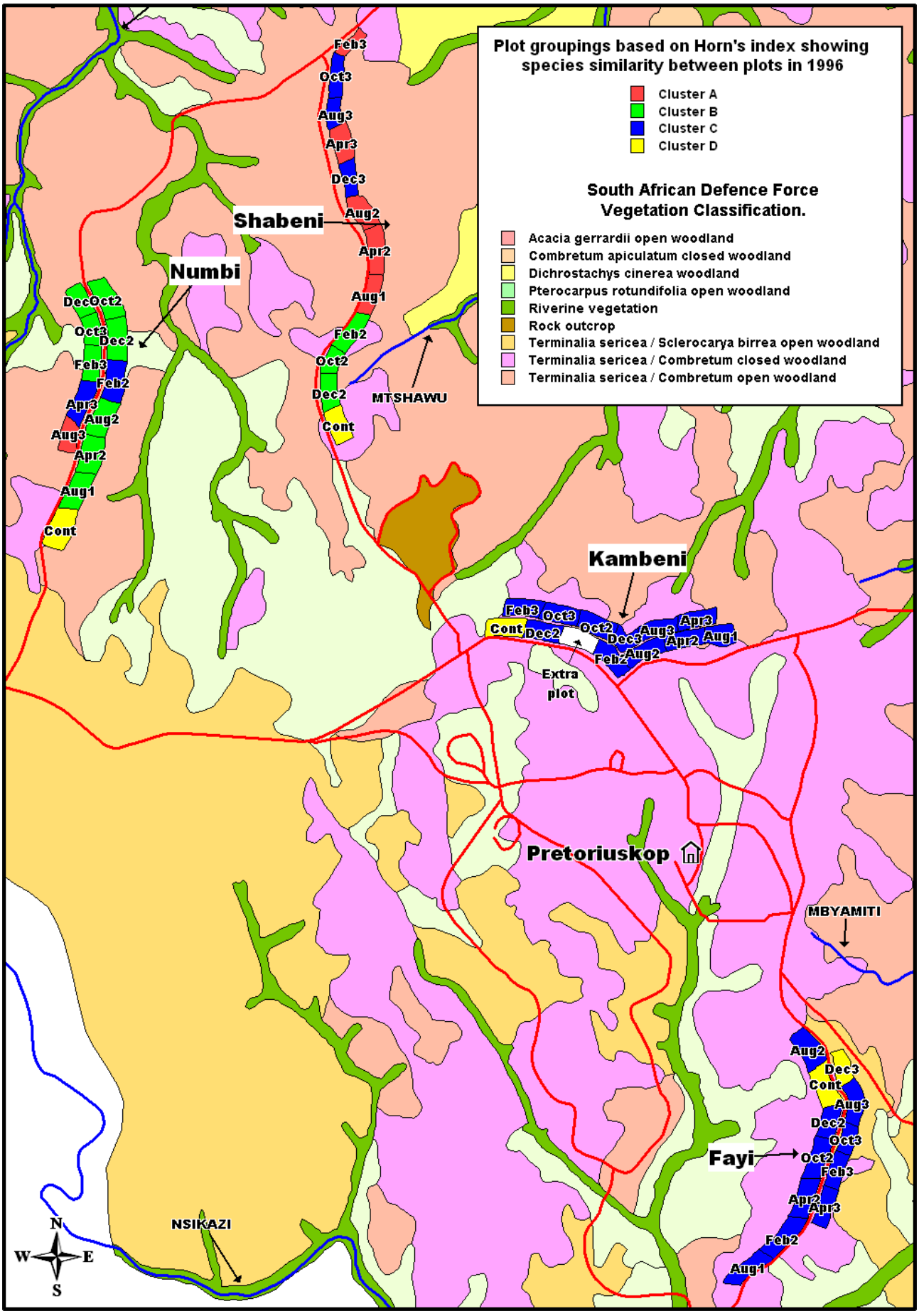


Figure 6-27: Map showing the clustering of the Pretoriuskop EBPs from a Pearson-Ward cluster analysis on Horn's indices of similarity in species between plots in 1996 shown in Figure 6-26.

6.2.3.3 Pearson-Ward cluster analysis on the similarity of structure between EBPs in 1954

In 1954, the first cluster grouping (distance 1) showed that cluster 2 comprised only Fayi replicate plots (Figure 6-28). The map of the Pretoriuskop EBPs showed that the plots in cluster 2 were adjacent to one another on the Fayi replicate (Figure 6-29). Cluster 7 comprised mainly Shabeni replicate plots, and the map showed that almost all the plots in cluster 7 were adjacent to one another on the Shabeni replicate. Cluster 8 comprised mainly Numbi replicate plots, and the map showed that the Control, Apr2, Aug1, and Aug2 plots were adjacent to one another, and the Oct2 and Dec2 plots were adjacent to one another. Cluster 9 comprised mainly Fayi replicate plots and the map showed that the Fayi plots in cluster 9 were adjacent to one another.

In 1954, the second cluster grouping (distance 2) showed that cluster A comprised 4 Kambeni plots, 2 Fayi plots, 1 Shabeni plot, and 1 Numbi plot (Figure 6-28, Figure 6-29). Cluster B comprised six Shabeni plots, five Kambeni plots, four Numbi plots, and three Fayi plots. Cluster C comprised four Shabeni plots, one Numbi plot, and one Kambeni plot. Cluster D comprised seven Fayi plots, six Numbi plots, two Kambeni plots, and one Shabeni plot.

Generally, the woody vegetation structure was similar on adjacent plots or plots that occur in close proximity. Plots from the four replicates were found in all the distance 2 clusters. This suggests that the woody vegetation structure on the plots was not affected by the vegetation type in which the plot occurred. Cluster D comprised seven Fayi plots and six Numbi plots. The vegetation on the locations of the original Fayi and Numbi replicates was burnt in 1953 just before the experiment was set up in 1954. Post fire age may be an important factor contributing to the structure of the woody vegetation of these plots, and may explain why the structure on most of the plots on the original Fayi and Numbi replicates was similar.

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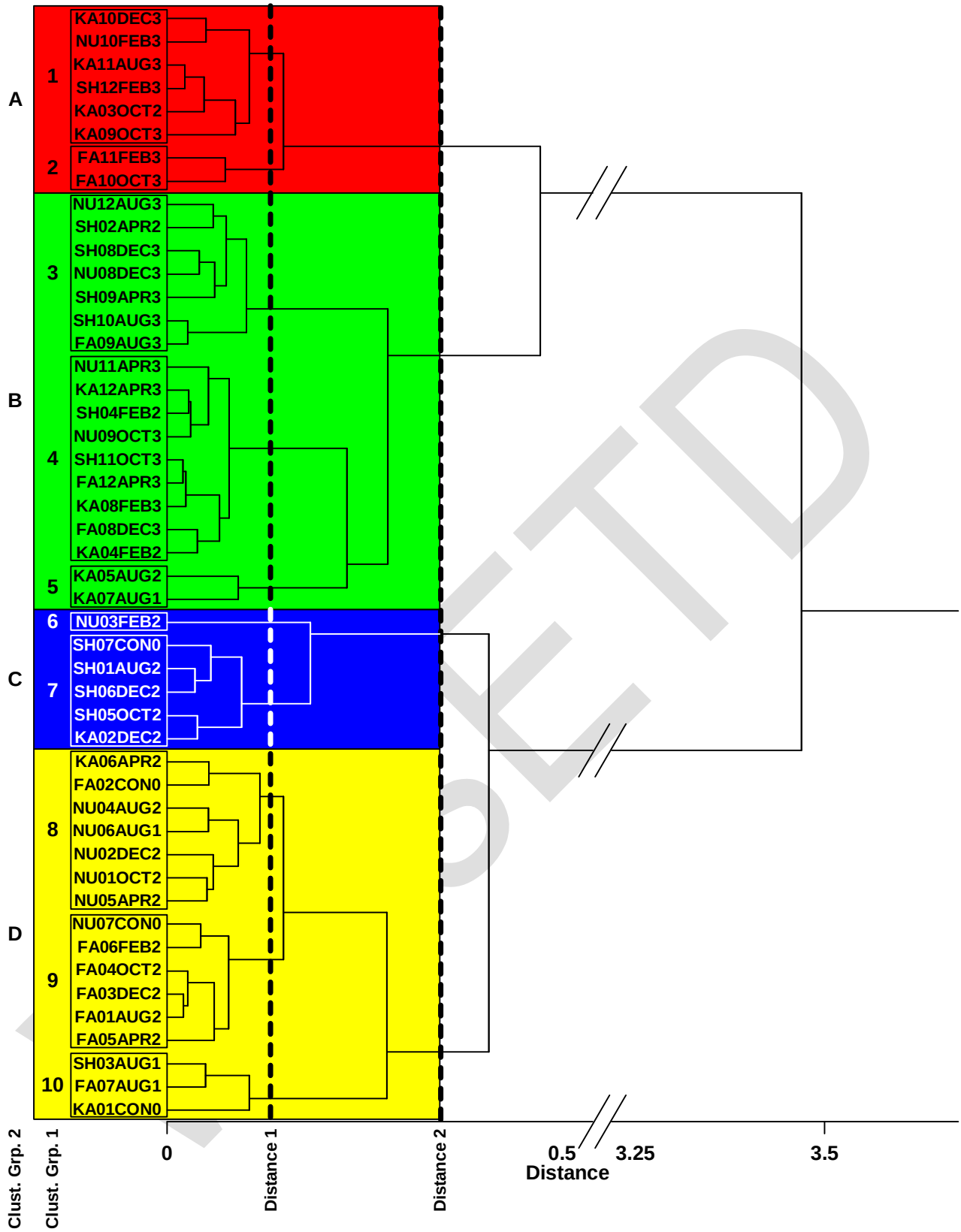


Figure 6-28: Hierarchical cluster tree from a Pearson-Ward cluster analysis on Horn's indices of similarity in structure between Pretoriuskop EBPs in 1954. The codes for the treatment plots are defined in Table 10-1 (p. 214)

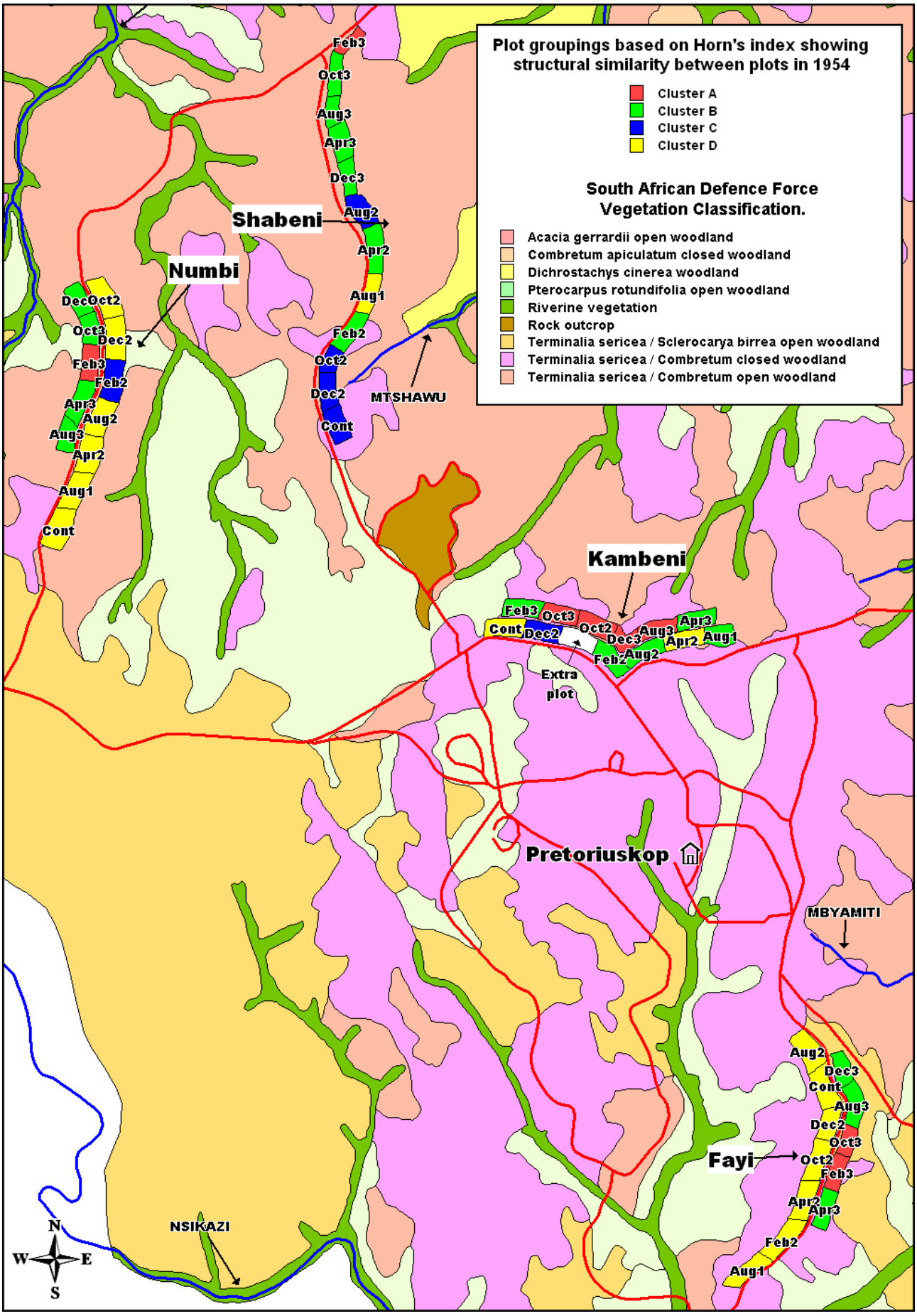


Figure 6-29: Map showing the clustering of the Pretoriuskop EBPs from a Pearson-Ward cluster analysis on Horn's indices of similarity in structure between plots in 1954 shown in Figure 6-28.

6.2.3.4 Pearson-Ward cluster analysis on the similarity of structure between EBPs in 1996

In 1996, the first cluster grouping (distance 1) showed that cluster 1 comprised mainly April fire treatment plots from the Kambeni and Numbi replicates (Figure 6-30). The map of the Pretoriuskop EBPs showed that the April treatment plots in cluster 1 on the Kambeni replicate were adjacent to one another (Figure 6-31). Cluster 2 comprised mainly February, April, and December treatment plots from the Fayi, Kambeni, Numbi, and Shabeni replicates. The map showed that some of the plots in cluster 2 were adjacent to one another, for example the Fayi April treatments, and the Kambeni Feb2 and Dec3 treatments. Cluster 3 comprised only the control treatments on the Kambeni and Shabeni replicates. Cluster 5 comprised mainly February, April, and December treatment plots from the Fayi, Kambeni, and Shabeni replicates. The map showed that the Kambeni Feb2 and Dec2 plots in cluster 5 were adjacent to one another. Cluster 8 comprised mainly August and October treatment plots from the Fayi, Numbi, and Shabeni replicates. The map showed that the Numbi Oct2, Oct3, and Dec2 plots of cluster 8 were adjacent to one another. Cluster 9 comprised two August treatment plots from the Fayi and Kambeni replicates. Cluster 10 comprised only August and October treatment plots from the Kambeni and Shabeni replicates. The map showed that the Kambeni Oct2 and Oct3 treatments of cluster 10 were adjacent to one another, and the Shabeni Aug3 and Oct3 treatments of cluster 10 were adjacent to one another. Cluster 12 comprised three August annual treatments from the Fayi, Numbi, and Shabeni replicates.

In 1996, the second cluster grouping (distance 2) showed that cluster A comprised mainly February, April, December and Control treatment plots that were from the Fayi, Kambeni, Numbi, and Shabeni replicates (Figure 6-30, Figure 6-31). Cluster B had two main groupings the first comprised mainly February, April and December treatments from the Fayi, Kambeni, and Shabeni replicates and the second comprised mainly August and October treatments from the Fayi, Numbi, and Shabeni replicates. Cluster C comprised August and October treatments from the Fayi, Kambeni, and Shabeni replicates. Cluster D comprised Aug1 treatments from the Fayi, Kambeni, Numbi, and Shabeni replicates and the Aug2 treatment from the Fayi replicate.

Generally, the structure of the woody vegetation on plots that was burnt annually in August between 1954 and 1996 was different to the plots that were burnt biennially, triennially or not burnt at all between 1954 and 1996. Plots that were burnt in February, April, and December had similar woody vegetation structure, and plots burnt in August and October had similar woody vegetation structure. The structure of the woody vegetation on plots that were not burnt between 1954 and 1996 was similar to plots that were burnt in February, April, and December.

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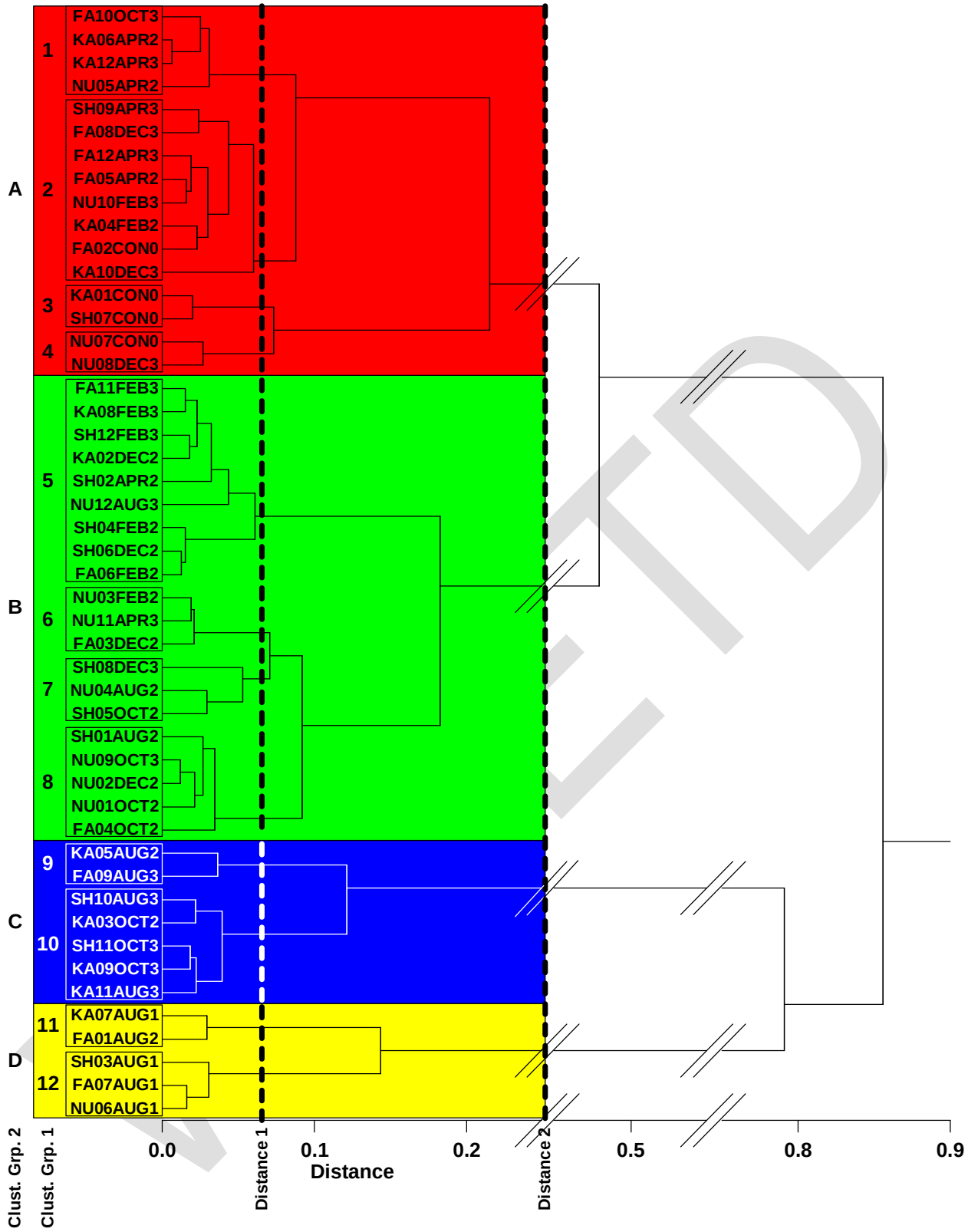


Figure 6-30: Hierarchical cluster tree from a Pearson-Ward cluster analysis on Horn's indices of similarity in structure between Pretoriuskop EBPs in 1996. The codes for the treatment plots are defined in Table 10-1 (p. 214)

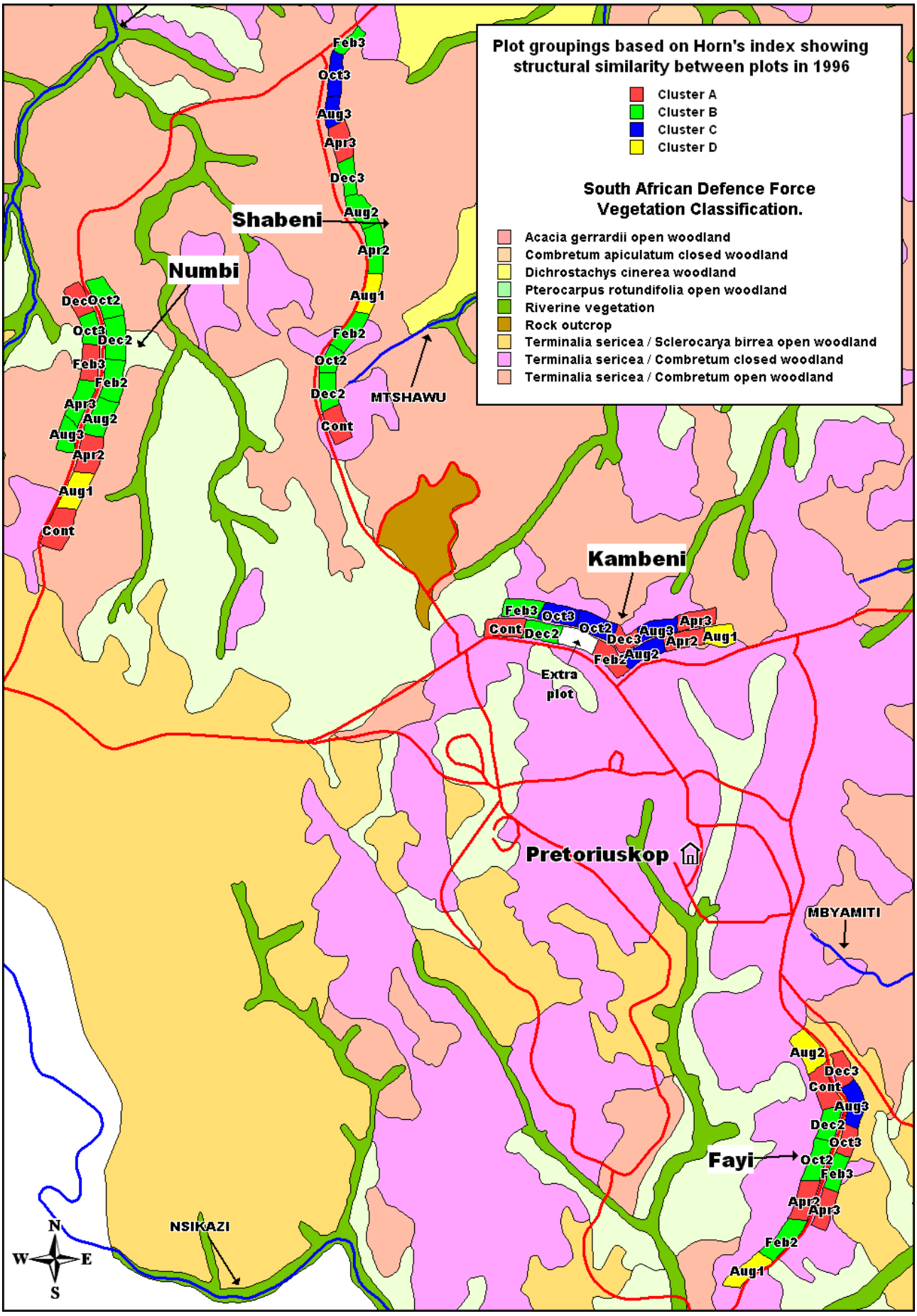


Figure 6-31: Map showing the clustering of the Pretoriuskop EBPs from a Pearson-Ward cluster analysis on Horn's indices of similarity in structure between plots in 1996 shown in Figure 6-30.

6.3 RESULTS FROM THE MULTIVARIATE ANALYSIS EXPLORING THE EFFECTS OF FIRE ON THE COMPOSITION AND STRUCTURE OF THE WOODY VEGETATION OF THE PRETORIUSKOP EXPERIMENTAL BURN PLOTS

In this section, the results from the Correspondence Analyses (CA's) on the 1954 and 1996 survey data are presented in two sections, the first section being the results of the CA's on the species by plot data and the second section being the results of the CA's on the structure by plot data.

For each CA two interpretations of the variation in weighted eigenvectors are presented. In the first interpretation, a traditional bi-plot graph of the first two eigenvectors was used to identify visually groupings in variation along the first two eigenvectors from the CA. In the second interpretation, a step-wise Gamma-Ward cluster analysis was used to identify groupings in variation along the first four eigenvectors from the CA. Many of the general patterns and relationships were similar between the two interpretations, and these general patterns are presented in a separate summary for each CA.

6.3.1 Results from the Correspondence Analysis on the 1954 species by plot data

The results from the CA performed on the 1954 species by plot data are presented in Table 6-10 (p. 125), Figure 6-32 (p. 129), Figure 6-33 (p. 130), Figure 6-34 (p. 131), and Figure 6-35 (p. 132). Table 6-10 shows the Eigenvalues for the first four ordination axes of the CA. Figure 6-32 is a hierarchical cluster tree showing the cluster groups from the step-wise Gamma-Ward cluster analysis on the first four ordination axes. Figure 6-33 is a bi-plot of the first two, weighted eigenvector plot score axes with the data points colour coded to the level 2 cluster colours in Figure 6-32. Figure 6-34 is a bi-plot of the first two, weighted eigenvector species score axes to the data points colour coded with the level 2 cluster colours in Figure 6-32. Figure 6-35 is a map showing the layout of the Pretoriuskop EBP experiment with the plots colour coded to the level 2 cluster colours in Figure 6-32. The weighted eigenvector plot scores for the first four ordination axes, the plot weights and the effective number of species that occur on the plots (N2 species diversity of plots) (Hill 1973) are presented in Appendix 7 Table 15-1 (p. 256). The weighted eigenvector species scores for the first four ordination axes, the species weights, and the effective number of occurrences of the species (N2 diversity of species) are presented in Appendix 7 Table 15-2 (p. 257).

Table 6-10: Eigenvalues for the first four ordination axes of a Correspondence Analysis (CA) on the species by plot data collected in 1954.

	Axis 1	Axis 2	Axis 3	Axis 4	Total
Eigenvalue	0.3176	0.2264	0.1716	0.1449	2.0086
% Variation	15.8	11.3	8.5	7.2	42.8

The Eigenvalues, for the first four axes of the CA on the 1954 data were 0.318, 0.226, 0.172, and 0.145 (Table 6-10). The first four eigenvectors accounted for 15.8%, 11.3%, 8.5%, and 7.2% of the variation in the species by plot data respectively in 1954, and 42.8% of the total variation in the species by plot data in 1954 (Table 6-10).

6.3.1.1 Bi-plots of the first two weighted species and plot eigenvectors showing the relationship between the species and plots in Pretoriuskop in 1954

There were four main groups of species and plots on the bi-plot graphs of the first two weighted eigenvectors from the Correspondence Analysis on the species by plot data in 1954 (Figure 6-33 and Figure 6-34). Group 1 comprised species and plots with x-axis eigenvector values greater than 0.5. Group 2 comprised species and plots with x-axis eigenvector values less than 0.5 and y-axis eigenvector values greater than 0.7. Group 3 comprised species and plots with x-axis eigenvector values less than 0.5 and y-axis eigenvector values between 0.7 and -0.24. Group 4 comprised species and plots with x-axis eigenvector values less than 0.5

and y-axis eigenvector values less than -0.24. The plots in groups 2, 3 and 4 were related to one another by their physical location in the Pretoriuskop landscape.

The plots in Group 1 were the Shabeni Apr3, Fayi Feb2, and Kambeni Aug3 plots (Figure 6-33). These plots occurred in both the open and closed *Terminalia sericea* - *Combretum* woodlands of Pretoriuskop (Figure 6-35). The species in Group 1 were *Acacia exuvialis*, *Acacia gerrardii*, *Combretum hereroense*, *Ormocarpum trichocarpum*, and *Ozoroa sphaerocarpa* (Figure 6-34). *Acacia gerrardii* occurred on all the plots in Group 1. *Acacia gerrardii* was also found in higher densities on the Group 1 plots than other Pretoriuskop EBPs in 1954 (i.e. > 300 plants/Ha). Half the occurrences of *Combretum hereroense* and *Ozoroa sphaerocarpa* on the Pretoriuskop EBPs occurred on the Group 1 plots in 1954. *Acacia exuvialis* was found only on the Group 1 plots in 1954, and it occurred on the Shabeni Apr3 plot.

Group 2 comprised the Kambeni Dec2 plot, the Numbi Oct2, Dec2, Aug2, Apr2, Aug1, Dec3, and Aug3 plots and the Shabeni Oct2, Dec2, Con0, and Dec3 plots (Figure 6-33). These plots occurred in the *Terminalia sericea* - *Combretum* open woodlands of Pretoriuskop (Figure 6-35). The species in Group 2 were *Annona senegalensis*, *Bridelia mollis*, *Bauhinia galpinii*, *Clerodendrum* species, *Combretum collinum*, *Commiphora mollis*, *Lannea discolor*, *Lonchocarpus capassa*, *Olea europaea*, *Papilionacea*, *Parinari curatellifolia*, *Pterocarpus angolensis*, *Senna petersiana*, *Turraea nilotica*, and *Vangueria infausta* (Figure 6-34). *Annona senegalensis* and *Senna petersiana* occurred on all the plots in Group 2 however, they were also found on many other Pretoriuskop EBPs in 1954. *Lonchocarpus capassa* was found on eleven of the twelve Group 2 plots however, it was also found on many other Pretoriuskop EBPs in 1954. Fifty percent of the occurrences of *Bridelia mollis*, *Lannea discolor*, and *Papilionacea*, fifty-seven percent of the occurrences of *Turraea nilotica*, and sixty-three percent of the occurrences of *Pterocarpus angolensis* occurred on the Group 2 plots in 1954. *Clerodendrum* species, *Olea europaea*, and *Commiphora mollis* were found only on Group 2 plots. *Clerodendrum* species was found on the Shabeni Oct2 plot, *Commiphora mollis* was found on the Numbi Oct2 and Dec3 plots, and the Shabeni Dec3 plot, and *Olea europaea* was found on the Numbi Dec3 plot.

