UNIVERSITY OF CAPE TOWN

A hierarchical phytosociology of the Greater Zandvlei Area

An ecology project towards BSc. Hons. Plant Ecology

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The Zanvlei Nature Reserve is to be expanded to form the Greater Zandvlei Estuary Nature Reserve and will encorporate a much greater area (250 more hectares). The Greater Zandvlei area was classified by means of Zürich Montpellier (Braun Blanquet) procedures. 60 relevés were used to create a hierarchical phytosociology using TWINSPAN and DCA-ordination analyses. 3 major community types were identified, which were then subdivided to reveal 6 community types important to future management: Moist Grassland/Wetland Disturbed Parkland, Dune Asteraceous Fynbos, Thicket/Shrub Mosaic, *Rhus-Euclea* Dune Thicket and Homogenous Patches. CCA-ordination indicates that the abiotic soil factors sampled (texture composition, pH, carbon content and visible disturbance) explain very little of the variation between the communities (r^2=0.002). This phytosociology is provided as a tool for future research in the area, and it is hoped to assist in future management decisions regarding the newly founded GZENR.

Anti-plagiarism Declaration

I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work. I was assisted in the field by Timm Hoffman and Robin Burnett. The ideas presented are my own or have been appropriately referenced.

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The Zandvlei estuary is the only functioning estuary on the False Bay coast, Cape Town, South Africa; and links the Zandvlei wetland system to the Atlantic Ocean (Figure 1). The wetland system is surrounded by urban development and, until very recently, only 24ha were classified as a nature reserve. This Zandvlei Nature Reserve is under local municipal management and will soon expand to encompass 270ha (Hoarau 2005) which will be known as the Greater Zandvlei Estuary National Reserve. The total catchment area is over 92km^2 (Thornton *et al*. 1995, tributaries listed as Appendix 1) bordered by Wynberg Hill, Cecilia Ridge, Constantiaberg, Silverpine Plateau, Muizenberg Mountain (Morant & Grindley 1982.