Group 3 comprised the Kambeni Feb3 and Apr3 treatments, the Numbi Feb2, Con0, Oct3, Feb3, and Apr3 treatments, and the Shabeni Apr2, Aug1, Feb2, Aug3, Oct3, and Feb3 treatments (Figure 6-33). These plots occurred in the *Terminalia sericea* - *Combretum* open woodlands of Pretoriuskop (Figure 6-35). The species in Group 3 were *Acacia sieberiana*, *Albizia versicolor*, *Catunaregam spinosa*, *Chaetachme aristata*, *Combretum apiculatum*, *Combretum molle*, *Diospyros mespiliformis*, *Dombeya rotundifolia*, *Euclea divinorum*, *Flacourtia indica*, *Grewia monticola*, *Lannea edulis*, *Maytenus heterophylla*, *Maytenus senegalensis*, *Pappea capensis*, *Pavetta schumanniana*, *Pseudarthria hookeri*, *Pterocarpus rotundifolius*, *Rhus pyroides*, *Rhus transvaalensis*, *Schotia brachypetala*, *Sclerocarya birrea*, *Strychnos madagascariensis*, *Syzygium cordatum*, *Vernonia colorata*, and an unidentified species (Figure 6-34). *Sclerocarya birrea* occurred on all the plots in Group 3 however, it was also found on many other Pretoriuskop EBPs in 1954. *Maytenus senegalensis* was found on eleven of the thirteen Group 3 plots and *Strychnos madagascariensis* was found on twelve of the thirteen Group 3 plots however, they were also found on many other plots in 1954. Sixty-seven percent of the occurrences of *Albizia versicolor*, *Catunaregam spinosa*, and *Combretum apiculatum*, and seventy-five percent of the occurrences of an unidentified species on the Pretoriuskop EBPs in 1954 occurred on the Group 3 plots. *Acacia sieberiana*, *Pseudarthria hookeri*, *Pterocarpus rotundifolius*, *Schotia brachypetala*, *Syzygium cordatum*, and *Vernonia colorata* were found only on Group 3 plots. *Acacia sieberiana* was found on the Kambeni Apr3 plot. *Pseudarthria hookeri* was found on the Numbi Oct3 plot. *Pterocarpus rotundifolius* was found on the Numbi Oct3 and Apr3 plots. *Schotia brachypetala* was found on the Numbi Oct3 plot. *Syzygium cordatum* was found on the Kambeni Feb3 plot. *Vernonia colorata* was found on the Kambeni Feb3 and Numbi Feb3 plots.

Group 4 comprised the Fayi Aug2, Con0, Dec2, Oct2, Apr2, Aug1, Dec3, Aug3, Oct3, Feb3, and Apr3 treatments, the Kambeni Con0, Oct2, Feb2, Aug2, Apr2, Aug1, Oct3, and Dec3 treatments, and the Shabeni Aug2 treatment (Figure 6-33). These plots occurred in the *Terminalia sericea* - *Combretum* closed woodlands of Pretoriuskop (Figure 6-35). The species in Group 4 were *Antidesma venosum*, *Cassine transvaalensis*, *Dalbergia melanoxylon*, *Dichrostachys cinerea*, *Diospyros lycioides*, *Ehretia obtusifolia*,

Euclea natalensis, *Ficus stuhlmannii*, *Grewia flavescens*, *Lannea schweinfurthii*, *Mundulea sericea*, *Ochna natalitia*, *Peltophorum africanum*, *Phyllanthus reticulatus*, *Piliostigma thonningii*, *Securinega virosa*, *Strychnos spinosa*, *Terminalia sericea*, *Trichilia emetica*, *Ximenia caffra*, *Zanthoxylum capense*, and *Ziziphus mucronata* (Figure 6-34). *Dichrostachys cinerea* and *Terminalia sericea* occurred on all the plots in Group 4 however, they were also found on all other Pretoriuskop EBPs in 1954. *Mundulea sericea* was found on fifteen of the twenty Group 4 plots and *Ziziphus mucronata* was found on eighteen of the twenty Group 4 plots, and they were found mainly on the plots in Group 4 in 1954. More than half of the occurrences of *Ochna natalitia*, *Zanthoxylum capense*, *Antidesma venosum*, *Grewia flavescens*, *Ehretia obtusifolia*, *Mundulea sericea*, *Piliostigma thonningii*, *Ziziphus mucronata*, and *Trichilia emetica* on the Pretoriuskop EBPs in 1954 occurred on the Group 4 plots. *Cassine transvaalensis*, *Ficus stuhlmannii*, *Lannea schweinfurthii*, and *Strychnos spinosa* were found only on the Group 4 plots. *Cassine transvaalensis* was found on the Fayi Oct2 plot. *Ficus stuhlmannii* was found on the Fayi Oct3 plot. *Lannea schweinfurthii* was found on the Shabeni Aug2 plot. *Strychnos spinosa* was found on the Fayi Dec3 and Kambeni Oct3 plots.

6.3.1.2 Step-wise Ward-Gamma cluster analysis of the first four weighted eigenvectors showing the relationship between the species and plots in Pretoriuskop in 1954

The step-wise Ward-Gamma cluster analysis was used to summarise the variation of plots and species along the first four eigenvectors of the Correspondence Analysis on the 1954 data. There were four main clusters of plots and species at level 2 of the step-wise Ward-Gamma cluster analysis (Figure 6-32). These clusters differed from the two dimensional grouping of plots and species along the first two eigenvectors described above (Figure 6-33 and Figure 6-34).

Cluster 1 comprised Fayi Aug2, Con0, Dec2, Apr2, Feb2, Aug1, Dec3, Oct3, and Apr3 treatments, the Kambeni Oct2, Feb2, Aug2, Apr2, Aug1, Aug3, and Apr3 treatments, and the Shabeni Apr3 treatment (Figure 6-32). A map of the Pretoriuskop EBPs showed that the Kambeni Feb2, Apr2, Apr3, Aug1, Aug2, and Aug3 plots were adjacent to one another, the Fayi Feb2, Apr2, Apr3, and Aug1 plots were adjacent to one another, and the Fayi Aug2, Oct3, Dec2, Dec3, and Con0 plots were adjacent to one another (Figure 6-35). The plots in cluster 1 occurred in the *Terminalia sericea* - *Combretum* closed woodlands of Pretoriuskop (Figure 6-35). These plots were associated with *Dichrostachys cinerea*, *Ehretia obtusifolia*, *Maytenus senegalensis*, *Mundulea sericea*, *Sclerocarya birrea*, *Strychnos madagascariensis*, and *Ziziphus mucronata*, which occurred on more than seventy percent of the plots in cluster 1 (Figure 6-32). Most of these species occurred on many other Pretoriuskop EBPs excepting *Ehretia obtusifolia* and *Ziziphus mucronata*, which occurred mainly on the plots in cluster 1. Some species were found only on the plots in cluster 1 for example, *Acacia exuvialis*, *Acacia sieberiana*, and *Ficus stuhlmannii* occurred on the Shabeni Apr3, Kambeni Apr3, and Fayi Oct3 plots respectively. More than seventy percent of the occurrences of *Phyllanthus reticulatus* on the Pretoriuskop EBPs occurred on the plots in cluster 1. *Phyllanthus reticulatus* occurred on the Fayi Aug2, Dec2, Feb2, and Aug1 plots, and the Kambeni Oct2, Aug1, Aug3, and Apr3 plots.

Cluster 2 comprised Fayi Oct2, Aug3, and Feb3 treatments, the Kambeni Con0, Oct3, and Dec3 treatments, and the Shabeni Aug2, Aug1, and Oct3 treatments (Figure 6-32). A map of the Pretoriuskop EBPs showed that the Fayi Oct2 and Feb3 plots were adjacent to one another (Figure 6-35). The plots in cluster 2 occurred in the open and closed *Terminalia sericea* - *Combretum* woodlands of Pretoriuskop (Figure 6-35). The only species found on more than seventy percent of the cluster 2 plots was *Terminalia sericea*, which however this was found on all the Pretoriuskop EBPs (Figure 6-32). Some species were found only on the plots in cluster 2, for example, *Cassine transvaalensis* and *Lannea schweinfurthii*, which were only found on the Fayi Oct2 and Shabeni Aug2 plots respectively. More than seventy percent of the occurrences of *Trichilia emetica* on the Pretoriuskop EBPs occurred on the cluster 2 plots. *Trichilia emetica* occurred on the Fayi Oct2 plot, and Kambeni Oct3 and Dec3 plots.

Cluster 3 comprised the Kambeni Dec2 plot, the Numbi Dec2 and Aug1 plots, and the Shabeni Apr2, Feb2, Oct2, Dec2, Con0, Dec3, and Aug3 plots (Figure 6-32). A map of the Pretoriuskop EBPs showed that the Shabeni Feb2, Oct2, Dec2, and Con0 plots were adjacent to one another (Figure 6-35). The plots in cluster 3

occur mainly on the *Terminalia sericea* - *Combretum* open woodlands of the Pretoriuskop region (Figure 6-35). These plots were associated with *Maytenus heterophylla*, *Lonchocarpus capassa*, *Pavetta schumanniana*, and *Senna petersiana*, which occurred on more than seventy percent of the plots in cluster 3 (Figure 6-32). These species also occurred on many other Pretoriuskop EBPs. *Clerodendrum* species was found only on the plots in cluster 3 and it occurred on Shabeni Oct2 plot.

Cluster 4 comprised the Kambeni Feb3 plot, the Numbi Oct2, Feb2, Aug2, Apr2, Con0, Dec3, Oct3, Feb3, Apr3, and Aug3 plots, and the Shabeni Feb3 plot (Figure 6-32). A map of the Pretoriuskop EBPs showed that the Numbi Feb2, Feb3, Apr2, Apr3, Aug2, Aug3, Oct2, Oct3, and Dec3 plots were adjacent to one another (Figure 6-35). The plots in cluster 4 occur mainly on the *Terminalia sericea* - *Combretum* open woodlands of the Pretoriuskop region (Figure 6-35). These plots were associated with *Combretum collinum*, *Grewia monticola*, *Parinari curatellifolia*, and *Annona senegalensis*, which occurred on more than seventy percent of the plots in cluster 4 (Figure 6-32). Most of these species occurred on many other Pretoriuskop EBPs excepting *Parinari curatellifolia*, which occurred mainly on the plots in cluster 4. Some species were found only on the plots in cluster 4 however, they did not occur on many plots. For example, *Bauhinia galpinii*, which occurred on the Numbi Aug2, Con0, and Apr3, plots. *Catunaregam spinosa*, which occurred on the Numbi Dec3, Oct3, and Apr3 plots. *Olea europaea*, which occurred on the Numbi Dec3 plot. *Pseudarthria hookeri*, which occurred on the Numbi Oct3 plot. *Pterocarpus rotundifolius*, which occurred on the Numbi Oct3 and Apr3 plots. *Schotia brachypetala*, which occurred on the Numbi Oct3 plot. *Syzygium cordatum*, which occurred on the Kambeni Feb3 plot. *Vernonia colorata*, which occurred on the Kambeni Feb3 and Numbi Feb3 plots. More than seventy percent of the occurrences of *Parinari curatellifolia* and *Lannea discolor* on the Pretoriuskop EBPs occurred on the cluster 4 plots. *Parinari curatellifolia* occurred on the Numbi Aug2 and Dec3 plots, and the Shabeni Feb3 plot. *Lannea discolor* occurred on the Kambeni Feb3 plot, the Numbi Aug2, Apr2, Con0, Dec3, Oct3, Feb3, Apr3, and Aug3 plots, and the Shabeni Feb3 plot.

6.3.1.3 Summary of the results from the CA's on the 1954 species by plot data

In 1954, as with the results from Horn's similarity index, similarity in species composition between plots was mainly because of proximity. Most often plots that were close to one another in space were more likely to be similar in species composition than plots that were further apart. Furthermore, the EBP replicates were located in two main vegetation types in the Pretoriuskop landscape, namely open and closed *Terminalia sericea* - *Combretum* woodlands. The Numbi and Shabeni replicates are located in areas that are dominated by open *Terminalia sericea* - *Combretum* woodlands, and the Kambeni and Fayi replicates are located in areas that are dominated by closed *Terminalia sericea* - *Combretum* woodlands. In 1954, plots on the Numbi and Shabeni replicates in the open *Terminalia sericea* - *Combretum* woodlands were more likely to be similar in species composition than with plots on the Kambeni and Fayi replicates, which were located in the closed *Terminalia sericea* - *Combretum* woodlands.

In 1954, the Numbi and Shabeni replicates in the open *Terminalia sericea* \ *Combretum* woodlands were associated with *Annona senegalensis*, *Senna petersiana*, *Lonchocarpus capassa*, *Bridelia mollis*, *Lannea discolor*, *Papilionacea*, *Turraea nilotica*, *Pterocarpus angolensis*, *Clerodendrum* species, *Olea europaea*, *Commiphora mollis*, *Maytenus heterophylla*, *Pavetta schumanniana*, *Combretum collinum*, *Grewia monticola*, *Bauhinia galpinii*, *Catunaregam spinosa*, *Pseudarthria hookeri*, *Pterocarpus rotundifolius*, *Schotia brachypetala*, *Syzygium cordatum*, and *Vernonia colorata*. Many of the species occurring on the Numbi and Shabeni replicates were found also on the Kambeni and Fayi replicates. In 1954, the Kambeni and Fayi replicates in the closed *Terminalia sericea* \ *Combretum* woodlands were associated with *Ochna natalitia*, *Zanthoxylum capense*, *Antidesma venosum*, *Grewia flavescens*, *Ehretia obtusifolia*, *Mundulea sericea*, *Piliostigma thonningii*, *Ziziphus mucronata*, *Trichilia emetica*, Cassine *transvaalensis*, *Ficus stuhlmannii*, *Lannea schweinfurthii*, *Strychnos spinosa*, *Maytenus senegalensis*, *Sclerocarya birrea*, *Strychnos madagascariensis*, *Acacia exuvialis*, *Acacia sieberiana*, *Ficus stuhlmannii*, and *Phyllanthus reticulatus*. Unlike the Numbi and Shabeni replicates, many of the species occurring on the Kambeni and Fayi replicates were found mainly on the Kambeni and Fayi replicates.

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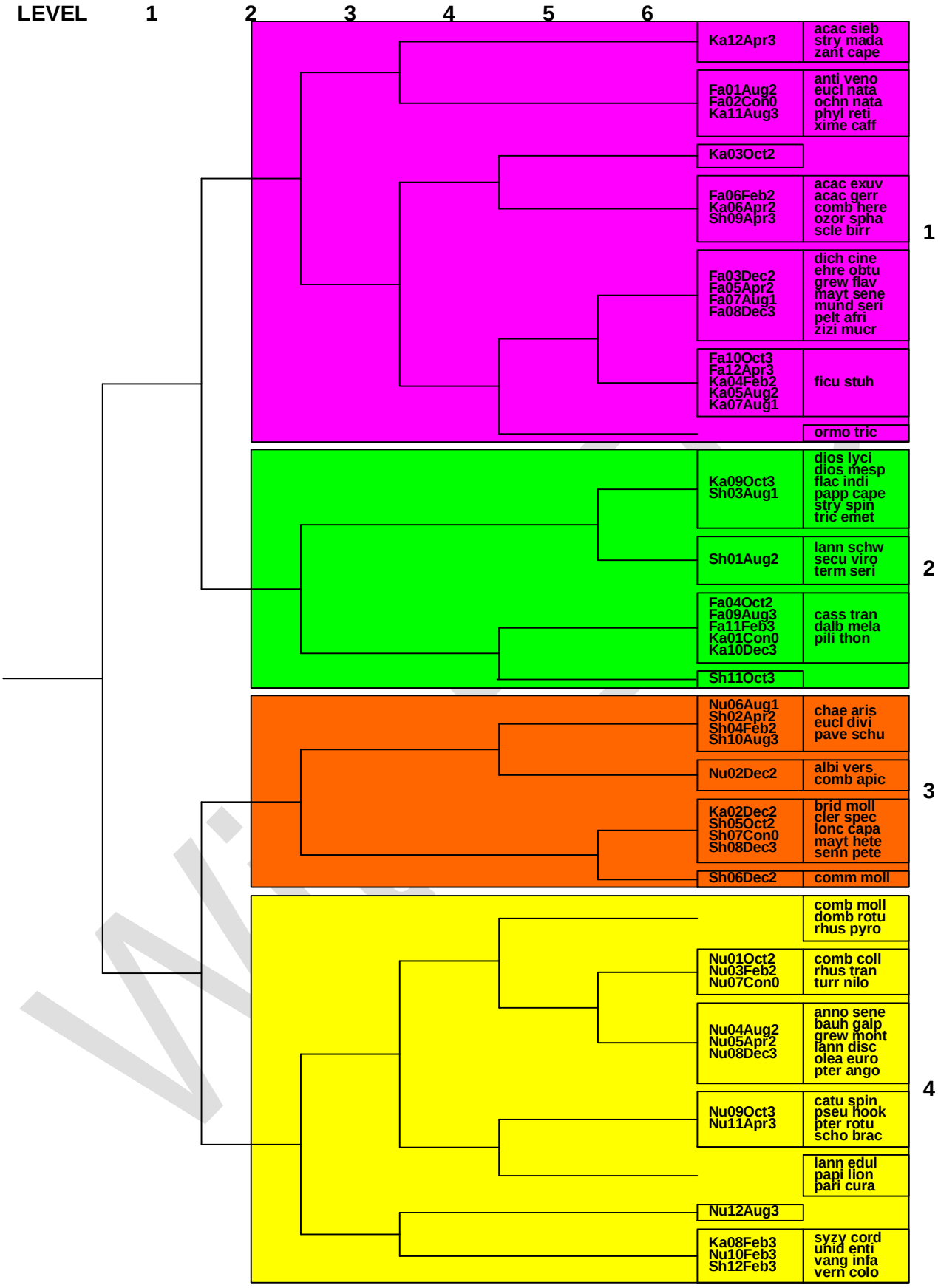


Figure 6-32: Classification of treatment plots and species using a step-wise Gamma-Ward cluster analysis on the first four ordination axes from the CA on the 1954 species by plot data. The codes for the treatment plots are defined in Table 10-1 (p. 214) and the codes for the species are defined in Table 9-1 (p. 210).

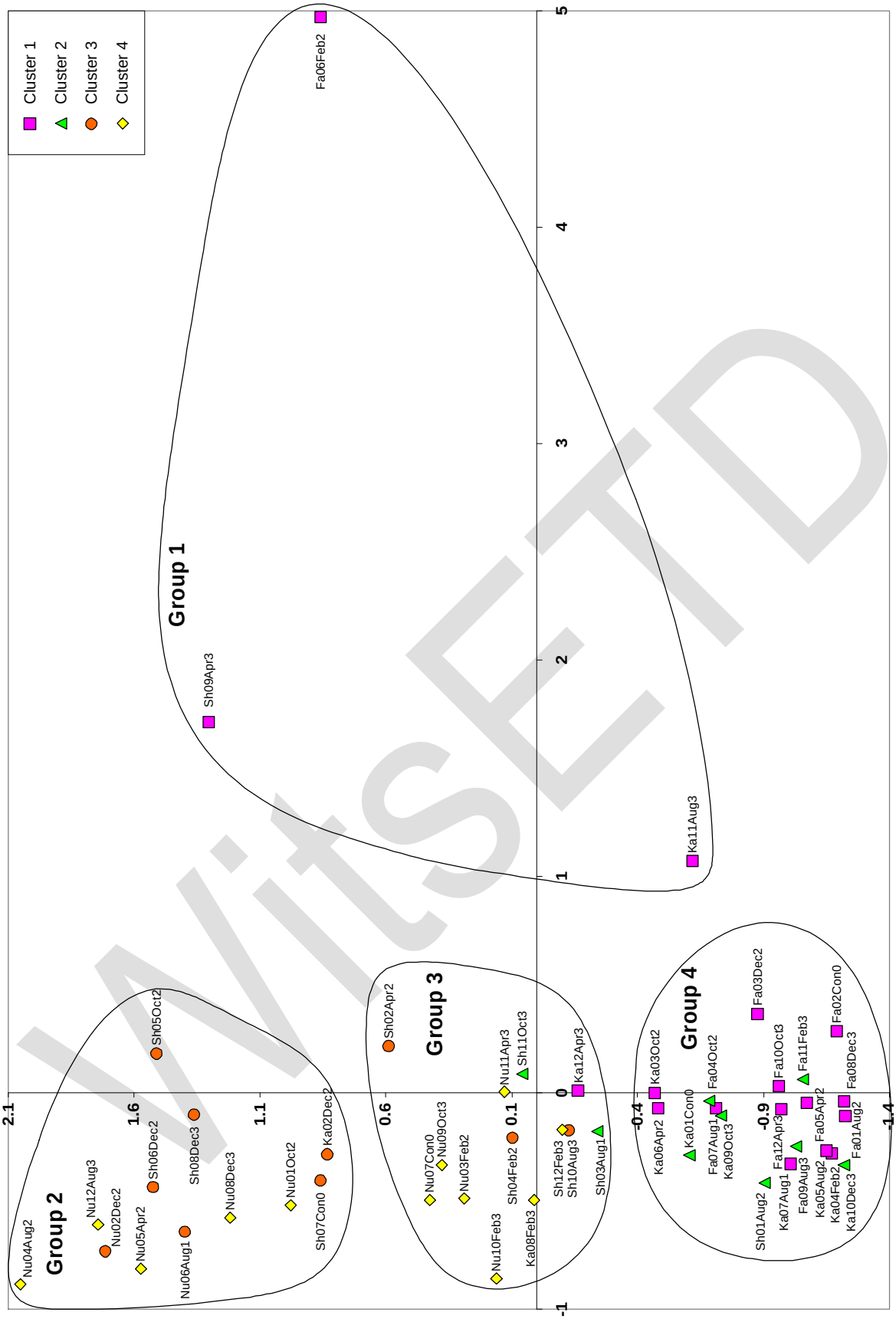


Figure 6-33: Bi-plot of the first two ordination axes from the CA on the 1954 species by plot data showing variation in species composition between treatment plots. The groups are the result of a visual assessment of the grouping of species and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-32). The codes for the treatments are defined in Table 10-1 (p. 214).

WitsETD

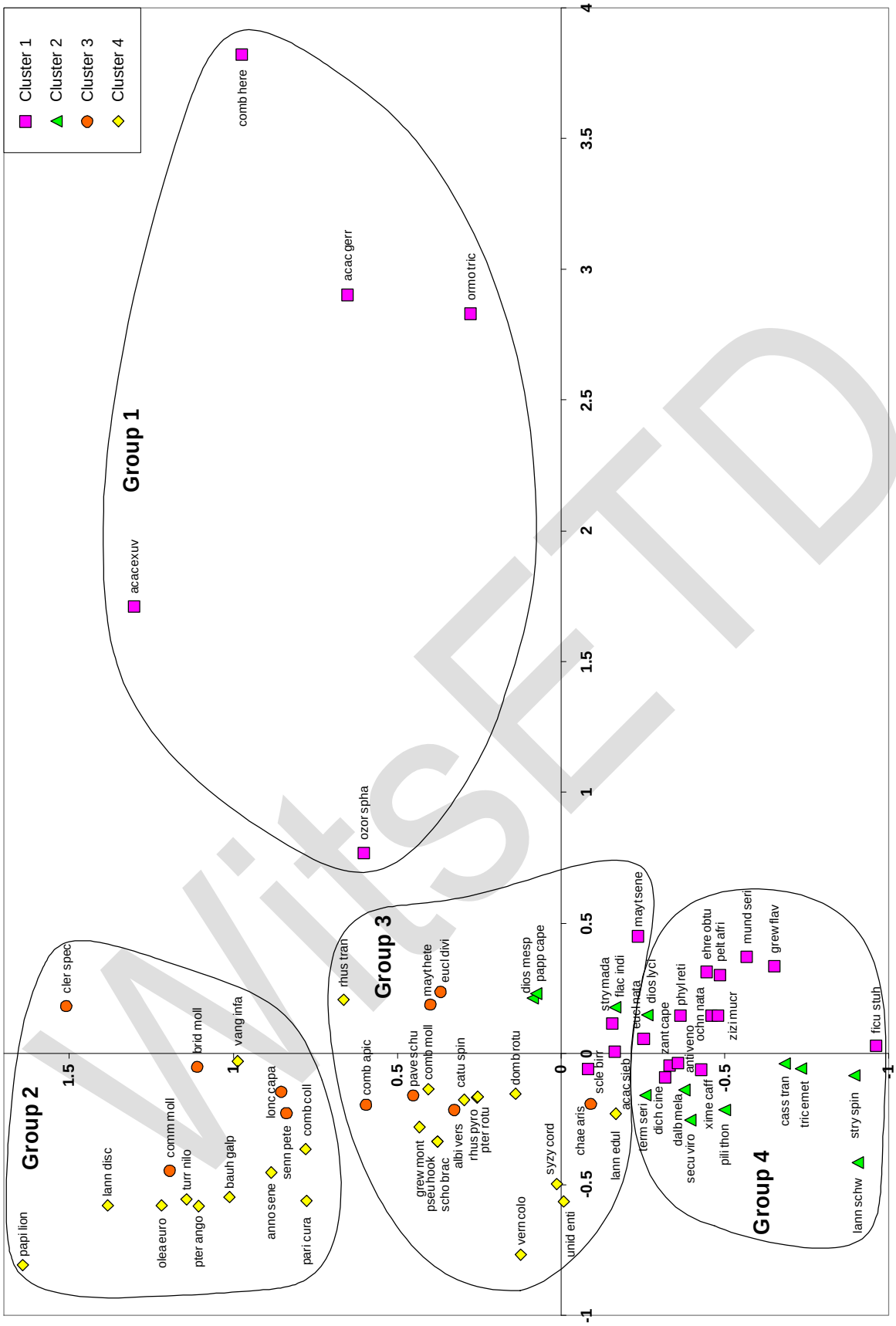


Figure 6-34: Bi-plot of the first two ordination axes from the CA on the 1954 species by plot data showing variation in location (plots) between species. The groups are the result of a visual assessment of the grouping of species and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-32). The codes for the species are defined in Table 9-1 (p. 210).

WitSETD

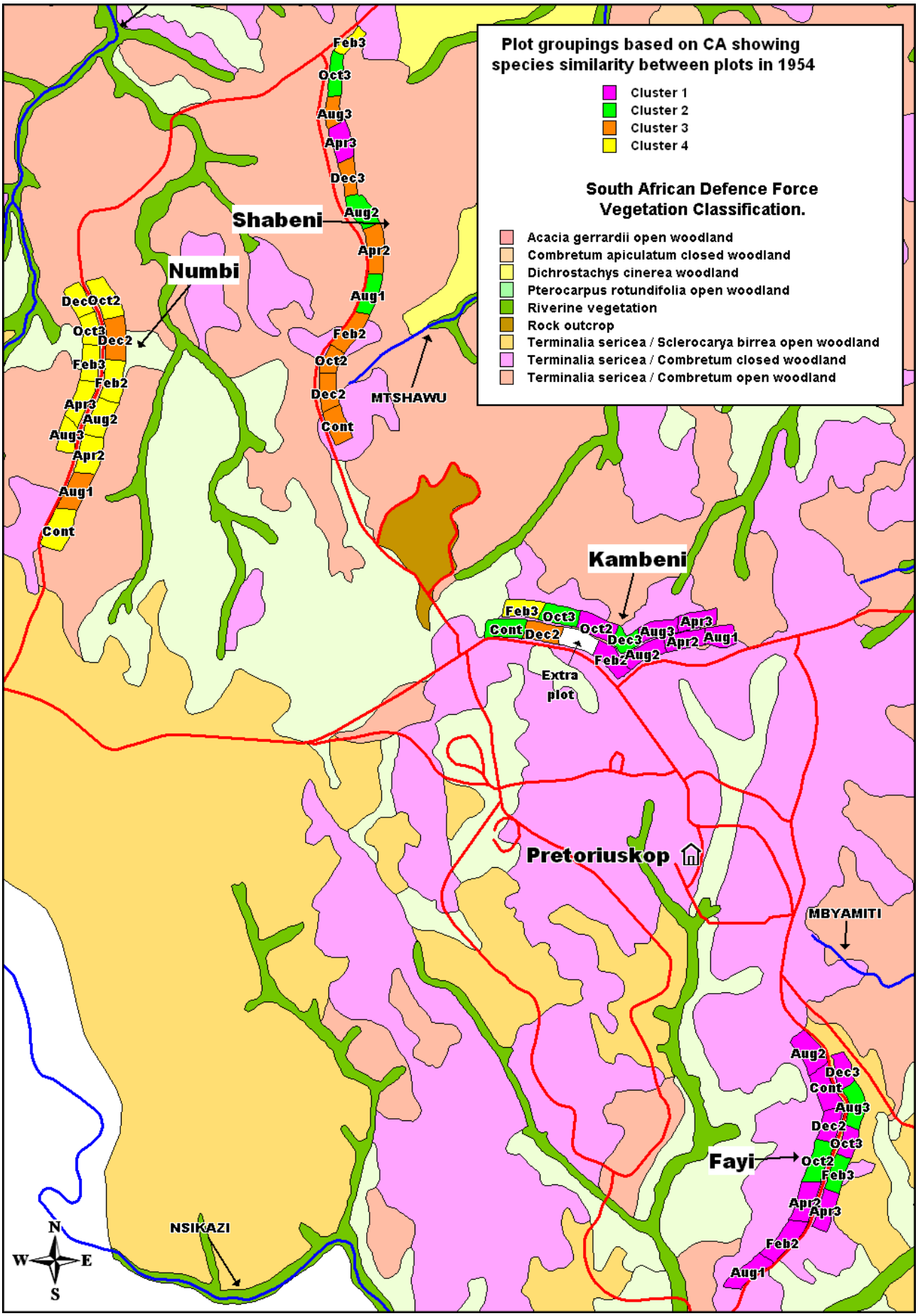


Figure 6-35: Map showing the level 2 clusters from the step-wise Gamma-Ward cluster analysis on the first four ordination axes of the CA on the 1954 species by plot data (Figure 6-32). The codes for the treatments are defined in Table 3-1 (p. 15).

6.3.2 Results from the Correspondence Analysis on the 1996 species by plot data

The results from the CA performed on the 1996 species by plot data are presented in Table 6-11 (p. 133), Figure 6-36 (p. 138), Figure 6-37 (p. 139), Figure 6-38 (p. 140), and Figure 6-39 (p. 141). Table 6-11 shows the Eigenvalues for the first four ordination axes of the CA. Figure 6-36 is a hierarchical cluster tree showing the cluster groups from the step-wise Gamma-Ward cluster analysis on the first four ordination axes. Figure 6-37 is a bi-plot of the first two, weighted eigenvector plots score axes with the data points colour coded to the level 2 cluster colours in Figure 6-36. Figure 6-38 is a bi-plot graph of the first two, weighted eigenvector species score axes with the data points colour coded to the level 2 cluster colours in Figure 6-36. Figure 6-39 is a map showing the layout of the Pretoriuskop EBP experiment with the plots colour coded to the level 2 cluster colours in Figure 6-36. The weighted eigenvector plot scores for the first four ordination axes, the plot weights and the effective number of species that occur on the plots (N2 species diversity of plots) (Hill 1973) are presented in Appendix 7, Table 15-3 (p. 259). The weighted eigenvector species scores for the first four ordination axes, the species weights, and the effective number of occurrences of the species (N2 diversity of species) are presented in Appendix 7, Table 15-4 (p. 260).

Table 6-11: Eigenvalues for the first four ordination axes of a Correspondence Analysis (CA) on the species by plot data collected in 1996

	Axis 1	Axis 2	Axis 3	Axis 4	Total
Eigenvalue	0.3282	0.2283	0.2015	0.1349	1.8750
% Variation	17.5	12.2	10.7	7.2	47.6

The Eigenvalues, for the first four axes of the CA on the 1996 data were 0.328, 0.228, 0.202, and 0.135 (Table 6-11). The first four eigenvectors accounted for 17.5%, 12.2%, 10.7%, and 7.2% of the variation in the species by plot data respectively in 1996, and 47.6% of the total variation in the species by plot data in 1996 (Table 6-11).

6.3.2.1 Bi-plots of the first two weighted species and plot eigenvectors showing the relationship between the species and plots in Pretoriuskop in 1996

There were four main groups of plots and species on the bi-plot graphs of the first two weighted eigenvectors from the Correspondence Analysis on the 1996 data (Figure 6-33 and Figure 6-34). Group 1 comprised species and plots with x-axis eigenvector values greater than 0.35. Group 2 comprised species and plots with x-axis eigenvector values less than 0.35 and y-axis eigenvector values greater than 0.5. Group 3 comprised species and plots with x-axis eigenvector values less than 0.35 and y-axis eigenvector values between 0.5 and -0.5. Group 4 comprised species and plots with x-axis eigenvector values less than 0.35 and y-axis eigenvector values less than -0.5. The plots in Group 1 were not burnt between 1954 and 1996, the plots in Group 2 were related to one another in 1954 (see Group 1 in 1954), and the plots in Group 4 were related to one another by the physical location of the plots and species in the Pretoriuskop region.

The plots in Group 1 were the Fayi Con0 and Dec3 plots, the Kambeni Con0 plot, the Numbi Con0 plot, and the Shabeni Con0 plot (Figure 6-37). Most of the plots in Group 1 were not burnt between 1954 and 1996. The species in Group 1 were *Acacia swazica*, *Bauhinia galpinii*, *Canthium* species, *Cassine aethiopica*, *Combretum mossambicense*, *Commiphora neglecta*, *Croton gratissimus*, *Diospyros lycioides*, *Diospyros whyteana*, *Euclea natalensis*, *Grewia flavescens*, *Heteropyxis natalensis*, *Hyperacanthus amoenus*, *Kraussia floribunda*, *Ochna natalitia*, *Olea europaea*, *Peltophorum africanum*, *Psydrax locuples*, *Putterlickia pyracantha*, *Tarenna supra-axillaris*, and *Zanthoxylum capense* (Figure 6-38). *Euclea natalensis*, *Grewia flavescens*, *Ochna natalitia*, and *Peltophorum africanum* occurred on all the plots in Group 1 however, they were also found on many other Pretoriuskop EBPs in 1996. However, *Euclea natalensis* was found in higher densities on the control plots than on any other Pretoriuskop EBP (> 500 plants/Ha). *Diospyros lycioides* was found on four of the five Group 1 plots, however it was also found on many other Pretoriuskop EBPs in 1954. Fifty percent of the occurrences of *Putterlickia pyracantha*, sixty percent of the occurrences of *Olea*

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europaea, and sixty-seven percent of the occurrences of *Commiphora neglecta* on the Pretoriuskop EBPs in 1996 occurred on the Group 1 plots. *Acacia swazica*, *Canthium* species, *Combretum mossambicense*, *Croton gratissimus*, *Diospyros whyteana*, *Hyperacanthus amoenus*, *Kraussia floribunda*, *Psydrax locuples*, and *Tarenna supra-axillaris* were found only on Group 1 plots. *Acacia swazica* was found on the Numbi Con0 plot. *Canthium* species was found on the Control plots of the Kambeni, Numbi, and Shabeni replicates. *Combretum mossambicense* was found on the Numbi Con0 plot. *Croton gratissimus* was found on the Kambeni Con0 plot. *Diospyros whyteana* was found on the Numbi Con0 plot. *Hyperacanthus amoenus* was found on the Numbi Con0 and Shabeni Con0 plots. *Kraussia floribunda* was found on the Kambeni Con0 and Numbi Con0 plots. *Psydrax locuples* was found on the Shabeni Con0 plot. *Tarenna supra-axillaris* was found on the Shabeni Con0 plot.

Group 2 comprised the Fayi Feb2, the Kambeni Aug3, and the Shabeni Apr2, Apr3, and Aug3 plots (Figure 6-37). The Shabeni Apr3, Fayi Feb2, and Kambeni Aug3 plots were grouped together in Group 1 in the CA on the 1954 data. The species in Group 2 were *Acacia exuvialis*, *Acacia gerrardii*, *Cassine transvaalensis*, *Combretum hereroense*, *Combretum imberbe*, *Ehretia obtusifolia*, *Euclea divinorum*, *Lannea edulis*, *Ormocarpum trichocarpum*, *Rhus leptodictya*, and *Rhus pentheri* (Figure 6-38). *Ehretia obtusifolia* occurred on all the plots in Group 2 however, it was also found on many other Pretoriuskop EBPs in 1996. *Acacia gerrardii* and *Ormocarpum trichocarpum* were found on four of the five Group 2 plots on 1996. Both *Acacia gerrardii* and *Ormocarpum trichocarpum* were associated with the Group 1 plots in 1954. *Acacia exuvialis* and *Combretum imberbe* were found only on Group 2 plots. *Acacia exuvialis* was found on the Shabeni Apr3 plot, and *Combretum imberbe* was found on the Shabeni Aug3 plot. In 1954, *Acacia exuvialis* was also only found on the Shabeni Apr3 plot.

Group 3 comprised the Fayi Aug2, Dec2, Oct2, Apr2, Aug1, Aug3, Oct3, Feb3, and Apr3 plots, the Kambeni Dec2, Oct2, Feb2, Aug2, Apr2, Aug1, Feb3, Oct3, Dec3, and Apr3 plots, the Numbi Feb2 and Apr2 plots, and the Shabeni Aug2, Dec2, Dec3, Oct3, and Feb3 plots (Figure 6-37). The species in Group 3 were *Acacia sieberiana*, *Acacia xanthophloea*, *Albizia harveyi*, *Antidesma venosum*, *Combretum apiculatum*, *Combretum collinum*, *Combretum molle*, *Dalbergia melanoxylon*, *Dichrostachys cinerea*, *Diospyros mespiliformis*, *Dombeya rotundifolia*, *Ficus sycomorus*, *Flacourtia indica*, *Gardenia volkensii*, *Grewia hexamita*, *Grewia monticola*, *Kigelia africana*, *Lannea schweinfurthii*, *Lonchocarpus capassa*, *Markhamia zanzibarica*, *Maytenus heterophylla*, *Maytenus senegalensis*, *Mundulea sericea*, *Ozoroa sphaerocarpa*, *Pappea capensis*, *Parinari curatellifolia*, *Phyllanthus reticulatus*, *Piliostigma thonningii*, *Pterocarpus angolensis*, *Pterocarpus rotundifolius*, *Rhus pyroides*, *Rhus transvaalensis*, *Schotia brachypetala*, *Sclerocarya birrea*, *Securinega virosa*, *Senna petersiana*, *Spirostachys africana*, *Strychnos madagascariensis*, *Syzygium guineense*, *Terminalia sericea*, *Trichilia emetica*, *Vangueria infausta*, *Ximenia caffra*, and *Ziziphus mucronata* (Figure 6-38). *Dalbergia melanoxylon*, *Dichrostachys cinerea*, *Maytenus senegalensis*, *Strychnos madagascariensis*, and *Terminalia sericea* occurred on all the plots in Group 3, and they were all mainly found on the plots in Group 3 in 1996. *Securinega virosa* was found on nineteen of the twenty-six Group 3 plots in 1996 and was found mainly on the Group 3 plots. *Diospyros mespiliformis* and *Ziziphus mucronata* were found on twenty of the twenty-six Group 3 plots in 1996 and were found mainly on the Group 3 plots. *Senna petersiana* was found on twenty-two of the twenty-six Group 3 plots in 1996 and was found mainly on the Group 3 plots. *Maytenus heterophylla* was found on twenty-three of the twenty-six Group 3 plots in 1996 and was found mainly on the Group 3 plots. *Sclerocarya birrea* was found on twenty-five of the twenty-six Group 3 plots in 1996 and was found mainly on the Group 3 plots. Between fifty and sixty percent of the occurrences of *Grewia hexamita*, *Kigelia africana*, *Pterocarpus rotundifolius*, *Trichilia emetica*, *Parinari curatellifolia*, *Antidesma venosum*, *Rhus transvaalensis*, *Maytenus heterophylla*, *Flacourtia indica*, *Diospyros mespiliformis*, *Sclerocarya birrea*, *Piliostigma thonningii*, *Phyllanthus reticulatus*, *Senna petersiana*, *Dichrostachys cinerea*, *Maytenus senegalensis*, *Terminalia sericea*, *Pappea capensis*, *Strychnos madagascariensis*, *Ximenia caffra*, *Dalbergia melanoxylon*, and *Securinega virosa* on the Pretoriuskop EBPs in 1996 occurred on the Group 3 plots. Between sixty and seventy percent of the occurrences of *Gardenia volkensii* and *Ziziphus mucronata* on the Pretoriuskop EBPs in 1996 occurred on the Group 3 plots. Between seventy and eighty percent of the occurrences of *Acacia sieberiana*, *Mundulea sericea*, *Ozoroa sphaerocarpa* on the Pretoriuskop EBPs in 1996 occurred on the Group 3 plots. *Acacia xanthophloea*,

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Albizia harveyi, *Ficus sycomorus*, *Lannea schweinfurthii*, *Markhamia zanzibarica*, *Syzygium guineense*, *Vangueria infausta* were found only on Group 3 plots. *Acacia xanthophloea* was found on the Kambeni Dec3 plot. *Albizia harveyi* was found on the Kambeni Apr3 plot. *Ficus sycomorus* was found on the Fayi Aug2 plot. *Lannea schweinfurthii* was found on the Kambeni Feb3 plot and Shabeni Dec2 plot. *Markhamia zanzibarica* was found on the Shabeni Dec2 plot. *Syzygium guineense* was found on the Fayi Aug1 plot. *Vangueria infausta* was found on the Fayi Aug1 plot, the Kambeni Aug1, Feb3, and Dec3 plots, and the Shabeni Aug2 and Dec2 plots.

Group 4 comprised the Numbi Oct2, Dec2, Aug2, Aug1, Dec3, Oct3, Feb3, Apr3, and Aug3 plots, the Shabeni Aug1, Feb2, and Oct2 plots (Figure 6-37). These plots occurred in the *Terminalia sericea* - *Combretum* open woodlands of Pretoriuskop (Figure 6-39). The species in Group 4 were *Acacia caffra*, *Albizia versicolor*, *Annona senegalensis*, *Berchemia zeyheri*, *Catunaregam spinosa*, *Faurea saligna*, *Hippobromus pauciflorus*, *Lannea discolor*, *Pavetta schumanniana*, *Strychnos spinosa*, *Syzygium cordatum*, *Turraea nilotica* (Figure 6-38). *Catunaregam spinosa*, *Pavetta schumanniana*, and *Turraea nilotica* occurred on all the plots in Group 4 however, they were also found on many other Pretoriuskop EBPs in 1996. *Annona senegalensis* was found on ten of the twelve Group 4 plots however, it was also found on many other Pretoriuskop plots on 1996. *Albizia versicolor* was found on eleven of the twelve Group 4 plots, and it was found mainly on the Group 4 plots on 1996. Fifty percent of the occurrences of *Hippobromus pauciflorus* and *Albizia versicolor* on the Pretoriuskop EBPs in 1996 were on the Group 4 plots. Sixty-seven percent of the occurrences of *Strychnos spinosa* on the Pretoriuskop EBPs in 1996 were on the Group 4 plots. *Acacia caffra*, *Berchemia zeyheri*, *Faurea saligna*, *Lannea discolor*, and *Syzygium cordatum* were found only on the Group 4 plots. *Acacia caffra* was found on the Numbi Oct3 and Apr3 plots. *Berchemia zeyheri* was found on the Numbi Apr3 plot. *Faurea saligna* was found on the Numbi Aug1 plot. *Lannea discolor* was found on the Numbi Oct2, Aug2, Dec3, Feb3, and Apr3 plots. *Syzygium cordatum* the Numbi Oct2 and Aug1 plots, the Shabeni Aug1 plot.

6.3.2.2 Step-wise Ward-Gamma cluster analysis of the first four weighted eigenvectors showing the relationship between the species and plots in Pretoriuskop in 1996

The step-wise Ward-Gamma cluster analysis was used to summarise the variation of plots and species along the first four eigenvectors of the Correspondence Analysis on the 1996 species by plot data. There were four main clusters of plots and species at level 2 of the step-wise Ward-Gamma cluster analysis (Figure 6-36). These clusters differed from the two dimensional grouping of plots and species along the first two eigenvectors described above (Figure 6-37 and Figure 6-38).

Cluster 1 was similar to Group 1 in 1996, the plots in Group 1 and Cluster 1 were the same, but there were more species in Cluster 1 than in Group 1 in 1996. Cluster 1 comprised the Fayi Con0 and Dec3 plots, the Kambeni Con0 plot, the Numbi Con0 plot, and the Shabeni Con0 plot (Figure 6-36). Cluster 1 contained all the plots that were not burnt between 1954 and 1996. The species in Cluster 1 were *Acacia swazica*, *Antidesma venosum*, *Bauhinia galpinii*, *Canthium* species, *Cassine aethiopica*, *Combretum mossambicense*, *Commiphora neglecta*, *Croton gratissimus*, *Dalbergia melanoxylon*, *Diospyros lycioides*, *Diospyros mespiliformis*, *Diospyros whyteana*, *Euclea natalensis*, *Grewia flavescens*, *Heteropyxis natalensis*, *Hyperacanthus amoenus*, *Kraussia floribunda*, *Ochna natalitia*, *Olea europaea*, *Peltophorum africanum*, *Phyllanthus reticulatus*, *Psydrax locuples*, *Putterlickia pyracantha*, *Rhus transvaalensis*, *Securinega virosa*, *Spirostachys africana*, *Tarenna supra-axillaris*, and *Zanthoxylum capense* (Figure 6-36). *Dalbergia melanoxylon*, *Diospyros mespiliformis*, *Euclea natalensis*, *Grewia flavescens*, *Ochna natalitia*, *Peltophorum africanum*, and *Securinega virosa* occurred on all the plots in Cluster 1 however, they were also found on many other Pretoriuskop EBPs in 1996. *Antidesma venosum*, *Diospyros lycioides*, *Phyllanthus reticulatus*, and *Rhus transvaalensis* were found on four of the five Cluster 1 plots in 1996 however, they were also found on many other Pretoriuskop plots in 1996. Fifty percent of the occurrences of *Putterlickia pyracantha* and *Spirostachys africana* on the Pretoriuskop EBPs in 1996 were on the Cluster 1 plots. Between sixty and seventy percent of the occurrences of *Commiphora neglecta* and *Olea europaea* on the Pretoriuskop EBPs in 1996 were on the Cluster 1 plots. *Acacia swazica*, *Canthium* species, *Combretum mossambicense*, *Croton*

gratissimus, *Diospyros whyteana*, *Hyperacanthus amoenus*, *Kraussia floribunda*, *Psydrax locuples*, and *Tarenna supra-axillaris* were found only on the Cluster 1 plots in 1996. *Acacia swazica* was found on the Numbi Con0 plot. *Canthium* species was found on the Kambeni Con0 plot, the Numbi Con0 plot, and the Shabeni Con0 plot. *Combretum mossambicense* was found on the Numbi Con0 plot. *Croton gratissimus* was found on the Kambeni Con0 plot. *Diospyros whyteana* was found on the Numbi Con0 plot. *Hyperacanthus amoenus* was found on the Numbi Con0 plot and the Shabeni Con0 plot. *Kraussia floribunda* was found on the Kambeni Con0 plot and the Numbi Con0 plot. *Psydrax locuples* was found on the Shabeni Con0 plot. Finally, *Tarenna supra-axillaris* was found on the Shabeni Con0 plot.

Cluster 2 was similar to Group 4 in 1996, the plots in Group 4 and Cluster 2 were the same, but there were more species in Cluster 2 than in Group 4 in 1996. Cluster 2 comprised the Numbi Oct2, Dec2, Aug2, Aug1, Dec3, Oct3, Feb3, Apr3, and Aug3 plots, and the Shabeni Aug1, Feb2, and Oct2 plots (Figure 6-36). Most of the plots in Cluster 2 were on the Numbi replicate (Figure 6-39). These plots occurred in the *Terminalia sericea* - *Combretum* open woodlands of Pretoriuskop (Figure 6-39). The Numbi Oct2, Dec2, Aug2, Dec3, Oct3, Feb3, Apr3, and Aug3 plots were adjacent to one another, and the Shabeni Aug1, Feb2, and Oct2 plots were adjacent to one another (Figure 6-39). The species in Cluster 2 were *Acacia caffra*, *Albizia versicolor*, *Annona senegalensis*, *Berchemia zeyheri*, *Catunaregam spinosa*, *Dombeya rotundifolia*, *Faurea saligna*, *Flacourtia indica*, *Hippobromus pauciflorus*, *Lannea discolor*, *Parinari curatellifolia*, *Pavetta schumanniana*, *Pterocarpus rotundifolius*, *Schotia brachypetala*, *Strychnos spinosa*, *Syzygium cordatum*, and *Turraea nilotica* (Figure 6-36). *Catunaregam spinosa*, *Pavetta schumanniana*, and *Turraea nilotica* occurred on all the plots on Cluster 2 however, they were also found on many Pretoriuskop EBPs in 1996. *Annona senegalensis* was found on ten of the twelve Cluster 2 plots however, it was also found on many other Pretoriuskop plots in 1996. *Albizia versicolor* was found on eleven of the twelve Cluster 2 plots, and it was found mainly on the Cluster 2 plots on 1996. Fifty percent of the occurrences of *Albizia versicolor*, *Hippobromus pauciflorus*, *Pterocarpus rotundifolius*, and *Schotia brachypetala* on the Pretoriuskop EBPs in 1996 were on the Cluster 2 plots. Sixty-seven percent of the occurrences of *Strychnos spinosa* on the Pretoriuskop EBPs in 1996 were on the Cluster 2 plots. *Acacia caffra*, *Berchemia zeyheri*, *Faurea saligna*, *Lannea discolor*, and *Syzygium cordatum* occurred only on the Cluster 2 plots. *Acacia caffra* was found on the Numbi Oct3 and Apr3 plots. *Berchemia zeyheri* was found on the Numbi Apr3 plot. *Faurea saligna* was found on the Numbi Aug1 plot. *Lannea discolor* was found on the Numbi Oct2, Aug2, Dec3, Feb3, and Apr3 plots. *Syzygium cordatum* the Numbi Oct2 and Aug1 plots, the Shabeni Aug1 plot.

Cluster 3 comprised many Group 3 plots and species in 1996. Cluster 3 comprised the Fayi Aug2, Dec2, Apr2, Aug1, Aug3, Oct3, Feb3, and Apr3 plots, the Kambeni Dec2, Oct2, Feb2, Aug2, Apr2, Aug1, Feb3, Oct3, Dec3, Aug3, and Apr3 plots, and the Shabeni Dec3 and Oct3 plots (Figure 6-36). Most of the plots in Cluster 3 occurred on the *Terminalia sericea* - *Combretum* closed woodlands of Pretoriuskop (Figure 6-39). The Fayi Dec2, Apr2, Aug3, Oct3, Feb3, and Apr3 plots were adjacent to one another and the Kambeni Dec2, Oct2, Feb2, Aug2, Apr2, Aug1, Feb3, Oct3, Dec3, Aug3, and Apr3 plots were adjacent to one another (Figure 6-36). The species in Cluster 3 were *Acacia xanthophloea*, *Albizia harveyi*, *Dichrostachys cinerea*, *Ficus sycomorus*, *Gardenia volkensii*, *Grewia hexamita*, *Kigelia africana*, *Maytenus senegalensis*, *Rhus leptodictya*, *Rhus pyroides*, *Strychnos madagascariensis*, *Syzygium guineense*, *Terminalia sericea*, *Ximenia caffra*, and *Ziziphus mucronata* (Figure 6-36). *Dichrostachys cinerea*, *Maytenus senegalensis*, *Strychnos madagascariensis*, and *Terminalia sericea* occurred on all the Cluster 3 plots however, they were also found on many other Pretoriuskop EBPs in 1996. *Ximenia caffra* occurred on fifteen of the twenty-one Cluster 3 plots in 1996. *Ziziphus mucronata* occurred on sixteen of the twenty-one Cluster 3 plots in 1996. Between fifty and sixty percent of the occurrences of *Grewia hexamita*, *Kigelia africana*, and *Ziziphus mucronata* on the Pretoriuskop EBPs in 1996 were on the Cluster 3 plots. Sixty-seven percent of the occurrences of *Rhus leptodictya* on the Pretoriuskop EBPs in 1996 were on Cluster 3 plots. *Acacia xanthophloea*, *Albizia harveyi*, *Ficus sycomorus*, *Syzygium guineense*, and *Gardenia volkensii* were found only on the Cluster 3 plots in 1996. *Acacia xanthophloea* was found on the Kambeni Dec3 plot. *Albizia harveyi* was found on the Kambeni Apr3 plot. *Ficus sycomorus* was found on the Fayi Aug2 plot. *Syzygium guineense* was found on the Fayi Aug1 plot. *Gardenia volkensii* was found on the Fayi Dec2 plot and the Kambeni Feb2 and Aug3 plots in 1996.

Cluster 4 comprised the Fayi Oct2 and Feb2 plots, the Numbi Feb2 and Apr2 plots, and the Shabeni Aug2, Apr2, Dec2, Apr3, Aug3, and Feb3 plots (Figure 6-36). These plots occurred mainly in the *Terminalia sericea* - *Combretum* open woodlands of Pretoriuskop (Figure 6-39). The Shabeni Aug2 and Apr2 plots were adjacent to one another and the Shabeni Apr3 and Aug3 plots were adjacent to one another (Figure 6-39). The species in Cluster 4 were *Acacia exuvialis*, *Acacia gerrardii*, *Acacia sieberiana*, *Cassine transvaalensis*, *Combretum apiculatum*, *Combretum collinum*, *Combretum hereroense*, *Combretum imberbe*, *Combretum molle*, *Ehretia obtusifolia*, *Euclea divinorum*, *Grewia monticola*, *Lannea edulis*, *Lannea schweinfurthii*, *Lonchocarpus capassa*, *Markhamia zanzibarica*, *Maytenus heterophylla*, *Mundulea sericea*, *Ormocarpum trichocarpum*, *Ozoroa sphaerocarpa*, *Pappea capensis*, *Piliostigma thonningii*, *Pterocarpus angolensis*, *Rhus pentheri*, *Sclerocarya birrea*, *Senna petersiana*, *Trichilia emetica*, and *Vangueria infausta* (Figure 6-36). *Maytenus heterophylla* occurred on all the plots in Cluster 4 however, it was also found on many other Pretoriuskop EBPs in 1996. *Acacia gerrardii*, *Ehretia obtusifolia*, and *Grewia monticola* were found on seven of the ten Cluster 4 plots in 1996. *Lonchocarpus capassa* was found on eight on the ten Cluster 4 plots in 1996. *Sclerocarya birrea* and *Senna petersiana* were found on nine of the ten Cluster 4 plots in 1996. Fifty percent of the occurrences of *Lannea schweinfurthii* on the Pretoriuskop EBPs in 1996 were on the Cluster 4 plots. *Acacia exuvialis*, *Combretum imberbe*, and *Markhamia zanzibarica* were found only on the Cluster 4 plots in 1996. *Acacia exuvialis* was found on the Shabeni Apr3 plot. *Combretum imberbe* was found on the Shabeni Aug3 plot. *Markhamia zanzibarica* was found on the Shabeni Dec2 plot.

6.3.2.3 Summary of the results from the CA's on the 1996 species by plot data

In 1996, similarity in species composition between plots was mainly due to location and proximity of the plots to one another instead of the treatment applied to the plots. Plots that occurred in the open *Terminalia sericea* - *Combretum* woodlands (Numbi and Shabeni) were more likely to have similar species compositions in comparison with plots that occurred in the closed *Terminalia sericea* - *Combretum* woodlands (Fayi and Kambeni). Furthermore, plots that were adjacent to one another were more likely to have similar species compositions than plots that were further apart. Some plots that were similar to one another in species composition in 1996 were also similar to one another in 1954 regardless of the treatment that had been applied to the plots.

In 1996, the Numbi and Shabeni plots in the open *Terminalia sericea* - *Combretum* woodlands were associated with *Catunaregam spinosa*, *Pavetta schumanniana*, *Turraea nilotica*, *Annona senegalensis*, *Albizia versicolor*, *Hippobromus pauciflorus*, *Albizia versicolor*, *Strychnos spinosa*, *Acacia caffra*, *Berchemia zeyheri*, *Faurea saligna*, *Lannea discolor*, *Syzygium cordatum*, *Pterocarpus rotundifolius*, *Schotia brachypetala*, *Maytenus heterophylla*, *Acacia gerrardii*, *Ehretia obtusifolia*, *Grewia monticola*, *Lonchocarpus capassa*, *Sclerocarya birrea*, *Senna petersiana*, *Lannea schweinfurthii*, *Acacia exuvialis*, *Combretum imberbe*, and *Markhamia zanzibarica*. As in 1954 many of the species occurring on the Numbi and Shabeni replicates were also found on the Kambeni and Fayi replicates. In 1996, the Fayi and Kambeni plots in the closed *Terminalia sericea* - *Combretum* woodlands were mainly associated with *Maytenus senegalensis*, *Strychnos madagascariensis*, *Ximenia caffra*, *Ziziphus mucronata*, *Grewia hexamita*, *Kigelia africana*, *Rhus leptodictya*, *Acacia xanthophloea*, *Albizia harveyi*, *Ficus sycomorus*, *Syzygium guineense*, and *Gardenia volkensii*. The species composition on the control plots was an exception to this. The plots that were not burnt between 1954 and 1996 had species compositions that were more similar to one another than with any of the other plots in Pretoriuskop. The species associated with the control plots were *Euclea natalensis*, *Diospyros lycioides*, *Putterlickia pyracantha*, *Olea europaea*, *Commiphora neglecta*, *Acacia swazica*, *Canthium* species, *Combretum mossambicense*, *Croton gratissimus*, *Diospyros whyteana*, *Hyperacanthus amoenus*, *Kraussia floribunda*, *Psydrax locuples*, *Tarenna supra-axillaris*, *Dalbergia melanoxylon*, *Grewia flavescens*, *Ochna natalitia*, *Peltophorum africanum*, *Securinega virosa*, *Antidesma venosum*, *Phyllanthus reticulatus*, *Rhus transvaalensis*, and *Spirostachys africana*. The density of *Euclea natalensis* on the control plots was high (> 500 plants/Ha).

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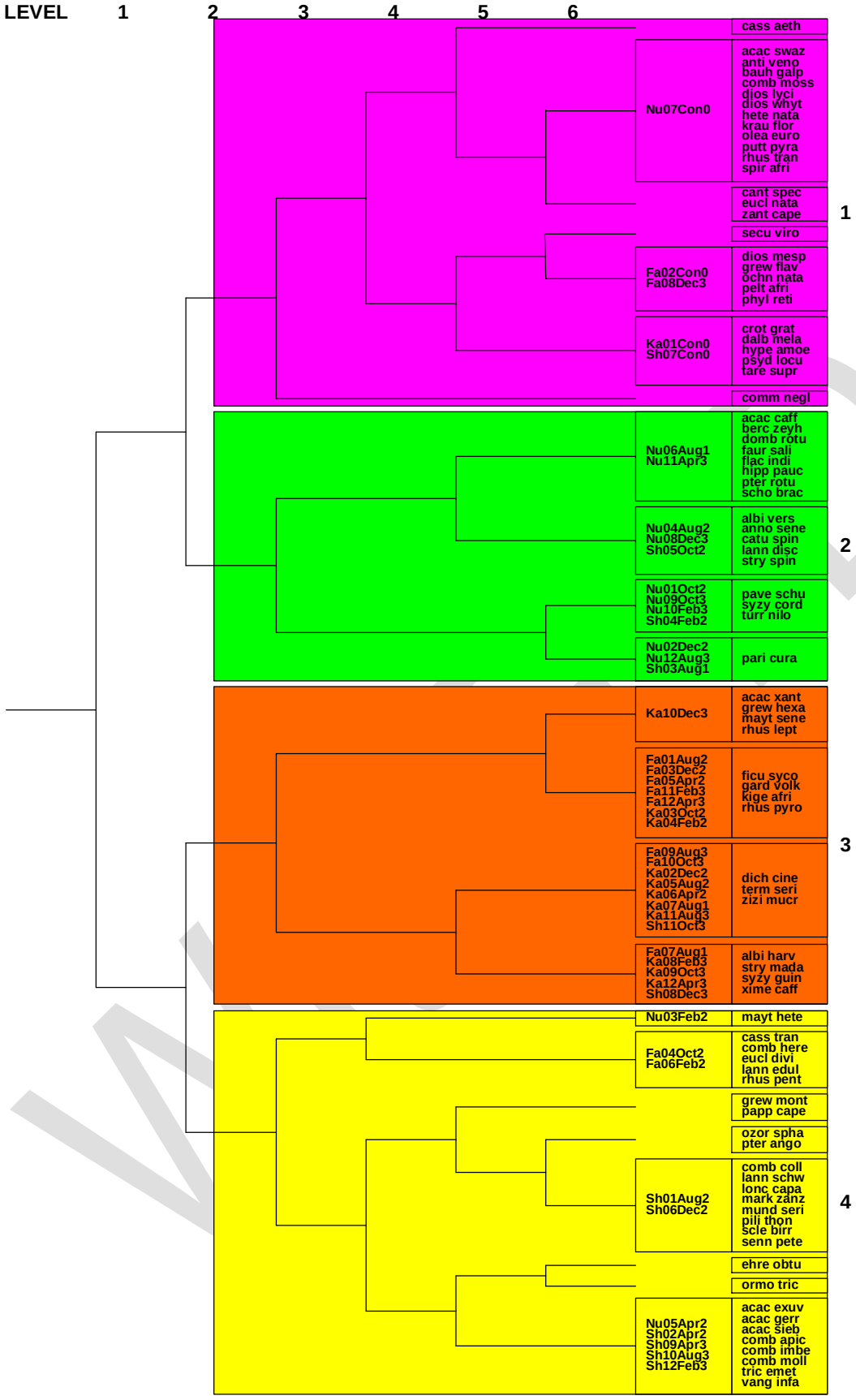


Figure 6-36: Classification of treatment plots and species using a step-wise Gamma-Ward cluster analysis on the first four ordination axes from the CA on the 1996 species by plot data. The codes for the treatment plots are defined in Table 10-1 (p. 214) and the codes for the species are defined in Table 9-1 (p. 210).

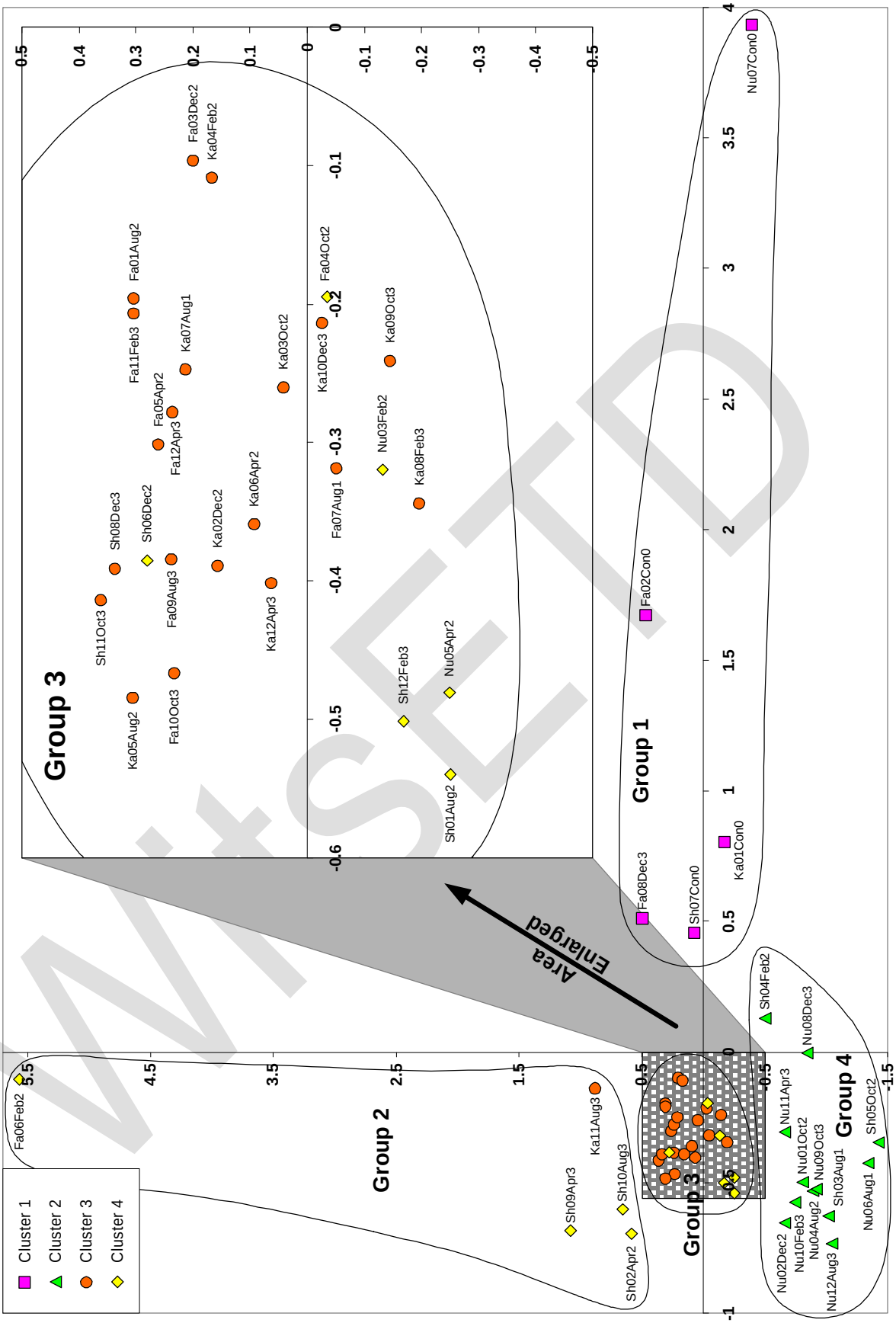


Figure 6-37: Bi-plot of the first two ordination axes from the CA on the 1996 species by plot data showing variation in species composition between treatment plots. The groups are the result of a visual assessment of the grouping of species and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-36). The codes for the treatment plots are defined in Table 10-1 (p. 214).

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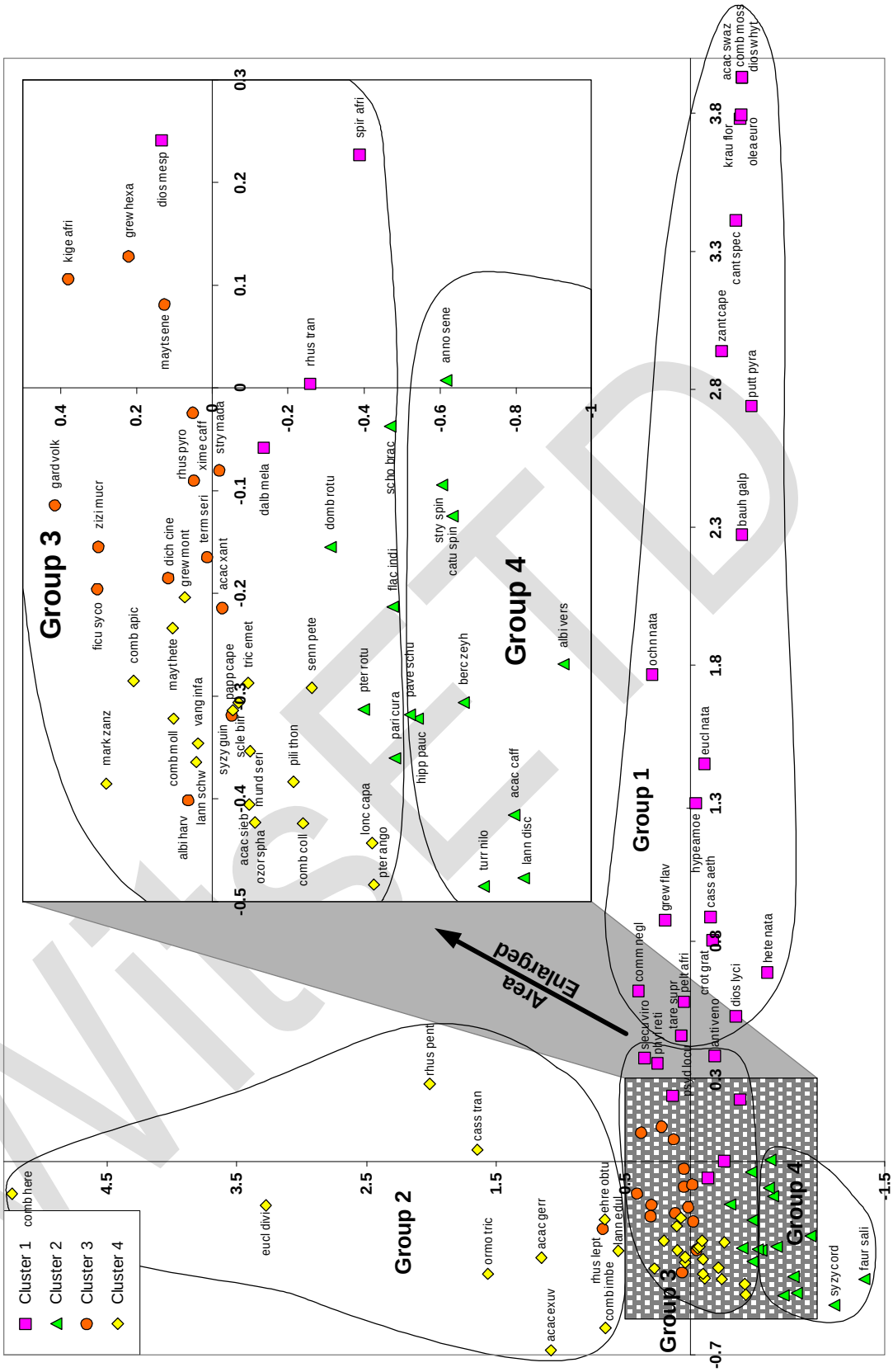


Figure 6-38: Bi-plot of the first two ordination axes from the CA on the 1996 species by plot data showing variation in location (plots) between species. The groups are the result of a visual assessment of the grouping of species and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-36). The codes for the species are defined in Table 9-1 (p. 210).

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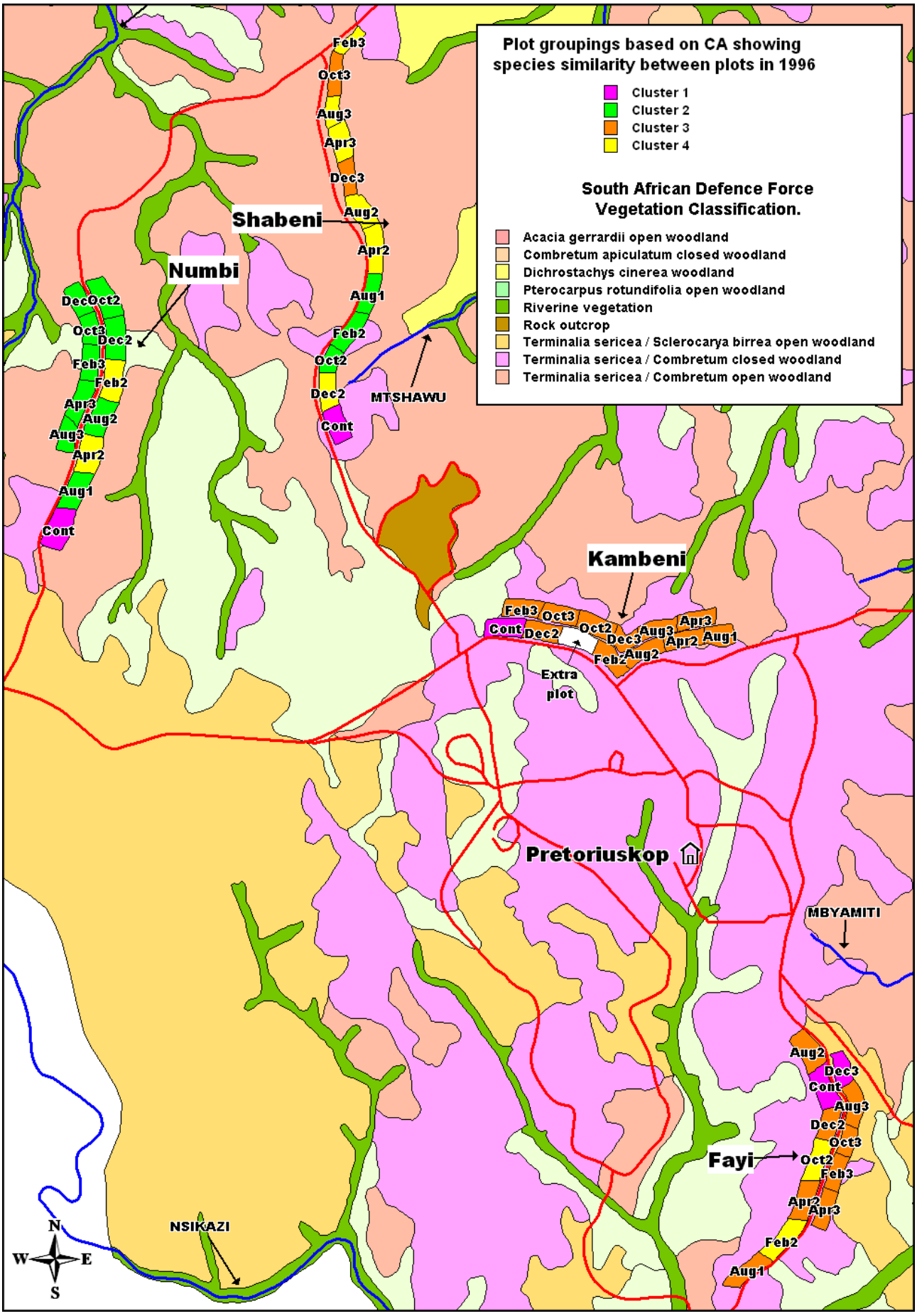


Figure 6-39: Map showing the level 2 groupings of a classification of treatment plots using a stepwise cluster analysis on the first four ordination axes of a CA on the 1996 species by plot data (Figure 6-36). The codes for the treatments are defined in Table 3-1 (p. 15).

6.3.3 Results from the Correspondence Analysis on the 1996 species by plot data with the first eight axes of the CA on the 1954 survey data as covariables

The results from the CA performed on the 1996 species by plot data with the 1954 covariables are presented in Table 6-12 (p. 142), Figure 6-40 (p. 147), Figure 6-41 (p. 148), Figure 6-42 (p. 149), and Figure 6-43 (p. 150). Table 6-12 shows the Eigenvalues for the first four ordination axes of the CA. Figure 6-40 is a hierarchical cluster tree showing the cluster groups from the step-wise Gamma-Ward cluster analysis on the first four ordination axes. Figure 6-41 is a bi-plot of the first two, weighted eigenvector plots score axes with the data points colour coded to the level 2 cluster colours in Figure 6-40. Figure 6-42 is a bi-plot of the first two, weighted eigenvector species score axes with the data points colour coded to the level 2 cluster colours in Figure 6-40. Figure 6-43 is a map showing the layout of the Pretoriuskop EBP experiment with the plots colour coded to the level 2 cluster colours in Figure 6-40. The weighted eigenvector plot scores for the first four ordination axes, the plot weights and the effective number of species that occur on the plots (N2 species diversity of plots) (Hill 1973) are presented in Table 15-5 (p. 262). The weighted eigenvector species scores for the first four ordination axes, the species weights, and the effective number of occurrences of the species (N2 diversity of species) are presented in Table 15-6 (p. 263).

Table 6-12: Eigenvalues for the first four ordination axes of a Correspondence Analysis (CA) on the species by plot data collected in 1996 with the first eight ordination axes of the 1954 CA as covariables.

	Axis 1	Axis 2	Axis 3	Axis 4	Total
Eigenvalue	0.2896	0.1232	0.1036	0.0883	1.2420
% Variation	23.3	9.9	8.3	7.1	48.7

The Eigenvalues, for the first four axes of the CA on the 1996 data with the 1954 covariables were 0.290, 0.123, 0.104, and 0.088 (Table 6-12). The first four eigenvectors accounted for 23.3%, 9.9%, 8.3%, and 7.1% of the variation in the species by plot data respectively in 1996, and 48.7% of the total variation in the species by plot data in 1996 (Table 6-10).

6.3.3.1 Bi-plots of the first two weighted species and plot eigenvectors showing the relationship between the species and plots in Pretoriuskop in 1996 accounting for the relationship between the species and plots in 1954

There were five main groups of plots and species on the bi-plots of the first two weighted eigenvectors from the Correspondence Analysis on the 1996 data with the 1954 covariables (Figure 6-41 and Figure 6-42). Group 1 comprised species and plots with x-axis eigenvector values greater than 0.35. Group 2 comprised species and plots with x-axis eigenvector values less than -0.7. Group 3 comprised plots and species with x-axis eigenvector values between 0.35 and -0.7, and y-axis eigenvector values greater than 0.1. Group 4 comprised plots and species with x-axis eigenvector values between 0.35 and -0.7, and y-axis eigenvector values between 0.1 and -0.45. Group 5 comprised plots and species with x-axis eigenvector values between 0.35 and -0.7, and y-axis eigenvector values less than -0.45.

Group 1 comprised the Fayi Con0 and Dec3 plots, the Kambeni Con0 plot, the Numbi Con0 plot, and the Shabeni Feb2 and Con0 plots (Figure 6-41). Most of the plots in Group 1 were not burnt between 1954 and 1996. The species in Group 1 were *Acacia swazica*, *Antidesma venosum*, *Bauhinia galpinii*, *Canthium* sp., *Cassine aethiopica*, *Combretum mossambicense*, *Commiphora neglecta*, *Croton gratissimus*, *Diospyros lycioides*, *Diospyros whyteana*, *Euclea natalensis*, *Grewia flavescens*, *Heteropyxis natalensis*, *Hyperacanthus amoenus*, *Kraussia floribunda*, *Ochna natalitia*, *Olea europaea*, *Peltophorum africanum*, *Psydrax locuples*, *Putterlickia pyracantha*, *Rhus pentheri*, *Securinega virosa*, *Tarenna supra-axillaris*, and *Zanthoxylum capense* (Figure 6-42). Most of the species and plots that were in Group 1 from the CA on the 1996 data using covariables were also in Group 1 from the CA on the 1996 data without covariables. *Euclea natalensis*, *Grewia flavescens*, *Ochna natalitia*, *Peltophorum africanum*, and *Securinega virosa* occurred on

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all the plots in Group 1 however, they were also found on many other Pretoriuskop EBPs in 1996. *Euclea natalensis* was found in higher densities on the control plots than on any other Pretoriuskop EBP (> 500 plants/Ha). *Antidesma venosum*, *Diospyros lycioides*, and *Rhus pentheri* was found on five of the six Group 1 plots however, they also were found on many other Pretoriuskop EBPs. Fifty percent of the occurrences of *Putterlickia pyracantha*, sixty percent of the occurrences of *Olea europaea*, and sixty-seven percent of the occurrences of *Commiphora neglecta* on the Pretoriuskop EBPs occurred on the Group 1 plots. *Acacia swazica*, *Canthium* species, *Combretum mossambicense*, *Croton gratissimus*, *Diospyros whyteana*, *Hyperacanthus amoenus*, *Kraussia floribunda*, *Psydrax locuples*, and *Tarenna supra-axillaris* were found only on Group 1 plots. *Acacia swazica* was found on the Numbi Con0 plot. *Canthium* species was found on the Control plots of the Kambeni, Numbi, and Shabeni replicates. *Combretum mossambicense* was found on the Numbi Con0 plot. *Croton gratissimus* was found on the Kambeni Con0 plot. *Diospyros whyteana* was found on the Numbi Con0 plot. *Hyperacanthus amoenus* was found on the Numbi Con0 and Shabeni Con0 plots. *Kraussia floribunda* was found on the Kambeni Con0 and Numbi Con0 plot. *Psydrax locuples* was found on the Shabeni Con0 plot. Finally, *Tarenna supra-axillaris* was found on the Shabeni Con0 plot.

Group 2 comprised the Numbi Oct2, Dec2, and Aug1 plots, and the Shabeni Aug2 plot (Figure 6-41). These plots occurred in the *Terminalia sericea* - *Combretum* open woodlands of Pretoriuskop (Figure 6-43). The species in Group 2 were *Faurea saligna* and *Syzygium cordatum* (Figure 6-42). Neither of the species on Group 2 occurred on all the Group 2 plots. Most of the plots and species in Group 2 from the CA on the 1996 data using covariables were in Group 4 of the CA on the 1996 data without covariables. Sixty-seven percent of the occurrences of Syzygium cordatum on the Pretoriuskop EBPs were on the Group 2 plots. *Faurea saligna* was found only on the Numbi Aug1 plot.

Group 3 comprised the Fayi Dec2 and Oct2 plots, the Kambeni Oct2, Feb3, and Dec3 plots, the Numbi Feb2, Feb3, and Apr3 plots, and the Shabeni Oct2 plot (Figure 6-41). The species in Group 3 were *Acacia caffra*, *Acacia xanthophloea*, *Albizia versicolor*, *Berchemia zeyheri*, *Cassine transvaalensis*, *Catunaregam spinosa*, *Dalbergia melanoxylon*, *Flacourtia indica*, *Grewia hexamita*, *Hippobromus pauciflorus*, *Kigelia africana*, *Lannea discolor*, *Lannea edulis*, *Lannea schweinfurthii*, *Maytenus heterophylla*, *Maytenus senegalensis*, *Mundulea sericea*, *Ozoroa sphaerocarpa*, *Pappea capensis*, *Pterocarpus rotundifolius*, *Rhus leptodictya*, *Schotia brachypetala*, and *Strychnos spinosa* (Figure 6-42). *Dalbergia melanoxylon* and *Maytenus senegalensis* occurred on all the plots in Group 3 however, they were also found in many other Pretoriuskop EBPs. *Catunaregam spinosa* and *Maytenus heterophylla* were found on eight of the nine Group 3 plots however, they were also found on many other Pretoriuskop EBPs. Fifty percent of the occurrences of *Acacia caffra*, *Grewia hexamita*, *Hippobromus pauciflorus*, *Lannea schweinfurthii*, and *Schotia brachypetala* on the Pretoriuskop EBPs were on the Group 3 plots. *Acacia xanthophloea*, *Berchemia zeyheri*, and *Pterocarpus rotundifolius* were found only on Group 3 plots. *Acacia xanthophloea* was found on the Kambeni Dec3 plot. *Berchemia zeyheri* was found on the Numbi Apr3 plot. *Pterocarpus rotundifolius* was found on the Numbi Feb2 and Apr3 plots.

Group 4 comprised the Fayi Aug2, Apr2, Feb2, Aug1, Aug3, Oct3, Feb3, and Apr3 plots, the Kambeni Feb2, Aug2, Apr2, and Aug1 plots, the Numbi Aug2 and Dec3 plots, and the Shabeni Aug1, Dec2, and Dec3 plots (Figure 6-41). The species in Group 4 were *Annona senegalensis*, *Combretum apiculatum*, *Combretum collinum*, *Combretum hereroense*, *Combretum molle*, *Dichrostachys cinerea*, *Diospyros mespiliformis*, *Dombeya rotundifolia*, *Ehretia obtusifolia*, *Euclea divinorum*, *Ficus sycomorus*, *Gardenia volkensii*, *Grewia monticola*, *Lonchocarpus capassa*, *Markhamia zanzibarica*, *Pavetta schumanniana*, *Phyllanthus reticulatus*, *Rhus pyroides*, *Rhus transvaalensis*, *Sclerocarya birrea*, *Senna petersiana*, *Spirostachys africana*, *Strychnos madagascariensis*, *Syzygium guineense*, *Terminalia sericea*, *Trichilia emetica*, *Turraea nilotica*, *Vangueria infausta*, *Ximenia caffra*, and *Ziziphus mucronata* (Figure 6-42). *Dichrostachys cinerea*, *Sclerocarya birrea*, *Strychnos madagascariensis*, and *Terminalia sericea* occurred on all plots in Group 4 however, they were also found on many other Pretoriuskop EBPs. *Diospyros mespiliformis* and *Ximenia caffra* were found on twelve of the seventeen Group 4 plots however, they were found on many other Pretoriuskop EBPs. *Phyllanthus reticulatus* and *Ziziphus mucronata* occurred on thirteen of the seventeen Group 4 plots, however they were found on many other Pretoriuskop EBPs. *Ehretia obtusifolia* and *Senna petersiana* were

found on fourteen of the seventeen Group 4 plots however, they were found on many other Pretoriuskop EBPs. *Pavetta schumanniana* was found on fifteen of the seventeen Group 4 plots however, it was also found on many other Pretoriuskop EBPs. Fifty percent of the occurrence of *Euclea divinorum*, *Spirostachys africana*, *Trichilia emetica*, and *Vangueria infausta* on the Pretoriuskop EBPs occurred on the Group 4 plots. *Ficus sycomorus*, *Markhamia zanzibarica*, and *Syzygium guineense* were found only on Group 4 plots. *Ficus sycomorus* was found on the Fayi Aug2 plot. *Markhamia zanzibarica* was found on the Shabeni Dec2 plot. *Syzygium guineense* was found on the Fayi Aug1 plot.

Group 5 comprised the Kambeni Dec2, Oct3, Aug3, and Apr3 plots, the Numbi Apr2, Oct3, and Aug3 plots, and the Shabeni Apr2, Apr3, Aug3, Oct3, and Feb3 plots (Figure 6-41). The species in Group 5 were *Acacia exuvialis*, *Acacia gerrardii*, *Acacia sieberiana*, *Albizia harveyi*, *Combretum imberbe*, *Ormocarpum trichocarpum*, *Parinari curatellifolia*, *Piliostigma thonningii*, and *Pterocarpus angolensis* (Figure 6-42). None of the species in Group 5 occurred on all the Group 5 plots. *Acacia exuvialis*, *Albizia harveyi*, and *Combretum imberbe* were found only on Group 5 plots. *Acacia exuvialis* was found on the Shabeni Apr3 plot. *Albizia harveyi* was found on the Kambeni Apr3 plot. *Combretum imberbe* was found on the Shabeni Aug3 plot.

6.3.3.2 Step-wise Ward-Gamma cluster analysis of the first four weighted eigenvectors showing the relationship between the species and plots in Pretoriuskop in 1996 accounting for the relationship between the species and plots in 1954

The step-wise Ward-Gamma cluster analysis was used to summarise the variation of plots and species along the first four eigenvectors of the Correspondence Analysis on the 1996 species by plot data using the first eight axes from the CA on the 1954 data as covariables. There were four main clusters of plots and species at level 2 of the step-wise Ward-Gamma cluster analysis (Figure 6-36). These clusters differed from the two dimensional grouping of plots and species along the first two eigenvectors described above (Figure 6-37 and Figure 6-38).

Cluster 1 comprised the Kambeni Feb3 plot, the Numbi Feb3 plot, and the Shabeni Oct2 plot (Figure 6-40). The species in Cluster 1 were *Acacia caffra*, *Albizia versicolor*, *Cassine transvaalensis*, *Combretum hereroense*, *Dalbergia melanoxylon*, *Euclea divinorum*, *Grewia hexamita*, *Kigelia africana*, *Maytenus senegalensis*, *Pavetta schumanniana*, *Strychnos madagascariensis*, and *Strychnos spinosa* (Table 15-5). *Dalbergia melanoxylon*, *Maytenus senegalensis*, *Pavetta schumanniana*, and *Strychnos madagascariensis* occurred on all the Cluster 1 plots however, they were also found on many other Pretoriuskop EBPs in 1996. The species in Cluster 1 were not found predominantly on the Cluster 1 plots, furthermore some species in Cluster 1 were not found on any of the Cluster 1 plots namely, *Acacia caffra*, *Cassine transvaalensis*, *Euclea divinorum*, *Grewia hexamita*, and *Kigelia africana*.

Cluster 2 comprised the Fayi Aug2, Dec2, Oct2, Apr2, Aug3, Oct3, Feb3, and Apr3 plots, the Kambeni Oct2, Aug2, Apr2, Aug1, and Dec3 plots, the Numbi Oct2, Feb2, Aug2, Aug1, and Apr3 plots, and the Shabeni Aug2 and Aug1 plots (Figure 6-40). The Fayi Dec2, Oct2, Apr2, Aug3, Oct3, Feb3, and Apr3 plots were adjacent to one another, the Kambeni Oct2, Aug2, Apr2, Aug1, and Dec3 plots were adjacent to one another, and the Numbi Feb2, Aug2, and Apr3 plots were adjacent to one another in 1996 (Figure 6-43). The species in Cluster 2 were *Acacia xanthophloea*, *Berchemia zeyheri*, *Catunaregam spinosa*, *Combretum collinum*, *Dichrostachys cinerea*, *Ehretia obtusifolia*, *Faurea saligna*, *Ficus sycomorus*, *Flacourtia indica*, *Hippobromus pauciflorus*, *Lannea discolor*, *Lannea edulis*, *Lannea schweinfurthii*, *Lonchocarpus capassa*, *Maytenus heterophylla*, *Mundulea sericea*, *Ozoroa sphaerocarpa*, *Pappea capensis*, *Pterocarpus rotundifolius*, *Rhus leptodictya*, *Schotia brachypetala*, *Sclerocarya birrea*, *Syzygium cordatum*, *Terminalia sericea*, *Turraea nilotica*, and *Vangueria infausta* (Figure 6-40). *Dichrostachys cinerea*, *Sclerocarya birrea*, and *Terminalia sericea* occurred on all the Cluster 2 plots however, they were also found on many other Pretoriuskop EBPs in 1996. *Ehretia obtusifolia* occurred on seventeen of the twenty Cluster 2 plots, *Maytenus heterophylla* occurred on eighteen of the twenty Cluster 2 plots, and *Catunaregam spinosa* occurred on nineteen of the twenty Cluster 2 plots however, they were also found on many other

Pretoriuskop EBPs. Fifty percent of the occurrences of *Ozoroa sphaerocarpa*, *Schotia brachypetala*, and *Vangueria infausta* on the Pretoriuskop EBPs were on the Cluster 2 plots. Between sixty and seventy percent of the occurrences of *Lannea discolor*, *Lannea edulis*, and *Rhus leptodictya* on the Pretoriuskop EBPs were on the Cluster 2 plots. Eighty-three percent of the occurrences of and *Hippobromus pauciflorus* on the Pretoriuskop EBPs were on the Cluster 2 plots. *Acacia xanthophloea*, *Berchemia zeyheri*, *Faurea saligna*, *Ficus sycomorus*, *Pterocarpus rotundifolius*, and *Syzygium cordatum* were found only on the Cluster 2 plots. *Acacia xanthophloea* was found on the Kambeni Dec3 plot. *Berchemia zeyheri* was found on the Numbi Apr3 plot. *Faurea saligna* was found on the Numbi Aug1 plot. *Ficus sycomorus* was found on the Fayi Aug2 plot. *Pterocarpus rotundifolius* was found on the Numbi Feb2 and Apr3 plots. *Syzygium cordatum* was found on the Numbi Oct2 and Aug1 plots, and the Shabeni Aug1 plot.

Cluster 3 comprised the Fayi Con0, Feb2, Aug1, and Dec3 plots, the Kambeni Con0, Dec2, and Feb2 plots, the Numbi Dec2, Con0, Dec3, and Oct3 plots, and the Shabeni Feb2, Con0, and Dec3 plots (Figure 6-40). The Fayi Con0 and Dec3 plots were adjacent to one another, the Fayi Feb2 and Aug1 plots were adjacent to one another, the Kambeni Con0 and Dec2 plots were adjacent to one another, and the Numbi Dec2, Dec3, and Oct3 plots were adjacent to one another (Figure 6-43). All the plots that were not burnt between 1954 and 1996 were in Cluster 3. The species in Cluster 3 were *Acacia swazica*, *Annona senegalensis*, *Antidesma venosum*, *Bauhinia galpinii*, *Canthium* species, *Cassine aethiopica*, *Combretum apiculatum*, *Combretum mossambicense*, *Commiphora neglecta*, *Croton gratissimus*, *Diospyros lycioides*, *Diospyros mespiliformis*, *Diospyros whyteana*, *Dombeya rotundifolia*, *Euclea natalensis*, *Grewia flavescens*, *Grewia monticola*, *Heteropyxis natalensis*, *Hyperacanthus amoenus*, *Kraussia floribunda*, *Ochna natalitia*, *Olea europaea*, *Peltophorum africanum*, *Phyllanthus reticulatus*, *Psydrax locuples*, *Pterocarpus angolensis*, *Putterlickia pyracantha*, *Rhus pentheri*, *Rhus pyroides*, *Rhus transvaalensis*, *Securinega virosa*, *Spirostachys africana*, *Syzygium guineense*, *Tarenna supra-axillaris*, and *Zanthoxylum capense* (Figure 6-40). *Euclea natalensis* occurred on all the Cluster 3 plots however, it was also found on many other Pretoriuskop EBPs in 1996. *Antidesma venosum*, *Diospyros lycioides*, and *Phyllanthus reticulatus* were found on ten of the fourteen Cluster 3 plots. *Grewia flavescens*, *Grewia monticola*, *Ochna natalitia*, *Peltophorum africanum*, and *Rhus pyroides* were found on eleven of the fourteen Cluster 3 plots. *Diospyros mespiliformis*, *Rhus transvaalensis*, and *Securinega virosa* were found on twelve of the fourteen Cluster 3 plots. However, all of these species were also found on many of the other Pretoriuskop EBPs. Between fifty and sixty percent of the occurrences of *Putterlickia pyracantha*, and *Rhus pentheri* on the Pretoriuskop EBPs occurred on the Cluster 3 plots. Sixty-seven percent of the occurrences of *Commiphora neglecta* on the Pretoriuskop EBPs occurred on the Cluster 3 plots. Seventy-five percent of the occurrences of *Heteropyxis natalensis* on the Pretoriuskop EBPs occurred on the Cluster 3 plots, Eighty percent of the occurrences of *Olea europaea* on the Pretoriuskop EBPs occurred on the Cluster 3 plots. *Acacia swazica*, *Canthium* species, *Combretum mossambicense*, *Croton gratissimus*, *Diospyros whyteana*, *Hyperacanthus amoenus*, *Kraussia floribunda*, *Psydrax locuples*, *Spirostachys africana*, *Syzygium guineense*, and *Tarenna supra-axillaris* were found only on Cluster 3 plots. *Acacia swazica* was found on the Numbi Con0 plot. *Canthium* species was found on the Control plots of the Kambeni, Numbi, and Shabeni replicates. *Combretum mossambicense* was found on the Numbi Con0 plot. *Croton gratissimus* was found on the Kambeni Con0 plot. *Diospyros whyteana* was found on the Numbi Con0 plot. *Hyperacanthus amoenus* was found on the Numbi Con0 and Shabeni Con0 plots. *Kraussia floribunda* was found on the Kambeni Con0 and Numbi Con0 plots. *Psydrax locuples* was found on the Shabeni Con0 plot. *Spirostachys africana* was found on the Numbi Dec3 plot, and the Shabeni Con0 plot. *Syzygium guineense* was found on the Fayi Aug1 plot. *Tarenna supra-axillaris* was found on the Shabeni Con0 plot. Most of these species were associated with the plots that were not burnt between 1954 and 1996. The control plots may be fire refuges for these fire sensitive species. The occurrence of these species on the control plots may be dependant on local fire refuges such as rock outcrops and large termite mounds on which the species survive and reproduce.

Cluster 4 comprised the Kambeni Oct3, Aug3, and Apr3 plots, the Numbi Apr2 and Aug3 plots, and the Shabeni Apr2, Dec2, Apr3, Aug3, Oct3, and Feb3 plots (Figure 6-40). These occurred mainly in the open *Terminalia sericea* - *Combretum* woodlands of Pretoriuskop (Figure 6-43). The species in Cluster 4 were *Acacia exuvialis*, *Acacia gerrardii*, *Acacia sieberiana*, *Albizia harveyi*, *Combretum imberbe*, *Combretum*

molle, *Gardenia volkensii*, *Markhamia zanzibarica*, *Ormocarpum trichocarpum*, *Parinari curatellifolia*, *Piliostigma thonningii*, *Senna petersiana*, *Trichilia emetica*, *Ximenia caffra*, and *Ziziphus mucronata* (Figure 6-40). No species occurred on all the Cluster 4 plots in 1996. *Combretum molle* occurred on eight of the eleven Cluster 4 plots and *Senna petersiana* occurred on nine of the eleven Cluster 4 plots however, they were both found on other Pretoriuskop EBPs in 1996. *Acacia exuvialis*, *Albizia harveyi*, *Combretum imberbe*, and *Markhamia zanzibarica* were found only on the Cluster 4 plots. *Acacia exuvialis* was found on the Shabeni Apr3 plot. *Albizia harveyi* was found on the Kambeni Apr3 plot. *Combretum imberbe* was found on the Shabeni Aug3 plot. *Markhamia zanzibarica* was found on the Shabeni Dec2 plot.

6.3.3.3 Summary of the results from the CA's on the 1996 species by plot data with covariables

In this analysis, some of the initial variation in species composition between the Pretoriuskop EBPs was accounted for. Location was still found to be a factor determining similarity in species composition between plots, but it was not as strong a factor as in the previous analyses. Proximity was also found still to be a strong factor determining similarity in species composition.

The control plots once again an exception to this. However, it was found that the many of the February and December Biennial and Triennial treatments had species compositions that were similar to those of the plots that were not burnt. The species associated with the control plots and many of the December and February Biennial and Triennial plots were *Euclea natalensis*, *Antidesma venosum*, *Diospyros lycioides*, *Phyllanthus reticulatus*, *Grewia flavescens*, *Grewia monticola*, *Ochna natalitia*, *Peltophorum africanum*, *Rhus pyroides*, *Diospyros mespiliformis*, *Rhus transvaalensis*, and *Securinega virosa*. However, these species were also found on many of the other Pretoriuskop EBPs. Other species associated with these plots were *Putterlickia pyracantha*, *Rhus pentheri*, *Commiphora neglecta*, *Heteropyxis natalensis*, and *Olea europaea*.

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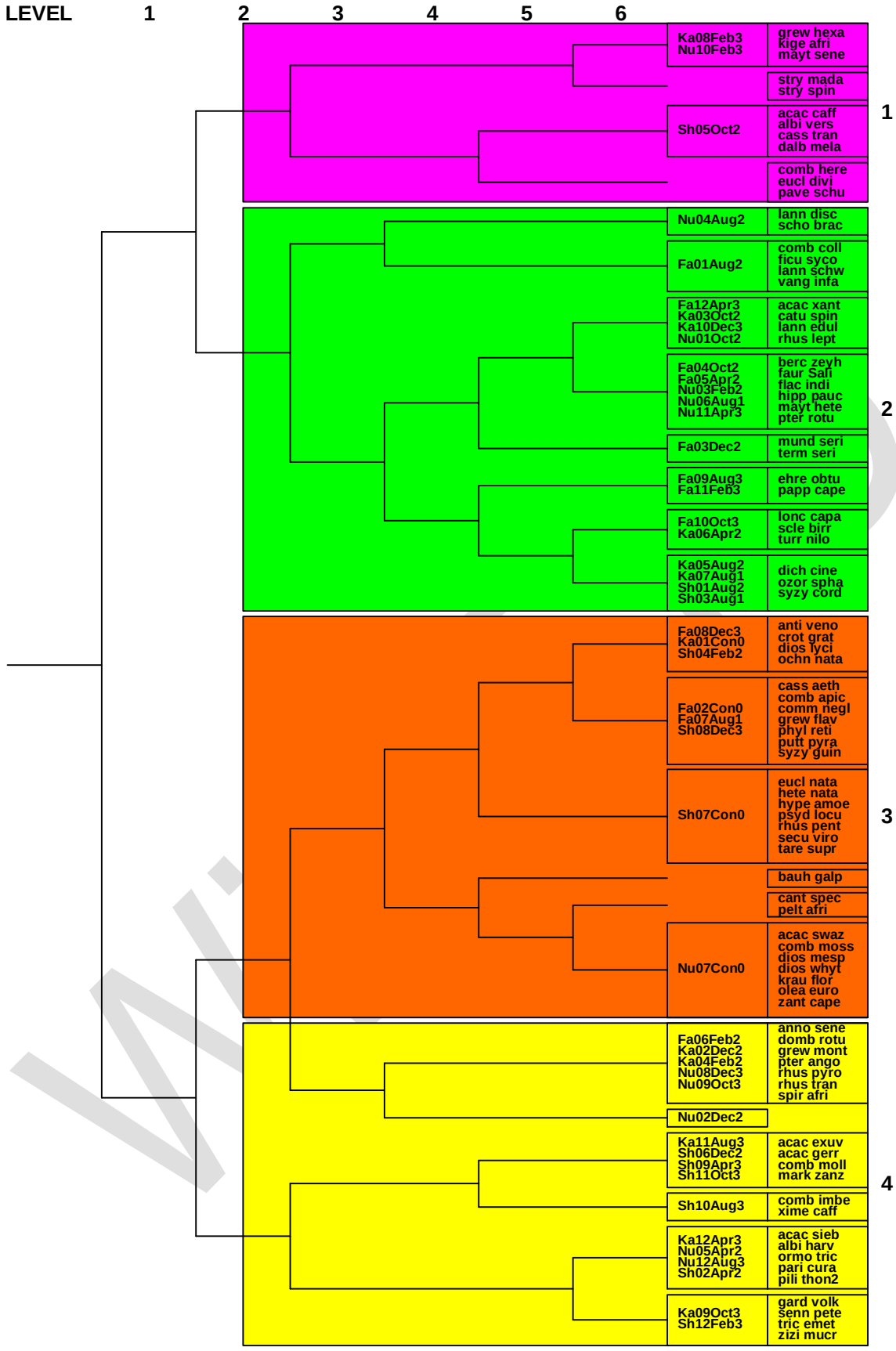


Figure 6-40: Classification of treatment plots and species using a step-wise Gamma-Ward cluster analysis on the first four ordination axes from the CA on the 1996 species by plot data with the first eight ordination axes of the 1954 species by plot CA as covariables. The codes for the treatment plots are defined in Table 10-1 (p. 214) and the codes for the species are defined in Table 9-1 (p. 210).

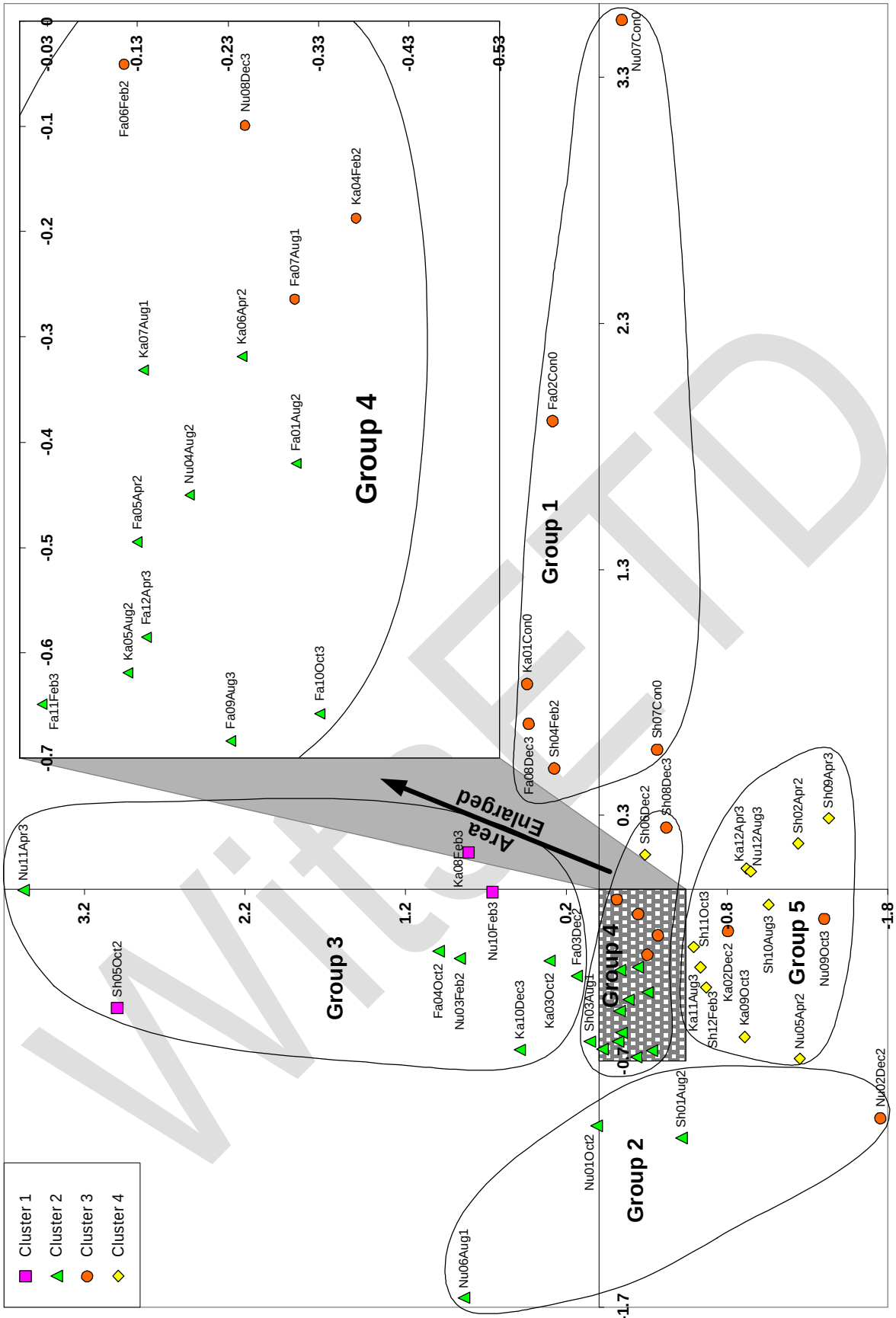


Figure 6-41: Bi-plot of the first two ordination axes from the CA on the 1996 species by plot data showing variation in species composition between treatment plots with the first eight ordination axes of the 1954 species by plot CA as covariables. The groups are the result of a visual assessment of the grouping of species and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-40). The codes for the treatment plots are defined in Table 10-1 (p. 214).

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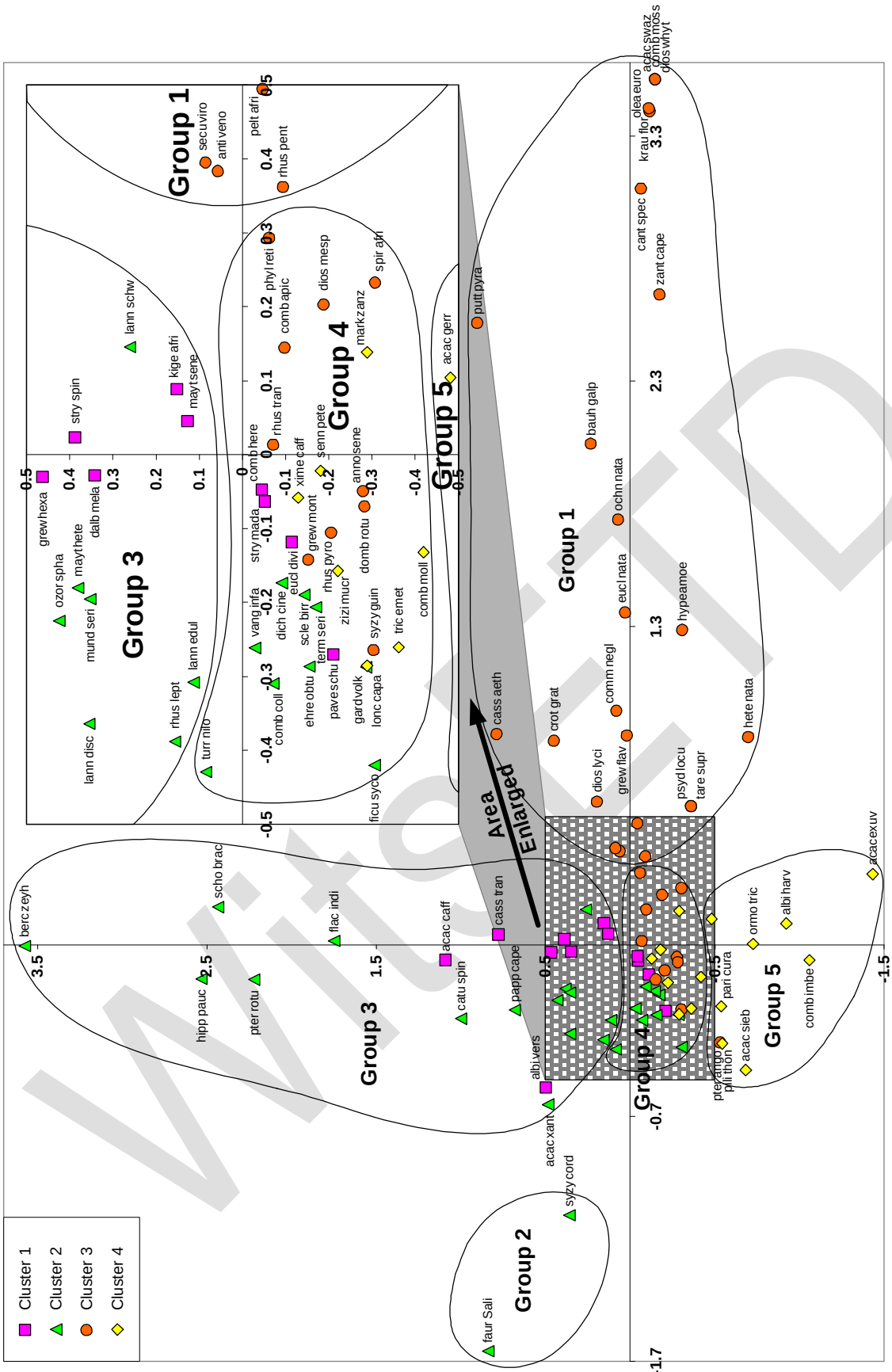


Figure 6-42: Bi-plot of the first two ordination axes from the CA on the 1996 species by plot data showing variation in location (plots) between species with the first eight ordination axes of the 1954 species by plot CA as covariables. The groups are the result of a visual assessment of the grouping of species and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-40). The codes for the species are defined in Table 9-1 (p. 210).

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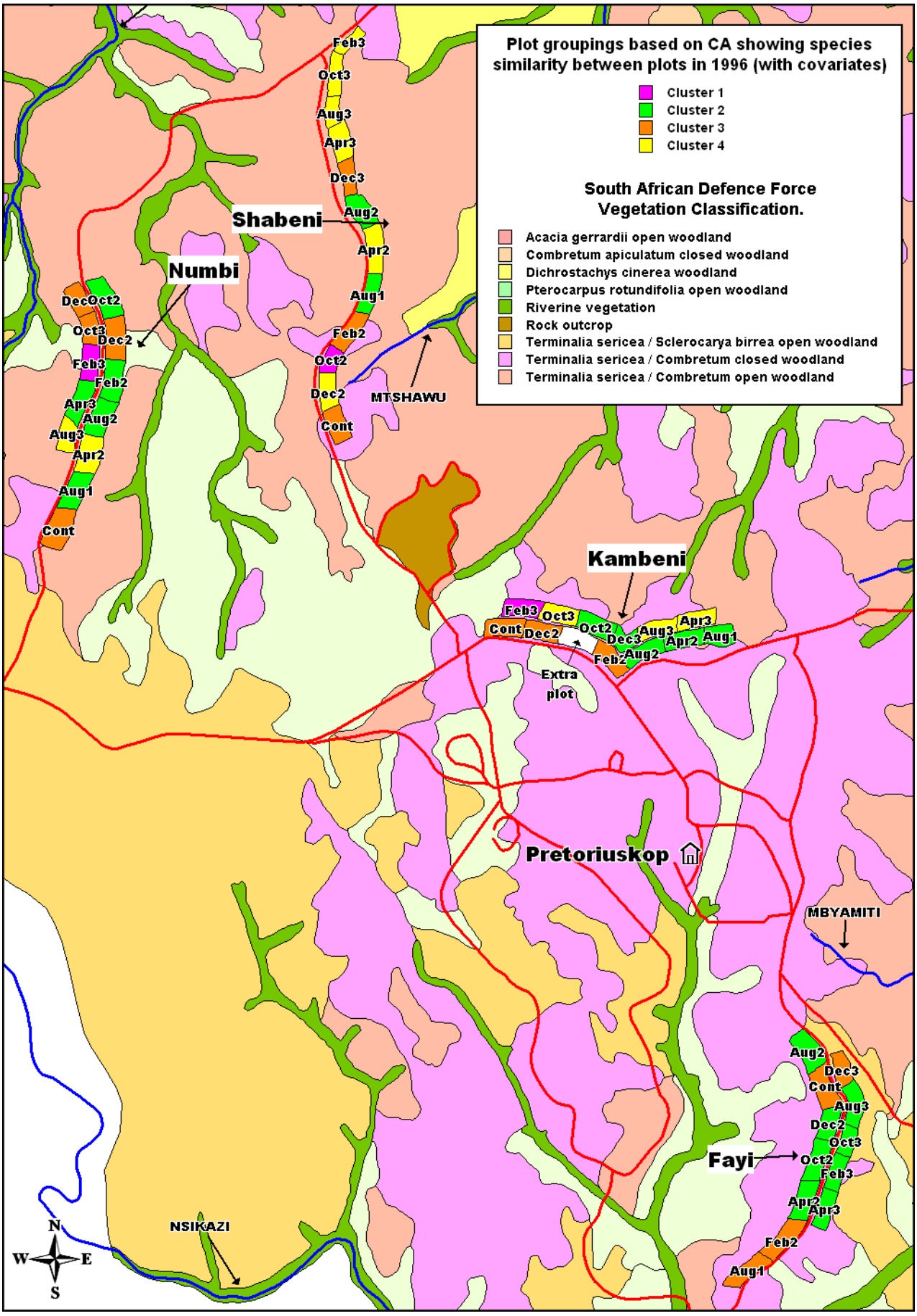


Figure 6-43: Map showing the level 2 groupings of a classification of treatment plots using a stepwise cluster analysis on the first four ordination axes of a CA on the 1996 species by plot data with the first eight ordination axes of the 1954 species by plot CA as covariables (Figure 6-40). The codes for the treatments are defined in Table 3-1 (p. 15).

6.3.4 Results from the Correspondence Analysis on the 1954 structure by plot data

The results from the CA performed on the 1954 structure by plot data are presented in Table 6-13 (p. 151), Figure 6-44 (p. 155), Figure 6-45 (p. 156), Figure 6-46 (p. 157), and Figure 6-47 (p. 158). Table 6-13 shows the Eigenvalues for the first four ordination axes of the CA. Figure 6-44 is a hierarchical cluster tree showing the cluster groups from the step-wise Gamma-Ward cluster analysis on the first four ordination axes. Figure 6-45 is a bi-plot of the first two, weighted eigenvector plot score axes with the data points colour coded to the level 2 cluster colours in Figure 6-44. Figure 6-46 is a bi-plot of the first two, weighted eigenvector structure score axes with the data points colour coded to the level 2 cluster colours in Figure 6-44. Figure 6-47 is a map showing the layout of the Pretoriuskop EBP experiment with the plots colour coded to the level 2 cluster colours in Figure 6-44. The weighted eigenvector plot scores for the first four ordination axes, the plot weights and the effective number of structural groups that occur on the plots (N2 structural diversity of plots) (Hill 1973) are presented in Table 15-7 (p. 265). The weighted eigenvector structure scores for the first four ordination axes, the structure weights, and the effective number of occurrences of the structures (N2 diversity of structures) are presented in Table 15-8 (p. 266).

Table 6-13: Eigenvalues for the first four ordination axes of a Correspondence Analysis on the structure by plot data collected in 1954

	Axis 1	Axis 2	Axis 3	Axis 4	Total
Eigenvalue	0.2492	0.0445	0.0311	0.0191	0.455
% Variation	54.8	9.8	6.8	4.2	75.6

The Eigenvalues, for the first four axes of the CA on the 1954 data were 0.249, 0.045, 0.031, and 0.019 (Table 6-13). The first four eigenvectors accounted for 54.8%, 9.8%, 6.8%, and 4.2% of the variation in the structure by plot data respectively in 1954, and 75.6% of the total variation in the structure by plot data in 1954 (Table 6-13).

6.3.4.1 Bi-plots of the first two weighted structure and plot eigenvectors showing the relationship between the structures and plots in Pretoriuskop in 1954

There were two main groups of plots and structures on the bi-plots of the first two weighted eigenvectors from the Correspondence Analysis on the 1954 data (Figure 6-45 and Figure 6-46). Group 1 comprised structure groups and plots with x-axis eigenvector values greater than zero, and Group 2 comprised structure groups and plots with x-axis eigenvector values less than zero.

Group 1 comprised the Fayi Dec3, Aug3, Oct3, Feb3, and Apr3 plots, the Kambeni Oct2, Feb2, Aug2, Feb3, Oct3, Dec3, Aug3, and Apr3 plots, the Numbi Dec3, Oct3, Feb3, Apr3, and Aug3 plots, and the Shabeni Apr2, Feb2, Dec3, Apr3, Aug3, Oct3, and Feb3 plots (Figure 6-45). The structures in Group 1 were single-stem individuals 0-1m high with basal diameters 12.7-17.8cm, and multi-stem individuals 0-1m high with basal diameters 0-30cm and 30-91cm, 1-3m high with basal diameters 0-30cm, 30-91cm, and greater than 91cm, 3-5m high with basal diameters 0-30cm, and taller than 5m with basal diameters 0-30cm (Figure 6-46). Multi-stem individuals 0-1m high with basal diameters 0-30cm, and 1-3m high with basal diameters 0-30cm and 30-91cm occurred on all Group 1 plots in 1954, and these structure groups were found mainly on the Group 1 plots in 1954. Multi-stem individuals 0-1m high with basal diameters 0-30cm, and 1-3m high with basal diameters 0-30cm, occurred on all Group 1 plots and they were found mainly on Group 1 plots in 1954. Multi-stem individuals 1-3m high with basal diameters greater than 91cm were found on eighteen of the twenty-five Group 1 plots and they occurred mainly on the Group 1 plots. Multi-stem individuals 1-3m high with basal diameters 30-91cm, and 3-5m high with basal diameters 0-30cm, were found on twenty of the twenty-five Group 1 plots in 1954. Multi-stem individuals 1-3m high with basal diameters 30-91cm, were found on many other Pretoriuskop EBPs, and multi-stem individuals 3-5m high with basal diameters 0-30cm, were found mainly on the Group 1 plots on 1954. Between fifty and sixty percent of the occurrences of single-stem individuals 0-1m high with basal diameters 12.7-17.8cm, and multi-stem individuals 0-1m high

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with basal diameters 0-30cm, and 1-3m high with basal diameters 0-30cm and greater than 91cm, on the Pretoriuskop EBPs were on the Group 1 plots in 1954. Eighty percent of the occurrences of multi-stem individuals 3-5m high with basal diameters 0-30cm, on the Pretoriuskop EBPs were in the Group 1 plots. Multi-stem individuals taller than 5m with basal diameters 0-30cm, occurred only on the Group 1 plots and were found on the Kambeni Dec3 and Aug3 plots, the Numbi Feb3 plot, and the Shabeni Feb2 plot.

Group 2 comprised the Fayi Aug2, Con0, Dec2, Oct2, Apr2, Feb2, and Aug1 plots, the Kambeni Con0, Dec2, Apr2, and Aug1 plots, the Numbi Oct2, Dec2, Feb2, Aug2, Apr2, Aug1, and Con0 plots, and the Shabeni Aug2, Aug1, Oct2, Dec2, and Con0 plots (Figure 6-45). The single stem structures in Group 2 were 0-1m high with basal diameters 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, and greater than 17.8cm, 1-3m high with basal diameters 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, 12.7-17.8cm, and greater than 17.8cm, 3-5m high with basal diameters 2.5-7.6cm, 7.6-12.7cm, 12.7-17.8cm, and greater than 17.8cm, and taller than 5m with basal diameters 0.0-2.5cm, 7.6-12.7cm, 12.7-17.8cm, and greater than 17.8cm (Figure 6-46). The multi-stem structures in Group 2 were 0-1m high with basal diameters greater than 91cm, and 3-5m high with basal diameters 30-91cm and greater than 91cm (Figure 6-46). Single-stem individuals 0-1m high with basal diameters 0.0-2.5cm, 1-3m high with basal diameters 0.0-2.5cm and 2.5-7.6cm, and taller than 5m with basal diameters greater than 17.8cm, occurred on all the Group 2 plots. Single-stem individuals taller than 5m with basal diameters greater than 17.8cm, were found mainly on the Group 2 plots however the rest were found on many other Pretoriuskop EBPs in 1954. Single-stem individuals 3-5m high with basal diameters greater than 17.8cm were found on seventeen of the twenty-three Group 2 plots and occurred mainly on the Group 2 plots in 1954. Single-stem individuals 0-1m high with basal diameters 2.5-7.6cm, and 3-5m high with basal diameters 7.6-12.7cm, were found on nineteen of the twenty-three Group 2 plots and occurred mainly on the Group 2 plots. Single-stem individuals 3-5m high with basal diameters 12.7-17.8cm, occurred on twenty of the twenty-three Group 2 plots and were found mainly on the Group 2 plots in 1954. Single-stem individuals 1-3m high with basal diameters 7.6-12.7cm, were found on twenty-one of the twenty-three Group 2 plots and occurred mainly on the Group 2 plots. Between fifty and sixty percent of the occurrences of single-stem individuals 0-1m high with basal diameters 2.5-7.6cm and greater than 17.8cm, 1-3m high with basal diameters 7.6-12.7cm and 12.7-17.8cm, 3-5m high with basal diameters 7.6-12.7cm and 12.7-17.8cm, and taller than 5m with basal diameters greater than 17.8cm, on the Pretoriuskop EBPs in 1954 occurred on the Group 2 plots. Between fifty and sixty percent of the occurrences of multi-stem individuals 0-1m high with basal diameters greater than 91cm, on the Pretoriuskop EBPs in 1954 occurred on the Group 2 plots. Between sixty and seventy percent of the occurrences of single-stem individuals 3-5m high with basal diameters greater than 17.8cm, and taller than 5m with basal diameters 7.6-12.7cm and 12.7-17.8cm, and multi-stem individuals 3-5m high with basal diameters 30-91cm and greater than 91cm, on the Pretoriuskop EBPs in 1954 occurred on the Group 2 plots. Seventy-nine percent of the occurrences of single-stem individuals 0-1m high with basal diameters 7.6-12.7cm, on the Pretoriuskop EBPs were on the Group 2 plots. Between eighty and ninety percent of the occurrences of single-stem individuals 1-3m high with basal diameters greater than 17.8cm, and 3-5m high with basal diameters 2.5-7.6cm, on the Pretoriuskop EBPs in 1954 were on the Group 2 plots. Single-stem individuals taller than 5m with basal diameters between 0.0-2.5cm occurred only on the Group 2 plots and they were found on the Fayi Feb2 plot.

6.3.4.2 Step-wise Ward-Gamma cluster analysis of the first four weighted eigenvectors showing the relationship between the structures and plots in Pretoriuskop in 1954

The step-wise Ward-Gamma cluster analysis was used to summarise the variation of plots and structures along the first four eigenvectors of the Correspondence Analysis on the 1954 structure by plot data. There were four main clusters of plots and structures at level 2 of the step-wise Ward-Gamma cluster analysis (Figure 6-32). These clusters differed from the two dimensional grouping of plots and structures along the first two eigenvectors described above (Figure 6-33 and Figure 6-34).

Cluster 1 comprised the Fayi Aug2, Con0, Dec2, Oct2, and Feb2 plots, the Kambeni Dec2, Aug2, Apr2, and Aug1 plots, and the Numbi Oct2, Dec2, Aug2, Apr2, Aug1, and Con0 plots (Figure 6-44). The Fayi Aug2, Con0, Dec2, and Oct2 plots were adjacent to one another, the Kambeni Aug2, Apr2, and Aug1 plots were

adjacent to one another, the Numbi Oct2 and Dec2 plots were adjacent to one another, and the Numbi Aug2, Apr2, Aug1, and Con0 plots were adjacent to one another (Figure 6-35). The plots on Cluster 1 were very similar to those in Cluster D of the Pearson-Ward Cluster analysis on the structural similarity in 1954 (Figure 6-28 p. 120). The plots in Cluster 1 occur on the Fayi and Numbi replicates in the areas, which were burnt in 1953 just before the experiment was set up in 1954. Post fire age of the vegetation may be an important factor contributing to the structure of the woody vegetation of these plots, and may explain why the structure on these plots was similar. The single-stem structures in Cluster 1 were 0-1m high with basal diameters 0.0-2.5cm, 7.6-12.7cm, and greater than 17.8cm, 1-3m high with basal diameters 0.0-2.5cm, 7.6-12.7cm, 12.7-17.8cm, and greater than 17.8cm, 3-5m high with basal diameters 7.6-12.7cm, 12.7-17.8cm, and greater than 17.8cm, and taller than 5m with basal diameters 0.0-2.5cm, 12.7-17.8cm, and greater than 17.8cm (Figure 6-44). The multi-stem structures in Cluster 1 were 0-1m high with basal diameters 30-91cm, 1-3m high with basal diameters 30-91cm, and 3-5m high with basal diameters 30-91cm and greater than 91cm (Figure 6-44). Single-stem individuals 0-1m high with basal diameters 0.0-2.5cm, and 1-3m high with basal diameters 0.0-2.5cm and 7.6-12.7cm, occurred on all Cluster 1 plots however, they were found on many Pretoriuskop EBPs in 1954. Single-stem individuals 3-5m high with basal diameters 7.6-12.7cm, were found on thirteen of the fifteen Cluster 1 plots however, they occurred on many other Pretoriuskop EBPs. Single-stem individuals 3-5m high with basal diameters 12.7-17.8cm, and taller than 5m with basal diameters greater than 17.8cm, and multi-stem individuals 1-3m high with basal diameters 30-91cm, were found on fourteen of the fifteen Cluster 1 plots however, they occurred on many other Pretoriuskop EBPs in 1954. Fifty-seven percent of the occurrences of single-stem individuals 0-1m high with basal diameters 7.6-12.7cm, on the Pretoriuskop EBPs in 1954 were on the Cluster 1 plots. Sixty-four percent of the occurrences of multi-stem individuals 3-5m high with basal diameters 30-91cm, on the Pretoriuskop EBPs was on the Cluster 1 plots in 1954. Eighty percent of the occurrences of multi-stem individuals 3-5m high with basal diameters greater than 91cm, on the Pretoriuskop EBPs were on the Cluster 1 plots in 1954. Single-stem individuals taller than 5m with basal diameters 0.0-2.5cm were found only on the Cluster 1 plots, and they occurred on the Fayi Feb2 plot.

Cluster 2 comprised the Numbi Feb2 and Dec3 plots, and the Shabeni Aug2, Oct2, Dec2, Con0, and Apr3 plots (Figure 6-44). The Shabeni Oct2, Dec2, and Con0 plots were adjacent to one another (Figure 6-35). The plots in Cluster 2 were very similar to those in Cluster C of the Pearson-Ward Cluster analysis on the structural similarity in 1954 (Figure 6-28). The structure group in Cluster 2 was the multi-stem individuals 0-1m high with basal diameters greater than 91cm (Figure 6-44). This structure group occurred on four out of seven Cluster 2 plots however, it also occurred on many other Pretoriuskop EBPs in 1954.

Cluster 3 comprised the Fayi Apr2, Aug1, Dec3, and Oct3 plots, the Kambeni Con0 plot, and the Shabeni Aug1 plot (Figure 6-44). Many of the plots in Cluster 3 were those plots in Cluster D of the Pearson-Ward Cluster analysis on the structural similarity in 1954 that were not in Cluster 1 (Figure 6-28). The structures in Cluster 3 were single-stem individuals 0-1m high with basal diameters 2.5-7.6cm, 1-3m high with basal diameters 2.5-7.6cm, 3-5m high with basal diameters 2.5-7.6cm, and taller than 5m with basal diameters 7.6-12.7cm, and multi-stem individuals 1-3m high with basal diameters greater than 91cm (Figure 6-44). single-Stem individuals 0-1m high with basal diameters 2.5-7.6cm, and 1-3m high with basal diameters 2.5-7.6cm, were found on all the Cluster 3 plots however, they also occurred on many other Pretoriuskop EBPs in 1954. Fifty percent of the occurrences of single-stem individuals 3-5m high with basal diameters 2.5-7.6cm, on the Pretoriuskop EBPs was on the Cluster 3 plots in 1954.

Cluster 4 comprised the Fayi Aug3, Feb3, and Apr3 plots, the Kambeni Oct2, Feb2, Feb3, Oct3, Dec3, Aug3, and Apr3 plots, the Numbi Oct3, Feb3, Apr3, and Aug3 plots, and the Shabeni Apr2, Feb2, Dec3, Aug3, Oct3, and Feb3 plots (Figure 6-44). The Fayi Feb3 and Apr3 were adjacent to one another, the Kambeni Oct2, Feb2, Feb3, Oct3, Dec3, Aug3, and Apr3 plots were adjacent to one another, the Numbi Oct3, Feb3, Apr3, and Aug3 plots were adjacent to one another, and Shabeni Aug3, Oct3, and Feb3 plots were adjacent to one another (Figure 6-35). Many of the plots in Cluster 4 were clustered together in Cluster B from the Pearson-Ward Cluster analysis on the structural similarity in 1954 (Figure 6-28). The structures in Cluster 4 were single-stem individuals 0-1m high with basal diameters 12.7-17.8cm, and multi-stem individuals 0-1m

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high with basal diameters 0-30cm, 1-3m high with basal diameters 0-30cm, 3-5m high with basal diameters 0-30cm, and taller than 5m with basal diameters 0-30cm (Figure 6-44). Multi-stem individuals 0-1m high with basal diameters 0-30cm, and 1-3m high with basal diameters 0-30cm, were found on all the Cluster 4 plots however, they also occurred on many other Pretoriuskop EBPs in 1954. Multi-stem individuals 3-5m high with basal diameters 0-30cm were found on seventeen of the twenty Cluster 4 plots and they occurred mainly on the Cluster 4 plots in 1954. Fifty percent of the occurrences of single-stem individuals 0-1m high with basal diameters 12.7-17.8cm, on the Pretoriuskop EBPs in 1954 were on the Cluster 4 plots. Sixty-eight percent of the occurrences of multi-stem individuals 3-5m high with basal diameters 0-30cm, on the Pretoriuskop EBPs were on the Cluster 4 plots in 1954. Multi-stem individuals taller than 5m with basal diameters 0-30cm, occurred only on the Cluster 4 plots and was found on the Kambeni Dec3 and Aug3 plots, the Numbi Feb3 plot, and the Shabeni Feb2 plot.

6.3.4.3 Summary of the results from the CA's on the 1954 structure by plot data

In 1954, similarity in the structural composition between plots was linked to the proximity of plots to one another. However, no strong patterns emerged regarding similarity in structural composition between plots and the location of the plots in the open and closed *Terminalia sericea* - *Combretum* woodlands of the Pretoriuskop region.

Generally, the structure of the woody vegetation on the control plots, the Annual plots, and the Biennial plots was more similar to one another than to the Triennial plots. The reason for this is that the EBPs in the Pretoriuskop region were established and surveyed in two distinct phases (Table 3-1 p.15 and Table 11-1 p.215). The control plots, the Annual plots, and the Biennial plots were established and surveyed in 1954 while the Triennial plots were established in 1956 and they were surveyed in 1957 and 1958 (Table 3-1 p.15 and Table 11-1 p.215). The establishment of the EBPs in two phases resulted in the baseline vegetation of the plots established in 1956 having been exposed to slightly different fire regimes than the plots that were established in 1954. It is believed that a difference in the time since the last fire event between the two phases is what is responsible for the differences in the structure of the woody vegetation between the two phases.

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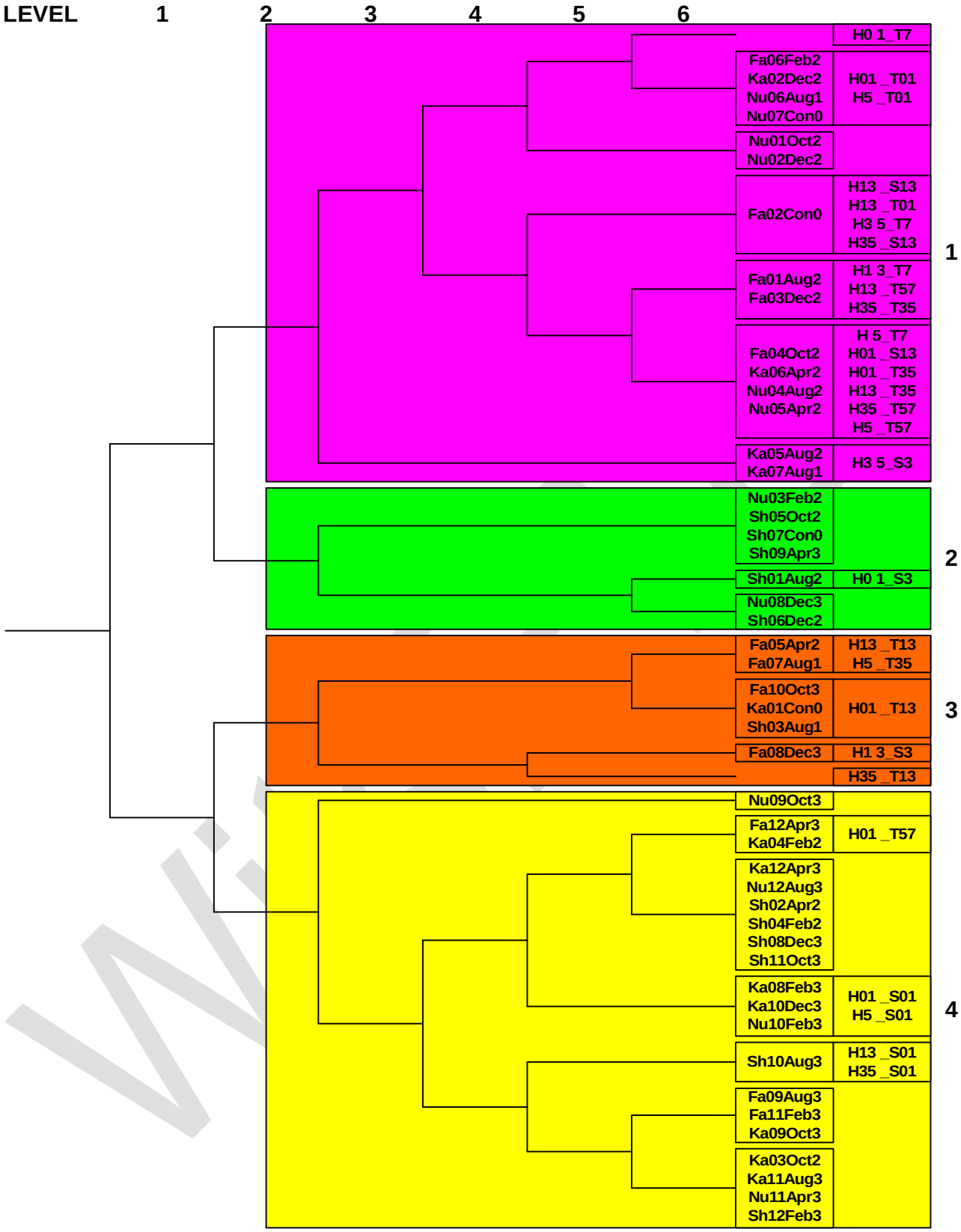


Figure 6-44: Classification of treatment plots and structures using a step-wise Gamma-Ward cluster analysis on the first four ordination axes from the CA on the 1954 structure by plot data. The codes for the treatment plots are defined in Table 10-1 (p. 214) and the codes for the structure groups are defined in Table 5-3 (p. 34).

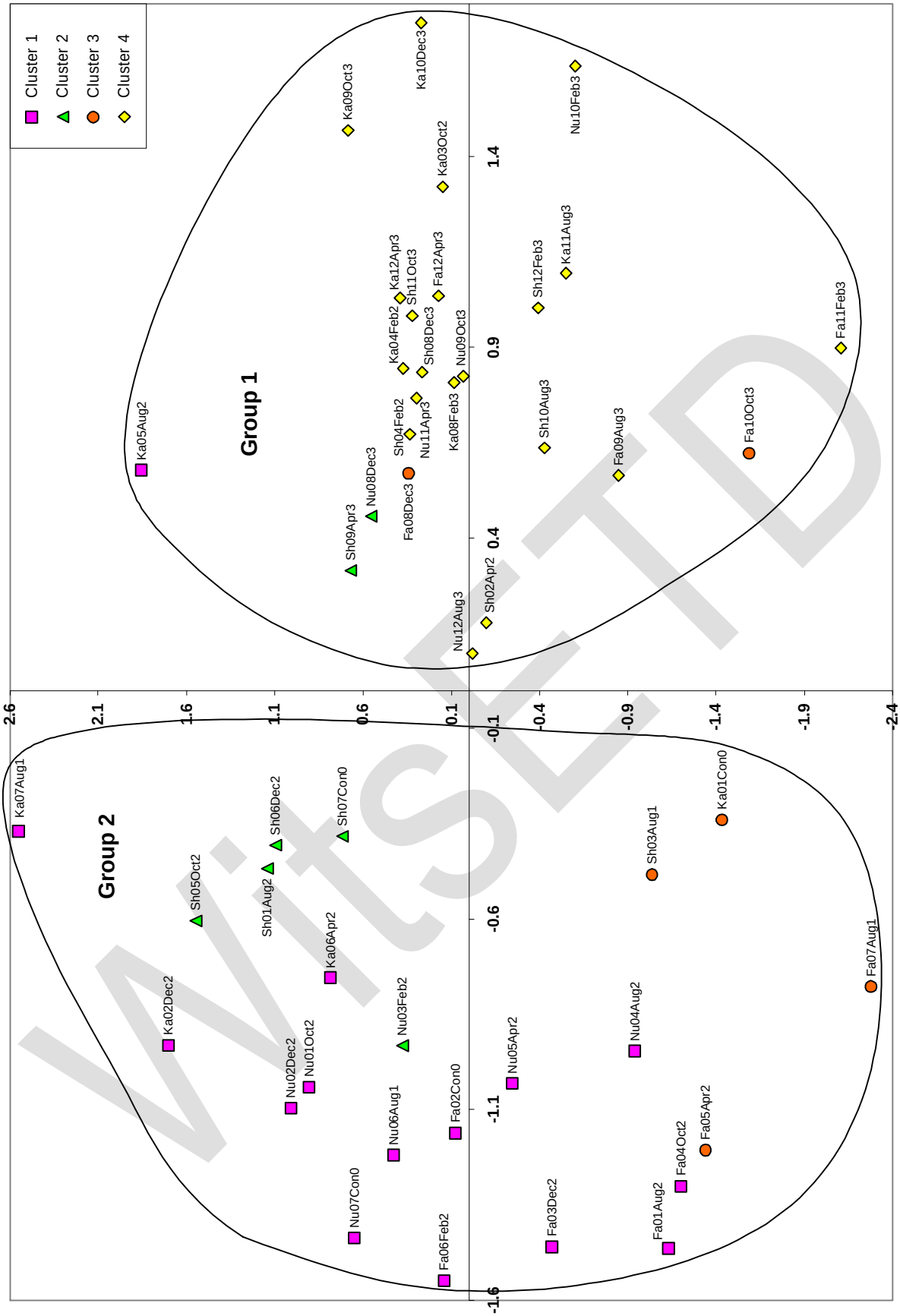


Figure 6-45: Bi-plot of the first two ordination axes from the CA on the 1954 structure by plot data showing variation in structural composition between treatment plots. The groups are the result of a visual assessment of the grouping of structures and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-44). The codes for the treatment plots are defined in Table 10-1 (p. 214).

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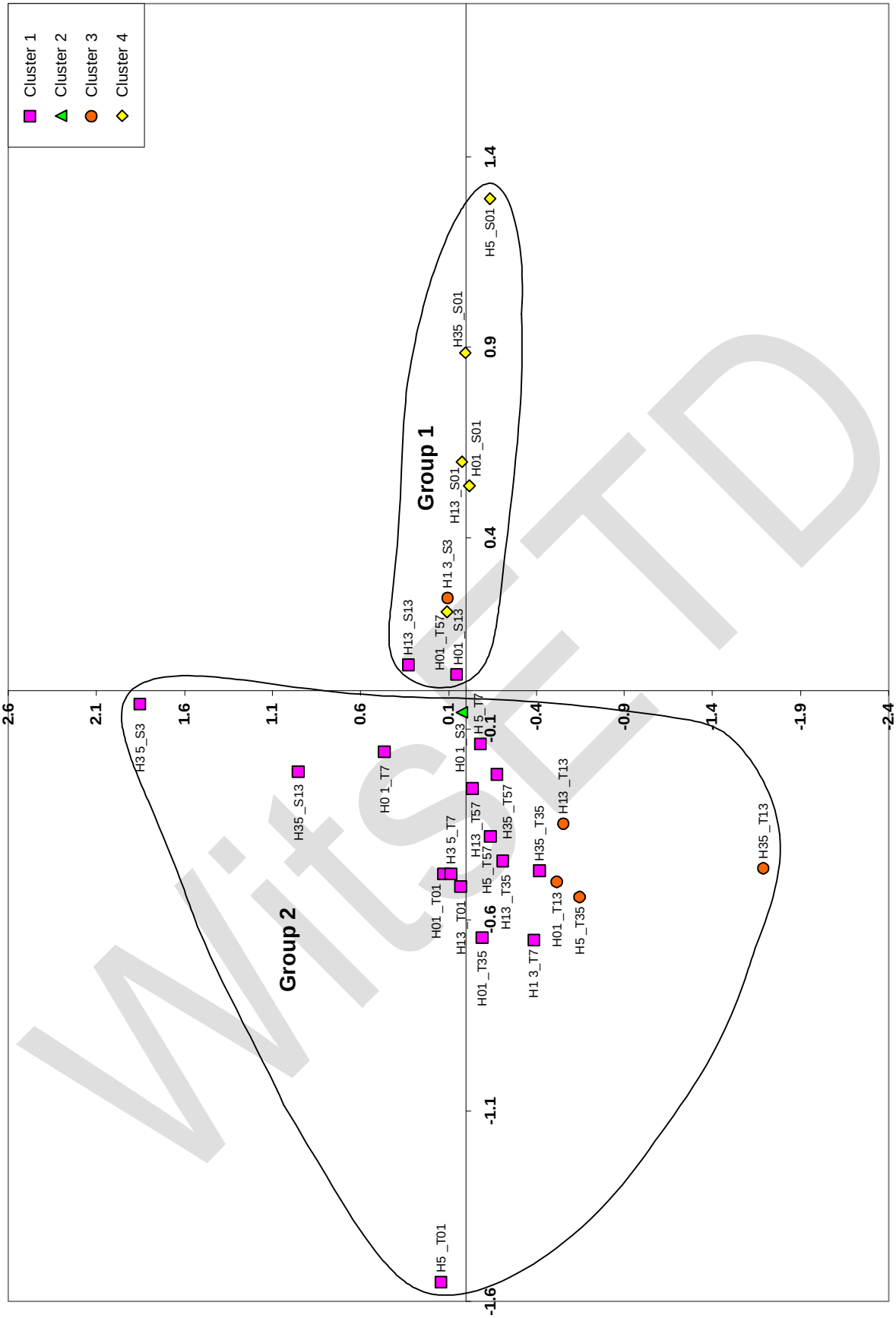


Figure 6-46: Bi-plot of the first two ordination axes from the CA on the 1954 structure by plot data showing variation in location (plots) between structures. The groups are the result of a visual assessment of the grouping of structures and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-44). The codes for the structure groups are defined in Table 5-3 (p. 34).

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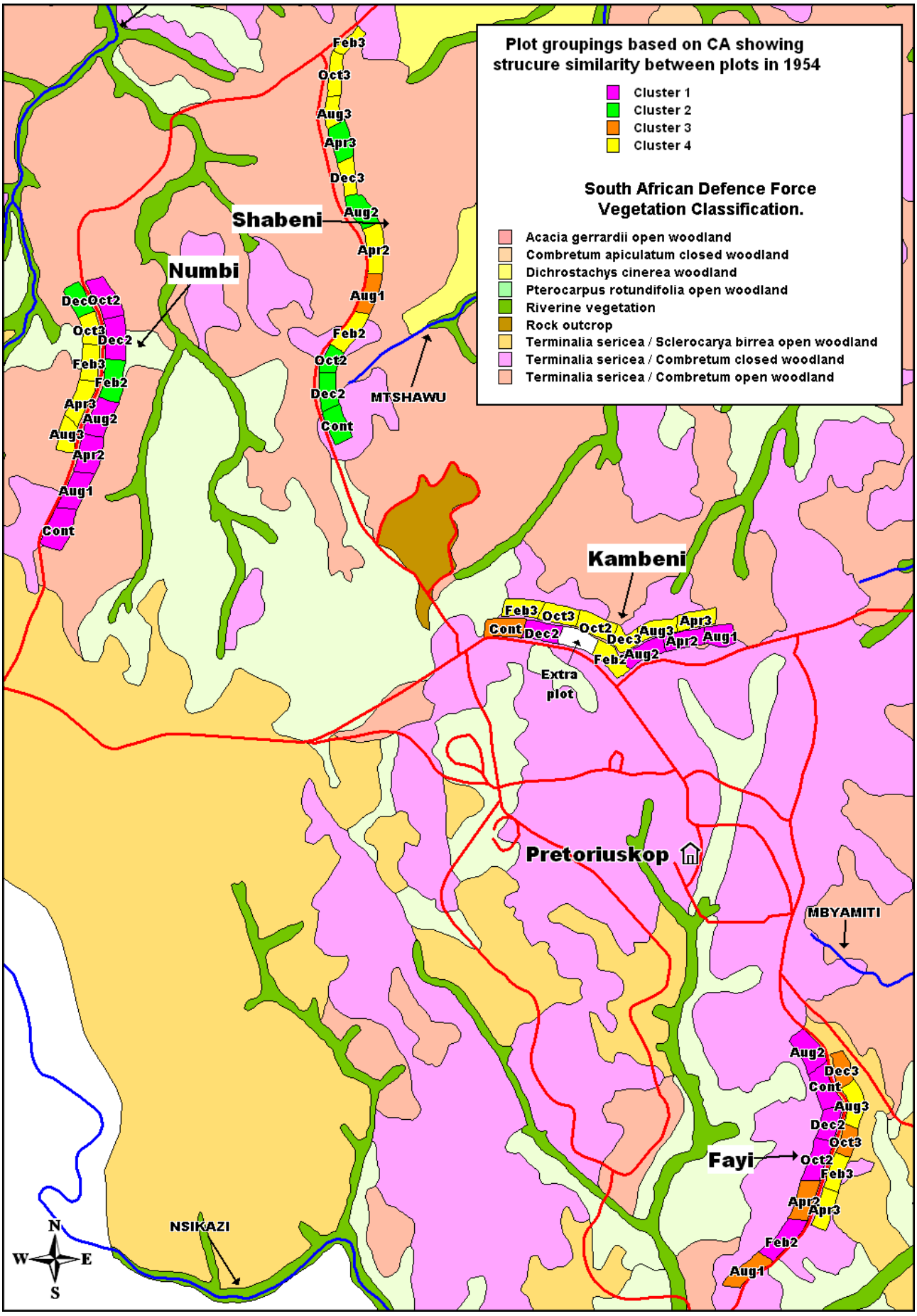


Figure 6-47: Map showing the level 2 clusters from the step-wise Gamma-Ward cluster analysis on the first four ordination axes of the CA on the 1954 structure by plot data (Figure 6-44). The codes for the treatments are defined in Table 3-1 (p. 15).

6.3.5 Results from the Correspondence Analysis on the 1996 structure by plot data

The results from the CA performed on the 1996 structure by plot data are presented in Table 6-14 (p. 159), Figure 6-48 (p. 163), Figure 6-49 (p. 164), Figure 6-50 (p. 165), and Figure 6-51 (p. 166). Table 6-14 shows the Eigenvalues for the first four ordination axes of the CA. Figure 6-48 is a hierarchical cluster tree showing the cluster groups from the step-wise Gamma-Ward cluster analysis on the first four ordination axes. Figure 6-49 is a bi-plot of the first two, weighted eigenvector plot score axes with the data points colour coded to the level 2 cluster colours in Figure 6-48. Figure 6-50 is a bi-plot of the first two, weighted eigenvector structure score axes with the data points colour coded to the level 2 cluster colours in Figure 6-48. Figure 6-51 is a map showing the layout of the Pretoriuskop EBP experiment with the plots colour coded to the level 2 cluster colours in Figure 6-48. The weighted eigenvector plot scores for the first four ordination axes, the plot weights and the effective number of structural groups that occur on the plots (N2 structural diversity of plots) (Hill 1973) are presented in Table 15-9 (p. 267). The weighted eigenvector structure scores for the first four ordination axes, the structure weights, and the effective number of occurrences of the structures (N2 diversity of structures) are presented in Table 15-10 (p. 268).

Table 6-14: Eigenvalues for the first four ordination axes of a Correspondence Analysis on the structure by plot data collected in 1996

	Axis 1	Axis 2	Axis 3	Axis 4	Total
Eigenvalue	0.0951	0.0794	0.0244	0.0146	0.2750
% Variation	34.6	28.9	8.9	5.3	77.6

The Eigenvalues, for the first four axes of the CA on the 1996 data were 0.095, 0.079, 0.024, and 0.015 (Table 6-14). The first four eigenvectors accounted for 34.6%, 28.9%, 8.9%, and 5.3% of the variation in the structure by plot data respectively in 1954, and 77.6% of the total variation in the structure by plot data in 1996 (Table 6-14).

6.3.5.1 Bi-plots of the first two weighted structure and plot eigenvectors showing the relationship between the structures and plots in Pretoriuskop in 1996

There were three main groups of plots and structures on the bi-plots of the first two weighted eigenvectors from the Correspondence Analysis on the 1996 data (Figure 6-49 and Figure 6-50). Group 1 comprised structure groups and plots with y-axis eigenvector values greater than 1.1. Group 2 comprised structure groups and plots with y-axis eigenvector values less than 1.1 and x-axis eigenvector values greater than -0.7. Group 3 comprised structure groups and plots with y-axis eigenvector values less than 1.1 and x-axis eigenvector values less than -0.7.

Group 1 comprised the Fayi Aug3 plot, the Kambeni Oct2, Aug2, Oct3, and Aug3 plots, and the Shabeni Aug3 and Oct3 plots (Figure 6-49). The Kambeni Oct2 and Oct3 plots were adjacent to one another, the Kambeni Aug2 and Aug3 plots were adjacent to one another and the Shabeni Aug3 and Oct3 plots were adjacent to one another (Figure 6-51). No structure groups were associated predominantly with the plots Group 1.

Group 2 comprised the Fayi Con0, Dec2, Oct2, Apr2, Feb2, Dec3, Oct3, Feb3, and Apr3 plots, the Kambeni Con0, Dec2, Feb2, Apr2, Feb3, Dec3, and Apr3 plots, the Numbi Oct2, Dec2, Feb2, Apr2, Con0, Dec3, Oct3, Feb3, Apr3, and Aug3 plots, and the Shabeni Aug2, Apr2, Feb2, Dec2, Con0, Dec3, Apr3, and Feb3 plots (Figure 6-49). The Fayi Con0, Dec2, Oct2, Apr2, Feb2, Dec3, Oct3, Feb3, and Apr3 plots were adjacent to one another (Figure 6-51). The Kambeni Con0, Dec2, and Feb3 plots were adjacent to one another, the Kambeni Feb2 and Dec3 plots were adjacent to one another, and the Kambeni Apr2, and Apr3 plots were adjacent to one another. The Numbi Oct2, Dec2, Feb2, Apr2, Dec3, Oct3, Feb3, Apr3, and Aug3 plots were adjacent to one another. The Shabeni Aug2, Apr2, Dec3, and Apr3 plots were adjacent to one another, and the Shabeni Dec2 and Con0 plots were adjacent to one another. The single-stem structures in

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Group 2 were single-stem individuals 0-1m high with basal diameters 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, and 12.7-17.8cm, 1-3m high with basal diameters greater than 17.8cm, 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, and 12.7-17.8cm, 3-5m high with basal diameters greater than 17.8cm, 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, and 12.7-17.8cm, and taller than 5m with basal diameters greater than 17.8cm, 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, and 12.7-17.8cm (Figure 6-50). The multi-stem structures in Group 2 were 0-1m high with basal diameters 0-30cm, 1-3m high with basal diameters greater than 91cm, 0-30cm, and 30-91cm, 3-5m high with basal diameters greater than 91cm, 0-30cm, and 30-91cm, and taller than 5m with basal diameters 0-30cm and 30-91cm (Figure 6-50). Single-stem individuals 0-1m high with basal diameters 0.0-2.5cm, and 1-3m high with basal diameters 0.0-2.5cm and 2.5-7.6cm, and multi-stem individuals 0-1m high with basal diameters 0-30cm, and 1-3m high with basal diameters 0-30cm and 30-91cm, occurred on all the Group 2 plots. These structures also occurred mainly on the Group 2 plots. Single-stem individuals 3-5m high with basal diameters greater than 17.8cm were found on twenty-four of the thirty-four Group 2 plots in 1996, and they occurred mainly on the Group 2 plots. Single-stem individuals 3-5m high with basal diameters 7.6-12.7cm, and multi-stem individuals 1-3m high with basal diameters greater than 91cm were found on twenty-five of the thirty-four Group 2 plots, and they occurred mainly on the Group 2 plots. Single-stem individuals 3-5m high with basal diameters 12.7-17.8cm, were found on twenty-seven of the thirty-four Group 2 plots in 1996, and they occurred mainly on the Group 2 plots. Multi-stem individuals 3-5m high with basal diameters 30-91cm, were found on twenty-eight of the thirty-four Group 2 plots, and they occurred mainly on the Group 2 plots. Single-stem individuals 1-3m high with basal diameters 7.6-12.7cm, were found on thirty of the thirty-four Group 2 plots, and they occurred mainly on the Group 2 plots. Single-stem individuals taller than 5m with basal diameters greater than 17.8cm, and multi-stem individuals 3-5m high with basal diameters 0-30cm, were found on thirty-two of the thirty-four Group 2 plots, and they were found mainly on the Group 2 plots. Single-stem individuals 0-1m high with basal diameters 2.5-7.6cm, were found on thirty-three of the thirty-four Group 2 plots, and they were found mainly on the Group 2 plots. Sixty to seventy percent of the occurrences of multi-stem individuals 1-3m high with basal diameters greater than 91cm, 3-5m high with basal diameters 30-91cm, and taller than 5m with basal diameters 30-91cm, on the Pretoriuskop EBPs occurred on the Group 2 plots. Seventy to eighty percent of the occurrences of single-stem individuals 0-1m high with basal diameters 0.0-2.5cm, 2.5-7.6cm, and 7.6-12.7cm, 1-3m high with basal diameters 0.0-2.5cm, 2.5-7.6cm, and 7.6-12.7cm, 3-5m high with basal diameters 7.6-12.7cm and greater than 17.8cm, and taller than 5m with basal diameters 12.7-17.8cm and 17.8cm, on the Pretoriuskop EBPs in 1996 were on the Group 2 plots. Seventy to eighty percent of the occurrences of multi-stem individuals 0-1m high with basal diameters 0-30 cm, 1-3m high with basal diameters 0-30 cm and 30-91cm, 3-5m high with basal diameters 0-30 cm and taller than 5m with basal diameters 0-30 cm, on the Pretoriuskop EBPs in 1996 were on the Group 2 plots. Eighty to ninety percent of the occurrences of single-stem individuals 1-3m high with basal diameters 12.7-17.8cm, 3-5m high with basal diameters 0.0-2.5cm, 2.5-7.6cm, and 12.7-17.8cm, and taller than 5m with basal diameters 0.0-2.5cm, on the Pretoriuskop EBPs in 1996 were on the Group 2 plots. Eighty to ninety percent of multi-stem individuals 3-5m high with basal diameters greater than 91cm, on the Pretoriuskop EBPs in 1996 were on the Group 2 plots. Ninety-four percent of the occurrences of single-stem individuals 1-3m high with basal diameters greater than 17.8cm, on the Pretoriuskop EBPs in were on the Group 2 plots. Single-stem individuals 0-1m high with basal diameters 12.7-17.8cm, and taller than 5m with basal diameters 2.5-7.6cm and 7.6-12.7cm, were found only on the Group 2 plots in 1996. Single-stem individuals 0-1m high with basal diameters 12.7-17.8cm, were found on the Kambeni Dec3 plot. Single-stem individuals taller than 5m with basal diameters between 2.5 and 7.6cm were found on the Fayi Dec3 plot and the Numbi Dec3 plot in 1996. Single-stem individuals taller than 5m with basal diameters 7.6-12.7cm, were found on the Fayi Apr2 and Feb3 plots, the Kambeni Feb2 and Dec3 plots, the Numbi Con0 and Feb3 plots, and the Shabeni Aug2 and Con0 plots in 1996.

Group 3 comprised the Fayi Aug2 and Aug1 plots, the Kambeni Aug1 plot, the Numbi Aug2 and Aug1 plots, and the Shabeni Aug1 and Oct2 plots (Figure 6-49). All the August Annual treatments were in Group 3, along with some August Biennial treatments. The structures in Group 3 were single-stem individuals 0-1m high with basal diameters greater than 17.8cm, and multi-stem individuals 0-1m high with basal diameters greater than 91cm and 30-91cm, and taller than 5m with basal diameters greater than 91cm (Figure 6-50). Multi-stem individuals 0-1m high with basal diameters 30-91cm and greater than 91cm occurred on all the

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plots in Group 3 however, they were also found on many other Pretoriuskop EBPs in 1996. Fifty percent of the occurrences of multi-stem individuals taller than 5m with basal diameters greater than 91cm, on the Pretoriuskop EBPs in 1996 were on the Group 2 plots. There were no structures in Group 3 that occurred only on the Group 3 plots.

6.3.5.2 Step-wise Ward-Gamma cluster analysis of the first four weighted eigenvectors showing the relationship between the structures and plots in Pretoriuskop in 1996

The step-wise Ward-Gamma cluster analysis was used to summarise the variation of plots and structures along the first four eigenvectors of the Correspondence Analysis on the 1996 structure by plot data. There were four main clusters of plots and structures at level 2 of the step-wise Ward-Gamma cluster analysis (Figure 6-48). These clusters differed from the two dimensional grouping of plots and structures along the first two eigenvectors described above (Figure 6-49 and Figure 6-50).

Cluster 1 comprised the Fayi Aug2, Aug1, and Aug3 plots, the Kambeni Aug2, Aug1, and Aug3 plots, the Numbi Feb2, Aug2, and Aug1 plots, and the Shabeni Aug2, Aug1, Oct2, and Dec3 plots (Figure 6-48). Cluster 1 comprised all the plots that were burnt annually and biennially in August, and many of the plots that were burnt triennially in August. The single-stem structures in Cluster 1 were 0-1m high with basal diameters greater than 17.8cm and taller than 5m with basal diameters greater than 17.8cm and 12.7-17.8cm (Figure 6-48). The multi-stem structures in Cluster 1 were 0-1m high with basal diameters greater than 91cm, 0-30cm, and 30-91cm, 1-3m high with basal diameters 30-91cm, 3-5m high with basal diameters 0-30cm and 30-91cm, and taller than 5m with basal diameters greater than 91cm and 30-91cm (Figure 6-48). Multi-stem individuals 0-1m high with basal diameters 0-30cm, and 1-3m high with basal diameters 30-91cm, occurred on all the Cluster 1 plots however, they occurred on many other Pretoriuskop EBPs in 1996. Multi-stem individuals 3-5m high with basal diameters 30-91cm, occurred on eleven of the thirteen Cluster 1 plots however, they occurred on many other Pretoriuskop EBPs. Single-stem individuals taller than 5m with basal diameters greater than 17.8cm, and multi-stem individuals 0-1m high with basal diameters 30-91cm, and 3-5m high with basal diameters 0-30cm, occurred on twelve of the thirteen Cluster 1 plots however, they occurred on many other Pretoriuskop EBPs in 1996. Fifty percent of the occurrences of single-stem individuals 0-1m high with basal diameters greater than 17.8cm, and multi-stem individuals taller than 5m with basal diameters greater than 91cm, on the Pretoriuskop EBPs occurred on the Cluster 1 plots in 1996. There were no structures in Cluster 1 that occurred only on the Cluster 1 plots.

Cluster 2 comprised the Fayi Oct2, Oct3, and Apr3 plots, the Kambeni Oct2, Feb2, Apr2, Oct3, and Apr3 plots, the Numbi Oct2, Dec2, and Apr2 plots, and the Shabeni Aug3 and Oct3 plots (Figure 6-48). Many of the October Annual and Biennial treatments were found in Cluster 2. The structures in Cluster 2 were multi-stem individuals 1-3m high with basal diameters greater than 91cm and 0-30cm, and taller than 5m with basal diameters 0-30cm (Figure 6-48). Multi-stem individuals 1-3m high with basal diameters 0-30cm, occurred on all Cluster 2 plots however, they were found on many other Pretoriuskop EBPs in 1996. Multi-stem individuals 1-3m high with basal diameters greater than 91cm were found on ten of the thirteen Cluster 2 plots however, they occurred on many Pretoriuskop EBPs in 1996. There were no structures in Cluster 2 that occurred only on the Cluster 2 plots.

Cluster 3 comprised the Fayi Dec2 plot, the Kambeni Con0 and Dec3 plots, and the Shabeni Con0 plot (Figure 6-48). Two of the four Control (no burn) treatments were in Cluster 3 along with two December treatments. In terms of fire timing, the December treatments had the least intense fires (see Table 3-7 p. 22). The structures in Cluster 3 were single-stem individuals 0-1m high with basal diameters 7.6-12.7cm and 12.7-17.8cm, and 3-5m high with basal diameters 2.5-7.6cm (Figure 6-48). Single-stem individuals 3-5m high with basal diameters 2.5-7.6cm, occurred on all the plots in Cluster 3 however, they were also found on many other Pretoriuskop EBPs in 1996. Single-stem individuals 0-1m high with basal diameters 12.7-17.8cm, were found only on the Kambeni Dec3 plot, which occurred on Cluster 3 in 1996.

Cluster 4 comprised the Fayi Con0, Apr2, Feb2, Dec3, and Feb3 plots, the Kambeni Dec2 and Feb3 plots, the Numbi Con0, Dec3, Oct3, Feb3, Apr3, and Aug3 plots, and the Shabeni Apr2, Feb2, Dec2, Apr3, and Feb3 plots (Figure 6-48). The Fayi Con0 and Dec3 plots were adjacent to one another and the Fayi Apr2 and Feb2 plots were adjacent to one another (Figure 6-51). The Kambeni Dec2 and Feb3 plots were adjacent to one another. Numbi Dec3, Oct3, Feb3, Apr3, and Aug3 plots were adjacent to one another. The single-stem structures in Cluster 4 were 0-1m high with basal diameters 0.0-2.5cm and 2.5-7.6cm, 1-3m high with basal diameters greater than 17.8cm, 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, and 12.7-17.8cm, 3-5m high with basal diameters greater than 17.8cm, 0.0-2.5cm, 7.6-12.7cm, and 12.7-17.8cm, and taller than 5m with basal diameters 0.0-2.5cm, 2.5-7.6cm, and 7.6-12.7cm (Figure 6-48). The multi-stem structures in Cluster 4 were 3-5m high with basal diameters greater than 91cm (Figure 6-48). Single-stem individuals 0-1m high with basal diameters 0.0-2.5cm, and 1-3m high with basal diameters 0.0-2.5cm and 2.5-7.6cm, occurred on all Cluster 4 plots however, they were also found on many other EBPs. Single-stem individuals 3-5m high with basal diameters 7.6-12.7cm, 12.7-17.8cm, and greater than 17.8cm, were found on thirteen of the eighteen Cluster 4 plots however, they were also found on many other Pretoriuskop EBPs. Single-stem individuals 1-3m high with basal diameters 7.6-12.7cm, were found on sixteen of the eighteen Cluster 4 plots however, they were also found on many other Pretoriuskop EBPs in 1996. Single-stem individuals 0-1m high with basal diameters 2.5-7.6cm, were found on seventeen of the eighteen Cluster 4 plots however, they were also found on many other Pretoriuskop EBPs. Fifty percent of the occurrences of single-stem individuals taller than 5m with basal diameters 7.6-12.7cm, and multi-stem individuals 3-5m high with basal diameters greater than 91cm, on the Pretoriuskop EBPs occurred on the Cluster 4 plots in 1996. Between sixty and seventy percent of the occurrences of single-stem individuals 1-3m high with basal diameters 12.7-17.8cm, and taller than 5m with basal diameters 0.0-2.5cm, on the Pretoriuskop EBPs in 1996, occurred on the Cluster 4 plots. Eighty percent of the occurrences of single-stem individuals 3-5m high with basal diameters 0.0-2.5cm, on the Pretoriuskop EBPs occurred on the Cluster 4 plots. Single-stem individuals taller than 5m with basal diameters 2.5-7.6cm, were found only on Cluster 4 plots, and occurred on the Fayi Dec3 plot, and the Numbi Dec3 plot in 1996.

6.3.5.3 Summary of the results from the CA's on the 1996 structure by plot data

In 1996, the predominant pattern that emerged regarding the structural composition of the Pretoriuskop EBPs was that the structural composition of the woody vegetation on plots that were not burnt or that were burnt in December, February and April was more similar to one another than to plots that were burnt in October and August.

The plots that were burnt in August and October were associated with multi-stem individuals of all coppice diameters 0-1m tall and 3-5m tall. The plots burnt in December, February, and April, and those not burnt at all were associated with both single and multi-stem individuals of all heights and basal diameters. In some cases, the structural composition of plots burnt in April was similar to plots that were burnt in August and April, and these plots had multi-stem individuals 1-3m high in common.

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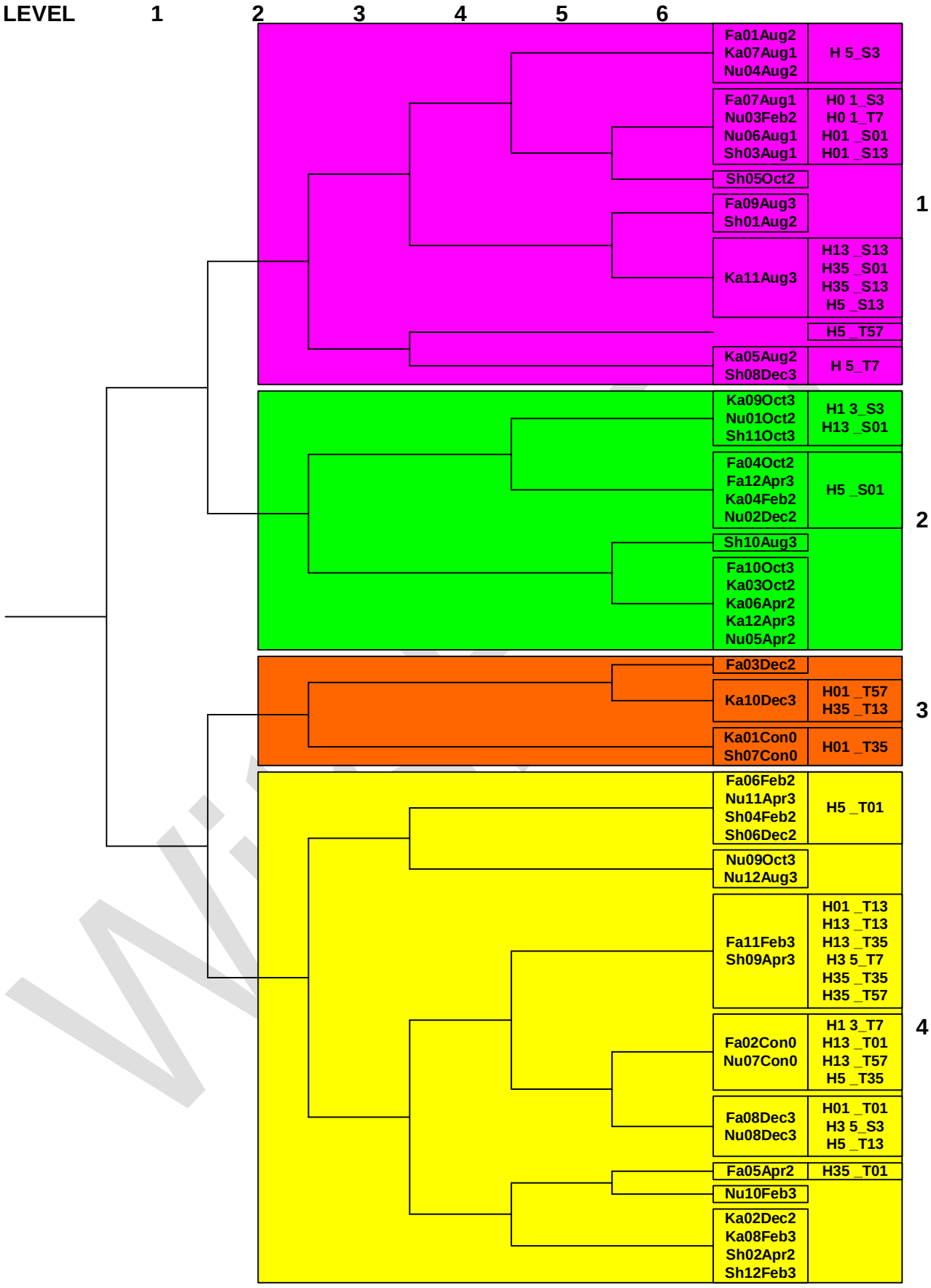


Figure 6-48: Classification of treatment plots and structures using a step-wise Gamma-Ward cluster analysis on the first four ordination axes from the CA on the 1996 structure by plot data. The codes for the treatment plots are defined in Table 10-1 (p. 214) and the codes for the structure groups are defined in Table 5-3 (p. 34).

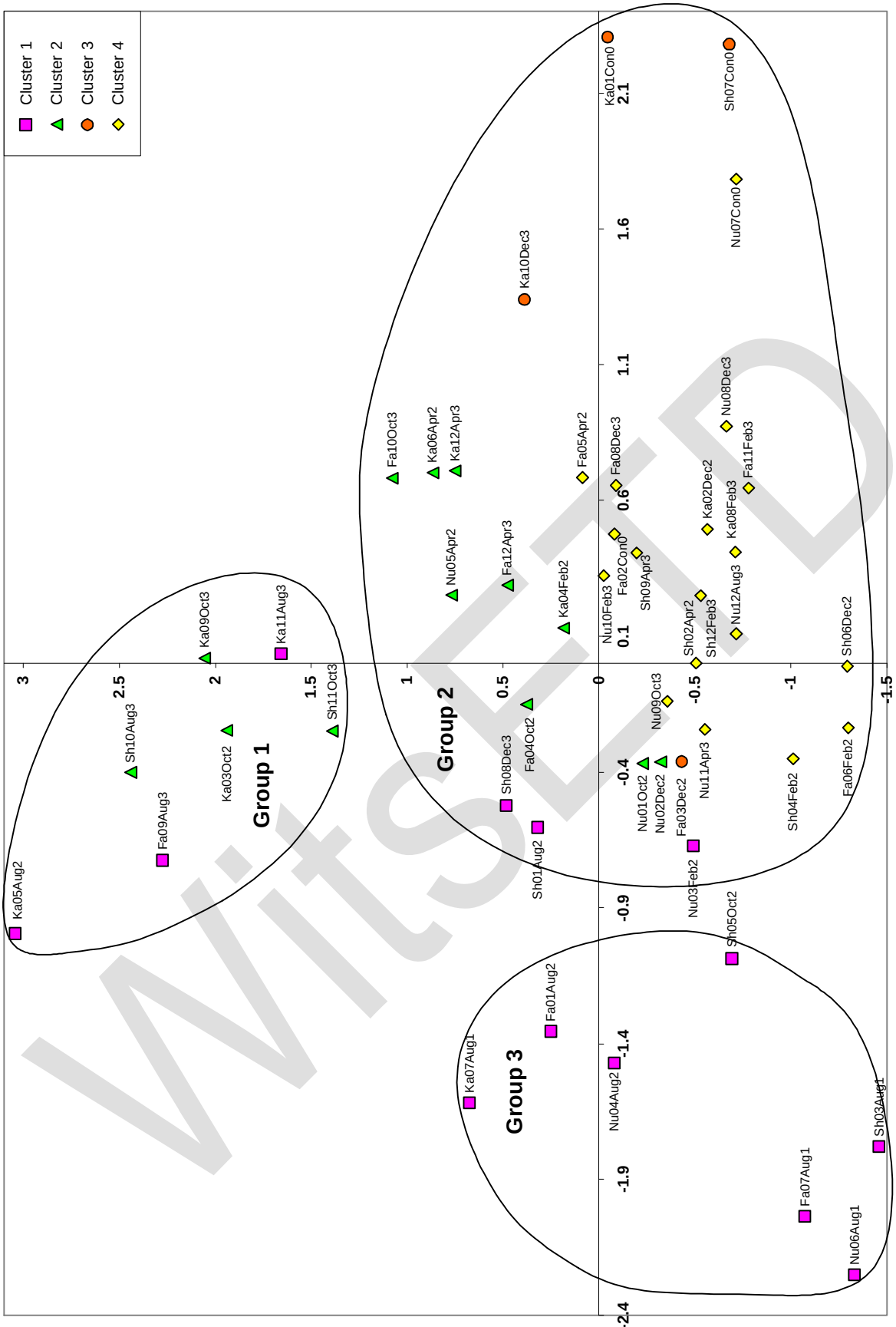


Figure 6-49: Bi-plot of the first two ordination axes from the CA on the 1996 structure by plot data showing variation in structural composition between treatment plots. The groups are the result of a visual assessment of the grouping of structures and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-48). The codes for the treatment plots are defined in Table 10-1 (p. 214).

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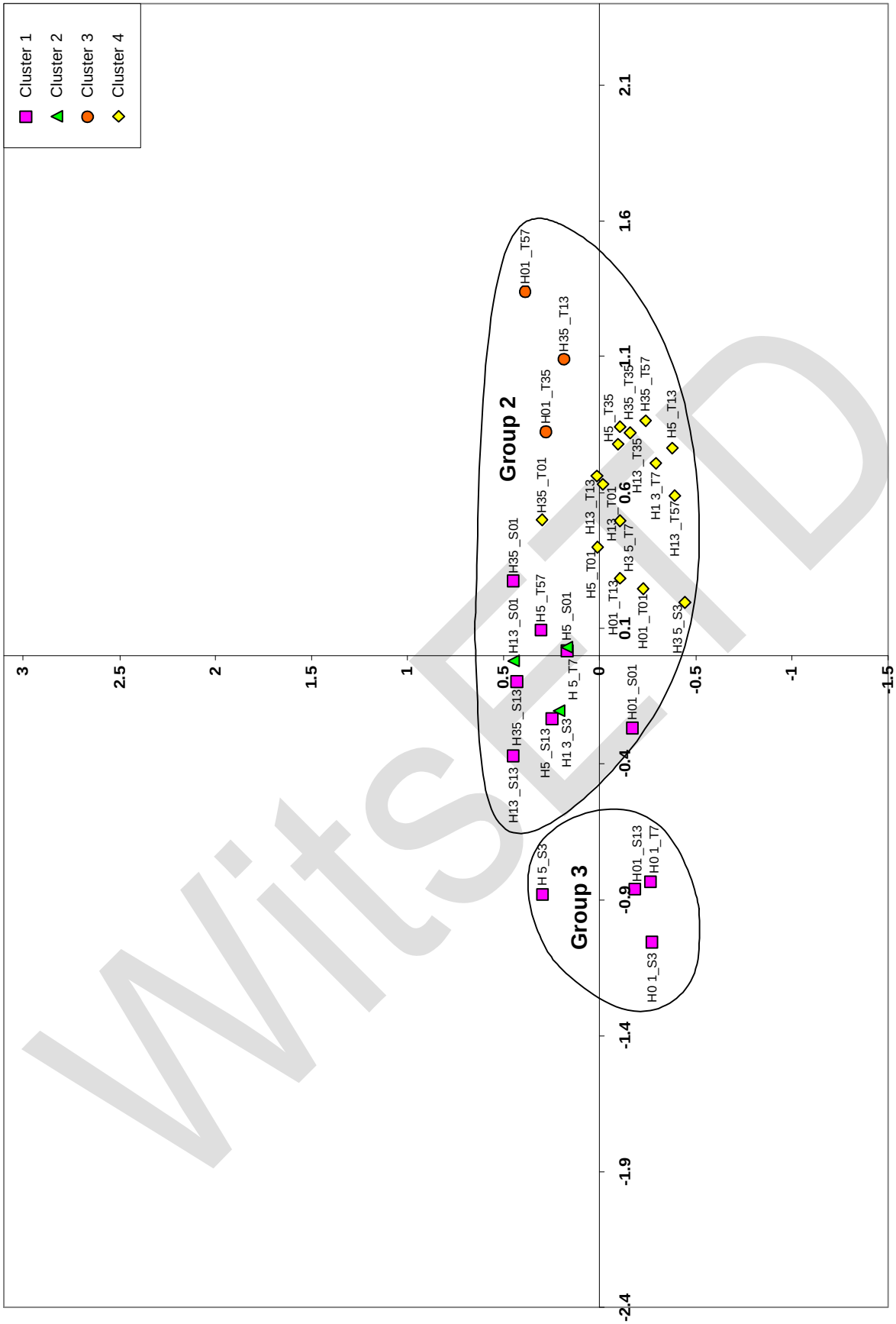


Figure 6-50: Bi-plot of the first two ordination axes from the CA on the 1996 structure by plot data showing variation in location (plots) between structures. The groups are the result of a visual assessment of the grouping of structures and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-48). The codes for the structure groups are defined in Table 5-3 (p. 34).

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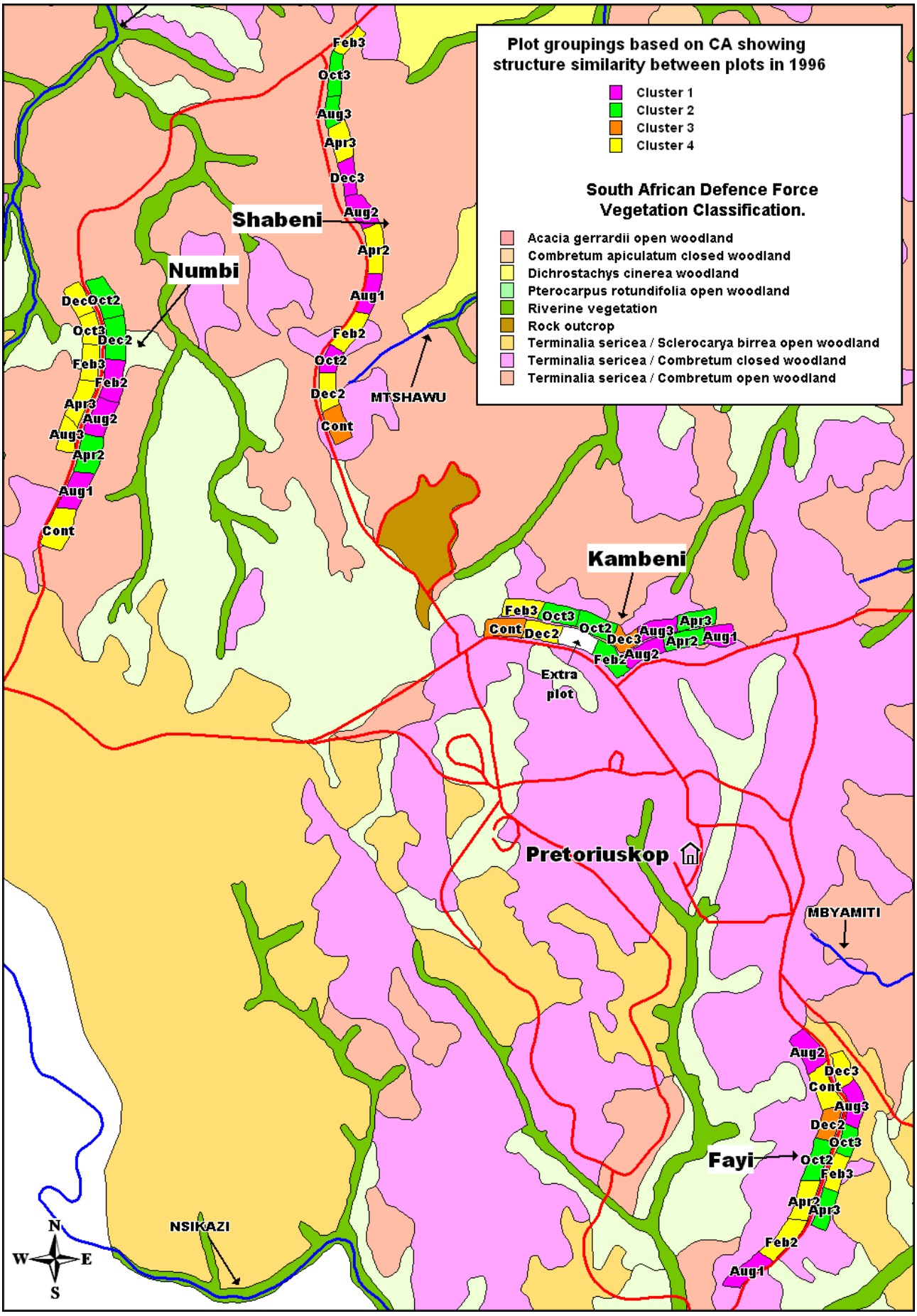


Figure 6-51: Map showing the level 2 clusters from the step-wise Gamma-Ward cluster analysis on the first four ordination axes of the CA on the 1954 structure by plot data (Figure 6-48). The codes for the treatments are defined in Table 3-1 (p. 15).

6.3.6 Results from the Correspondence Analysis on the 1996 structure by plot data with the first eight axes of the CA on the 1954 survey data as covariables

The results from the CA performed on the 1996 structure by plot data with the 1954 covariables are presented in Table 6-15 (p. 167), Figure 6-52 (p. 171), Figure 6-53 (p. 172), Figure 6-54 (p. 173), and Figure 6-55 (p. 174). Table 6-15 shows the Eigenvalues for the first four ordination axes of the CA. Figure 6-52 is a hierarchical cluster tree showing the cluster groups from the step-wise Gamma-Ward cluster analysis on the first four ordination axes. Figure 6-53 is a bi-plot of the first two, weighted eigenvector plot score axes with the data points colour coded to the level 2 cluster colours in Figure 6-52. Figure 6-54 is a bi-plot of the first two, weighted eigenvector structure score axes with the data points colour coded to the level 2 cluster colours in Figure 6-52. Figure 6-55 is a map showing the layout of the Pretoriuskop EBP experiment with the plots colour coded to the level 2 cluster colours in Figure 6-52. The weighted eigenvector plot scores for the first four ordination axes, the plot weights and the effective number of structural groups that occur on the plots (N2 structural diversity of plots) (Hill 1973) are presented in Table 15-11 (p. 269). The weighted eigenvector structure scores for the first four ordination axes, the structure weights, and the effective number of occurrences of the structures (N2 diversity of structures) are presented in Table 15-12 (p. 270).

Table 6-15: Eigenvalues for the first four ordination axes of a Correspondence Analysis on the structure data collected in 1996 with the first four ordination axes of the 1954 Correspondence analysis as covariables.

	Axis 1	Axis 2	Axis 3	Axis 4	Total
Eigenvalue	0.0715	0.0440	0.0157	0.0106	0.2750
% Variation	26.0	16.0	5.7	3.9	51.6

The Eigenvalues, for the first four axes of the CA on the 1996 data with the 1954 covariables were 0.072, 0.044, 0.016, and 0.011 (Table 6-15). The first four eigenvectors accounted for 26.0%, 16.0%, 5.7%, and 3.9% of the variation in the structure by plot data respectively in 1996, and 51.6% of the total variation in the structure by plot data in 1996 (Table 6-15).

6.3.6.1 Bi-plots of the first two weighted structure and plot eigenvectors showing the relationship between the structures and plots in Pretoriuskop in 1996 accounting for the relationship between the structures and plots in 1954

There were four main groups of plots and structures on the bi-plots of the first two weighted eigenvectors from the Correspondence Analysis on the 1996 data with the 1954 covariables (Figure 6-53 and Figure 6-54). Group 1 comprised structure groups and plots with x-axis eigenvector values greater than 1.5. Group 2 comprised structure groups and plots with x-axis eigenvector values between 1.5 and -1.5, and y-axis eigenvector values greater than 1.2. Group 3 comprised structure groups and plots with x-axis eigenvector values between 1.5 and -1.5, and y-axis eigenvector values less than 1.2. Group 4 comprised structure groups and plots with x-axis eigenvector values less than -1.5. The structures are spread along the first eigenvector axis and concentrated along the second eigenvector axis in the structure bi-plot (Figure 6-54). This resulted in a number of outlying plot groupings not having any associated structures, for example Group 1, Group 2, and Group 4.

Group 1 comprised the Fayi Apr2 and Feb3 plots, the Numbi Con0 plot, and the Shabeni Con0 plot (Figure 6-53). Two of the four Control (no burn) plots in the Pretoriuskop region were in Group 1. No structure groups were associated predominantly with the plots Group 1.

Group 2 comprised the Fayi Aug3 plot, the Kambeni Oct2, Oct3, and Aug3 plots, and the Shabeni Aug3 and Oct3 plots (Figure 6-53). The Kambeni Oct2 and Oct3 plots were adjacent to one another and the Shabeni Aug3 and Oct3 plots were adjacent to one another (Figure 6-55). Three of the four August Triennial treatments were in Group 2. No structure groups were associated predominantly with the plots Group 2.

Group 3 comprised the Fayi Aug2, Con0, Dec2, Oct2, Feb2, Dec3, Oct3, and Apr3 plots, the Kambeni Con0, Dec2, Feb2, Aug2, Apr2, Aug1, Feb3, Dec3, and Apr3 plots, the Numbi Oct2, Dec2, Feb2, Aug2, Apr2, Dec3, Oct3, Feb3, Apr3, and Aug3 plots, and the Shabeni Aug2, Apr2, Feb2, Oct2, Dec2, Dec3, Apr3, and Feb3 plots (Figure 6-53). Group 3 comprised thirty-five of the forty-eight Pretoriuskop EBPs, and all the structures present in 1996 were in Group 3. The single-stem structures in Group 3 were 0-1m high with basal diameters 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, 12.7-17.8cm, and greater than 17.8cm, 1-3m high with basal diameters 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, 12.7-17.8cm, and greater than 17.8cm, 3-5m high with basal diameters 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, 12.7-17.8cm, and greater than 17.8cm, and taller than 5m with basal diameters 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, 12.7-17.8cm, and greater than 17.8cm (Figure 6-54). The multi-stem structures in Group 3 were 0-1m high with basal diameters 0-30cm, 30-91cm, and greater than 91cm, 1-3m high with basal diameters 0-30cm, 30-91cm, and greater than 91cm, 3-5m high with basal diameters 0-30cm, 30-91cm, and greater than 91cm, and taller than 5m with basal diameters 0-30cm, 30-91cm, and greater than 91cm (Figure 6-54). Single-stem individuals 0-1m high with basal diameters 0.0-2.5cm, and 1-3m high with basal diameters 2.5-7.6cm, and multi-stem individuals 0-1m high with basal diameters 0-30cm, and 1-3m high with basal diameters 0-30cm and 30-91cm, occurred on all the Group 3 plots and they were found mainly on the Group 3 plots. A

Group 4 comprised the Fayi Aug1 plot, the Numbi Aug1 plot, and the Shabeni Aug1 plot (Figure 6-53). Three of the four August Annual treatments on the Pretoriuskop EBPs were in Group 4. No structure groups were associated predominantly with the plots Group 4.

6.3.6.2 Step-wise Ward-Gamma cluster analysis of the first four weighted eigenvectors showing the relationship between the structures and plots in Pretoriuskop in 1996 accounting for the relationship between the structures and plots in 1954

The step-wise Ward-Gamma cluster analysis was used to summarise the variation of plots and structures along the first four eigenvectors of the Correspondence Analysis on the 1996 structure by plot data using the first eight axes from the CA on the 1954 data as covariables. There were four main clusters of plots and structures at level 2 of the step-wise Ward-Gamma cluster analysis (Figure 6-48). These clusters differed from the two dimensional grouping of plots and structures along the first two eigenvectors described above (Figure 6-49 and Figure 6-50).

Cluster 1 comprised the Fayi Aug2, Dec2, Aug1, and Aug3 plots, the Kambeni Oct2, Oct3, and Aug3 plots, the Numbi Oct2, Feb2, Aug2, and Aug1 plots, and the Shabeni Aug2, Aug1, Oct2, Dec3, Aug3, and Oct3 plots (Figure 6-52). Nine of the twelve August Annual, Biennial, and Triennial treatment plots were in Cluster 1, and five of the eight October Biennial and Triennial treatment plot were in cluster 1. The Fayi Dec2 and Aug3 plots were adjacent to one another (Figure 6-55). The Kambeni Oct2 and Oct3 were adjacent to one another. The Numbi Feb2 and Aug2 plots were adjacent to one another. The Shabeni Aug2 and Dec3 plots were adjacent to one another and the Shabeni Aug3 and Oct3 plots were adjacent to one another. The single-stem structures in Cluster 1 were 0-1m high with basal diameters greater than 17.8cm and taller than 5m with basal diameters greater than 17.8cm (Figure 6-52). The multi-stem structures in Cluster 1 were 0-1m high with basal diameters greater than 91cm, 0-30cm, and 30-91cm, 1-3m high with basal diameters greater than 91cm, 0-30cm, and 30-91cm, 3-5m high with basal diameters 0-30cm and 30-91cm, and taller than 5m with basal diameters greater than 91cm, 0-30cm, and 30-91cm (Figure 6-52). Multi-stem individuals 0-1m high with basal diameters 0-30cm, and 1-3m high with basal diameters 0-30cm and 30-91cm, occurred on all the Cluster 1 plots however, they were found on many other Pretoriuskop EBPs in 1996. Multi-stem individuals 1-3m high with basal diameters greater than 91cm were found on fourteen of the seventeen Cluster 1 plots however, they were found on many other Pretoriuskop EBPs. Multi-stem individuals 3-5m high with basal diameters between 30 and 91cm were found on fifteen of the seventeen Cluster 1 plots however, they were found on many other Pretoriuskop EBPs in 1996. Single-stem individuals taller than 5m with basal diameters greater than 17.8cm, and multi-stem individuals 0-1m high with basal diameters 30-91cm, and 3-5m high with basal diameters 0-30cm, were found on sixteen of the seventeen Cluster 1 plots however, they were found on many other Pretoriuskop EBPs in 1996. Fifty percent of the occurrences of

single-stem individuals 0-1m high with basal diameters greater than 17.8cm, on the Pretoriuskop EBPs in 1996 were on the Cluster 1 plots. Multi-stem individuals taller than 5m with basal diameters greater than 91cm, were found only on Cluster 1 plots and they occurred on the Kambeni Oct3 plot, and the Shabeni Aug1 plot.

Cluster 2 comprised the Fayi Oct2 and Oct3 plots, the Kambeni Aug2, Apr2, and Apr3 plots, the Numbi Dec2 and Apr2 plots, and the Shabeni Apr2 plot (Figure 6-52). Five of the eight April Biennial and Triennial treatments were in Cluster 2. The Kambeni Aug2, Apr2, and Apr3 plots were adjacent to one another, and the Fayi Oct2 and Oct3 plots were adjacent to one another (Figure 6-55). There were no structures in Cluster 2 (Figure 6-52).

Cluster 3 comprised the Fayi Apr3 plot, the Kambeni Aug1 and Dec3 plots, the Numbi Apr3 plot, and the Shabeni Apr3 plot (Figure 6-52). Three of the four April Triennial treatments were in Cluster 3. The structures in Cluster 3 were single-stem individuals 0-1m high with basal diameters 7.6-12.7cm and 12.7-17.8cm, 3-5m high with basal diameters 2.5-7.6cm, and taller than 5m with basal diameters 0.0-2.5cm (Figure 6-52). Single-stem individuals 0-1m high with basal diameters 12.7-17.8cm, were found only on Cluster 3 plots, and they occurred on the Kambeni Dec3 plot.

Cluster 4 comprised the Fayi Con0, Apr2, Feb2, Dec3, and Feb3 plots, the Kambeni Con0, Dec2, Feb2, and Feb3 plots, the Numbi Con0, Dec3, Oct3, Feb3, and Aug3 plots, and the Shabeni Feb2, Dec2, Con0, and Feb3 plots (Figure 6-52). All the Control (no burn) treatments in the Pretoriuskop EBPs were in Cluster 4. Seven of the eight February Biennial and Triennial Pretoriuskop EBP treatments were in Cluster 4, and half the December Biennial and Triennial treatments were in Cluster 4. The Fayi Con0 and Dec3 plots were adjacent to one another, and the Fayi Apr2, Feb2, and Feb3 plots were adjacent to one another (Figure 6-55). The Kambeni Con0, Dec2, and Feb3 plots were adjacent to one another. The Numbi Dec3, Oct3, and Feb3 plots were adjacent to one another. The Shabeni Dec2 and Con0 plots were adjacent to one another. The single-stem structures on Cluster 3 were 0-1m high with basal diameters 0.0-2.5cm and 2.5-7.6cm, 1-3m high with basal diameters greater than 17.8cm, 0.0-2.5cm, 2.5-7.6cm, 7.6-12.7cm, and 12.7-17.8cm, 3-5m high with basal diameters greater than 17.8cm, 0.0-2.5cm, 7.6-12.7cm, and 12.7-17.8cm, and taller than 5m with basal diameters 2.5-7.6cm, 7.6-12.7cm, and 12.7-17.8cm (Figure 6-52). The multi-stem structures on Cluster 3 were 3-5m high with basal diameters greater than 91cm (Figure 6-52). Single-stem individuals 0-1m high with basal diameters 0.0-2.5cm and 2.5-7.6cm, and 1-3m high with basal diameters 0.0-2.5cm and 2.5-7.6cm, occurred on all Cluster 4 plots however, they were found on many other Pretoriuskop EBPs. Single-stem individuals 3-5m high with basal diameters 12.7-17.8cm, were found on thirteen of the eighteen Cluster 4 plots however, they were found on many other Pretoriuskop EBPs. Single-stem individuals 3-5m high with basal diameters 7.6-12.7cm and greater than 17.8cm were found on fourteen of the eighteen Cluster 4 plots however, they were found on many other Pretoriuskop EBPs in 1996. Single-stem individuals 1-3m high with basal diameters 7.6-12.7cm, were found on seventeen of the eighteen Cluster 4 plots however, they were found on many other Pretoriuskop EBPs. Sixty to seventy percent of the occurrences of single-stem individuals 1-3m high with basal diameters 12.7-17.8cm and greater than 17.8cm, and 3-5m high with basal diameters 0.0-2.5cm, on the Pretoriuskop EBPs were on the Cluster 4 plots in 1996. Seventy-five percent of the occurrences of single-stem individuals taller than 5m with basal diameters 7.6-12.7cm, and multi-stem individuals 3-5m high with basal diameters greater than 91cm, on the Pretoriuskop EBPs were on the Cluster 4 plots. Single-stem individuals taller than 5m with basal diameters 2.5-7.6cm, occurred only on the Cluster 4 plots and was found on the Fayi Dec3 plot and the Numbi Dec3 plot.

6.3.6.3 Summary of the results from the CA's on the 1996 structure by plot data with covariables

The findings from the CA on the 1996 with covariables were similar to the findings from the CA on the 1996 data without covariables. The main pattern to emerge from the analysis on the structural composition of the Pretoriuskop EBPs was that the structural composition of the woody vegetation on plots that were not burnt or that were burnt in December, February and April was more similar to one another than to plots that were

burnt in October and August. The structural compositions of the August Annual plots were more similar to one another than the structural composition of the other plots. As with the CA on the 1996 data without covariables, the structural composition of some of the April treatments was also found to be similar to that of some of the August and October treatments.

WitsETD

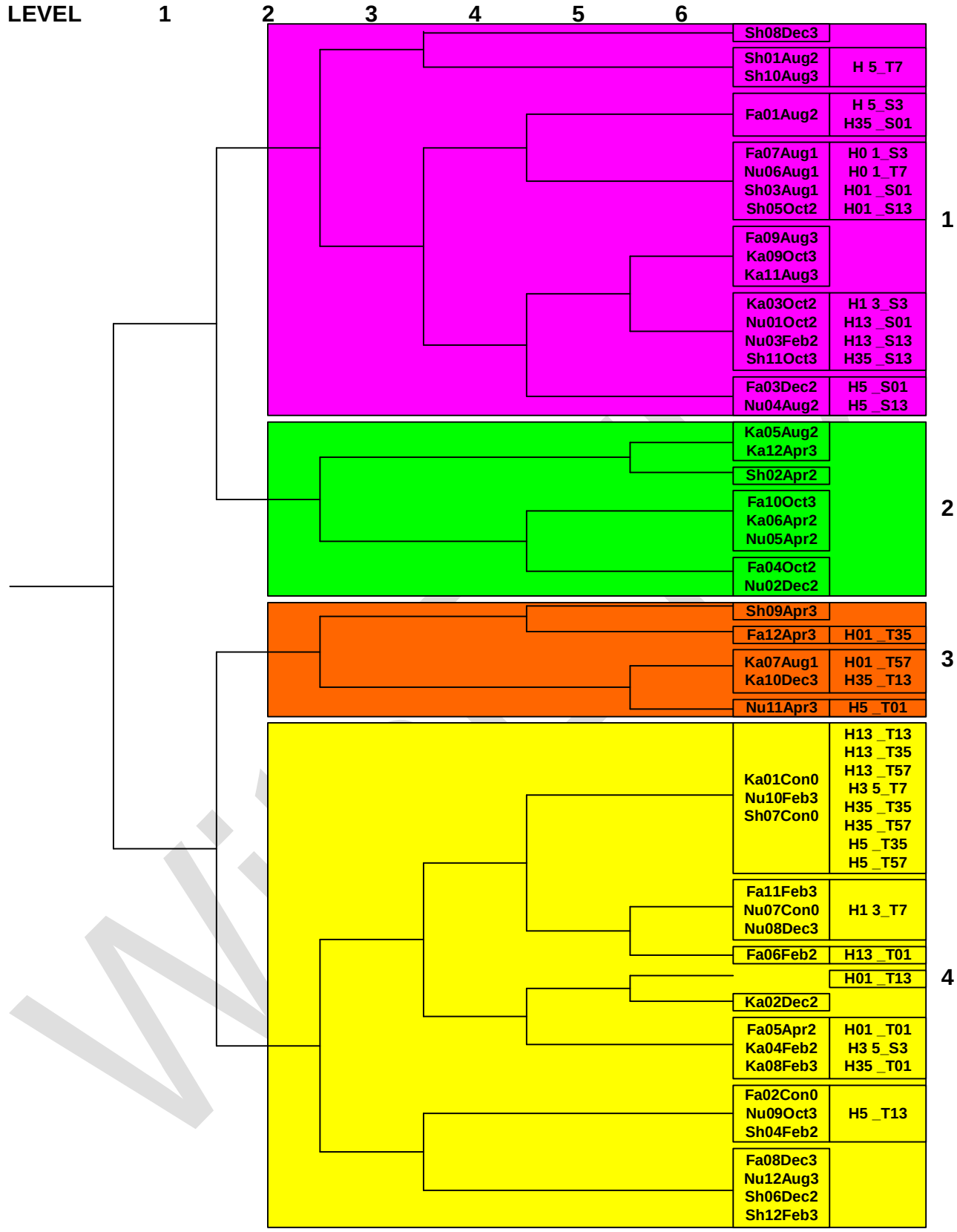


Figure 6-52: Classification of treatment plots and structures using a step-wise Gamma-Ward cluster analysis on the first four ordination axes from the CA on the 1996 structure by plot data with the first eight ordination axes of the 1954 structure by plot CA as covariables. The codes for the treatment plots are defined in Table 10-1 (p. 214) and the codes for the structure groups are defined in Table 5-3 (p. 34).

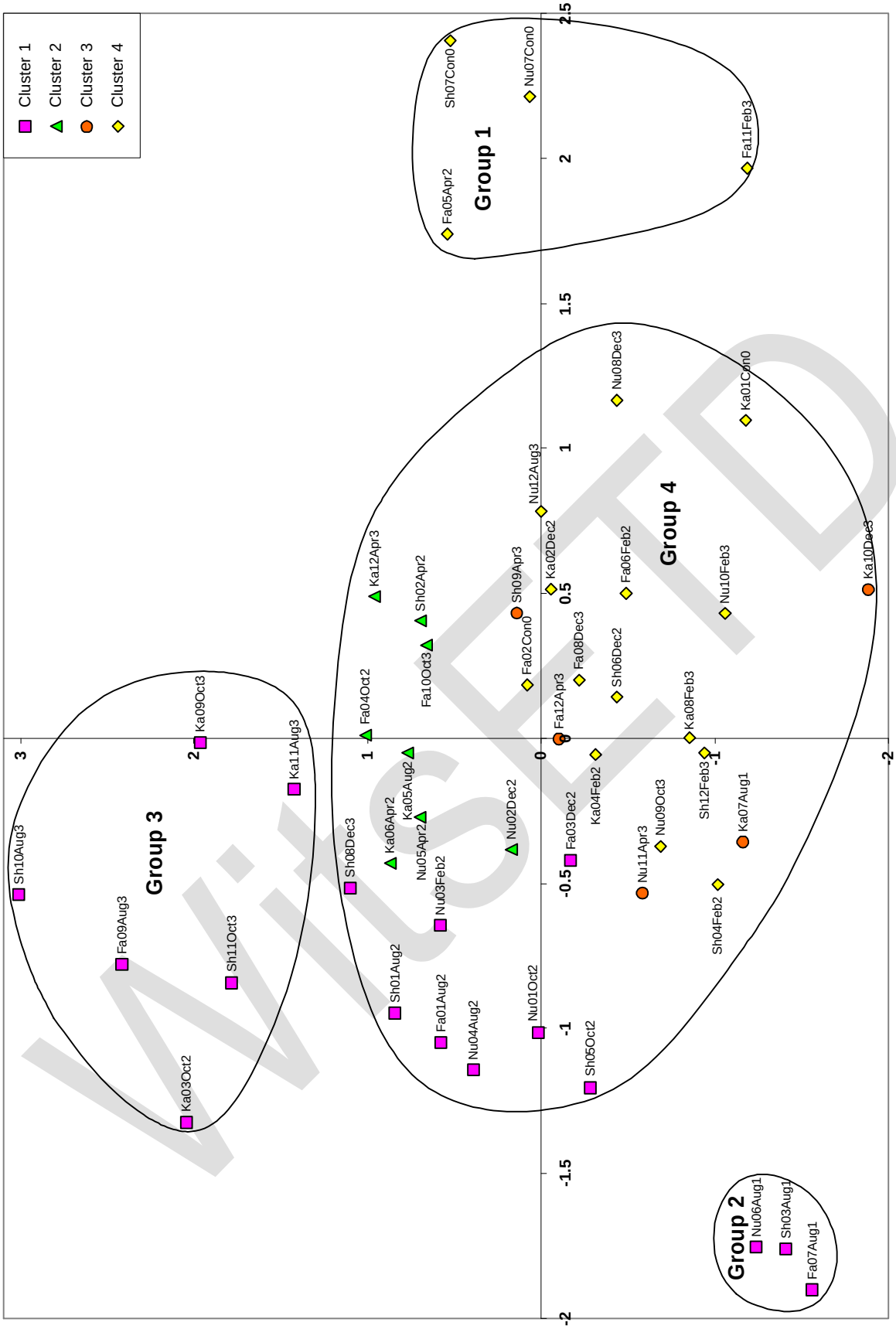


Figure 6-53: Bi-plot of the first two ordination axes from the CA on the 1996 structure by plot data showing variation in structural composition between treatment plots with the first eight ordination axes of the 1954 structure by plot CA as covariables. The groups are the result of a visual assessment of the grouping of structures and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-52). The codes for the treatment plots are defined in Table 10-1 (p. 214).

Visited

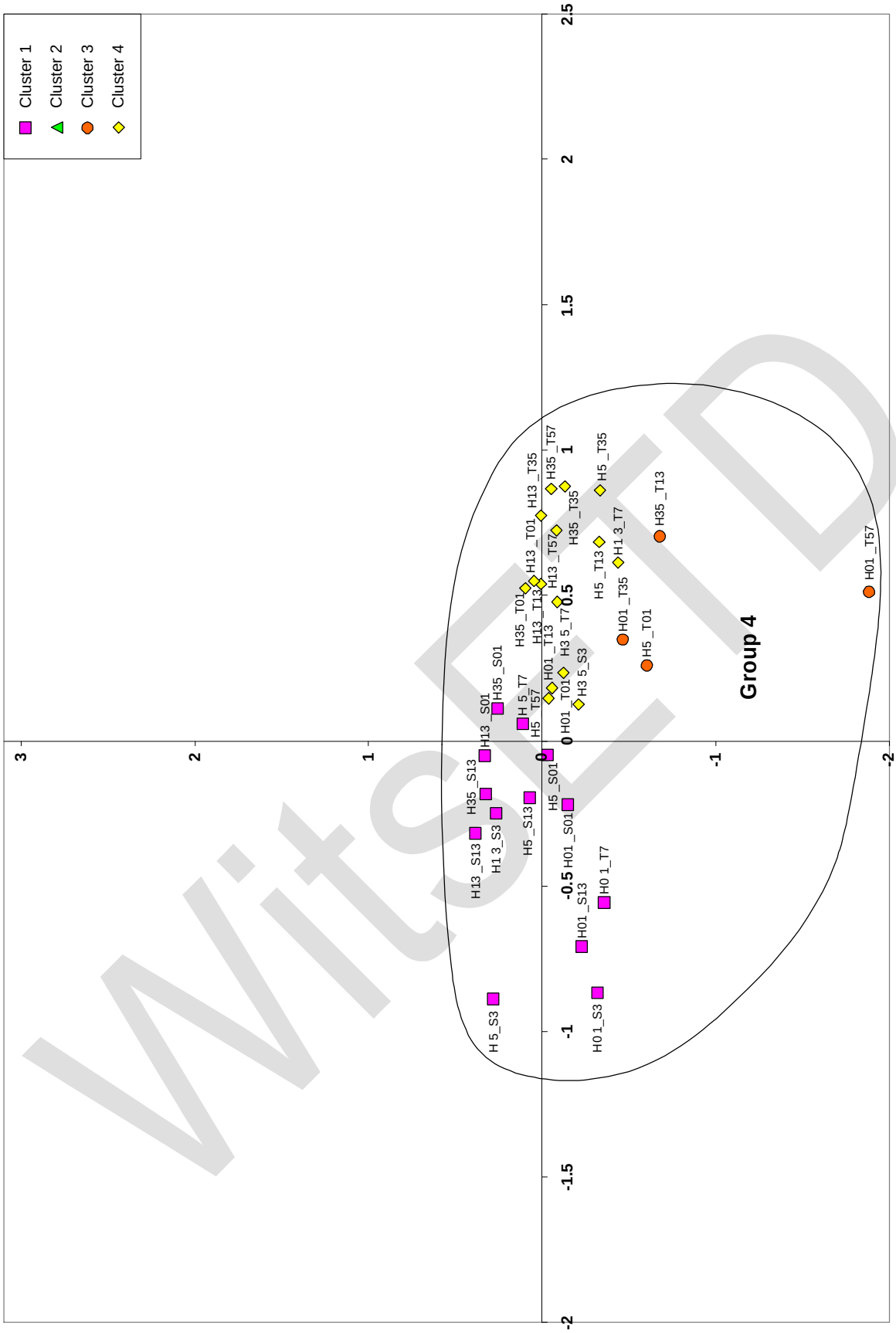


Figure 6-54: Bi-plot of the first two ordination axes from the CA on the 1996 structure by plot data showing variation in location (plots) between structures with the first eight ordination axes of the 1954 structure by plot CA as covariables. The groups are the result of a visual assessment of the grouping of structures and plots along the first two eigenvectors, and the graph points are colour coded to the level 2 clusters from the stepwise Gamma-Ward cluster analysis on the first four eigenvectors (Figure 6-52). The codes for the structure groups are defined in Table 5-3 (p. 34).

WitsETD

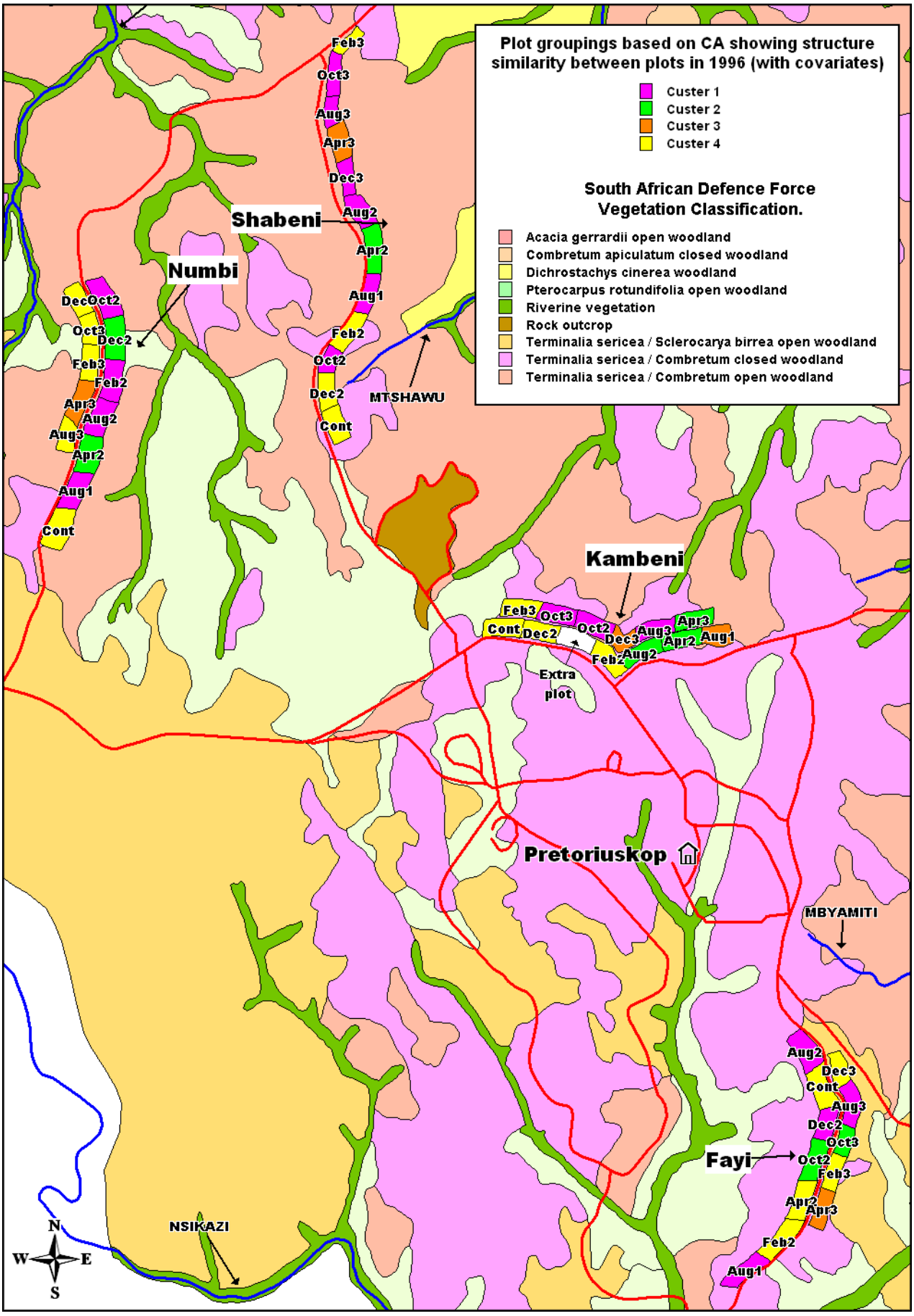


Figure 6-55: Map showing the level 2 groupings of a classification of treatment plots using a stepwise cluster analysis on the first four ordination axes of a CA on the 1996 structure by plot data with the first eight ordination axes of the 1954 structure by plot CA as covariables (Figure 6-52). The codes for the treatments are defined in Table 3-1 (p. 15).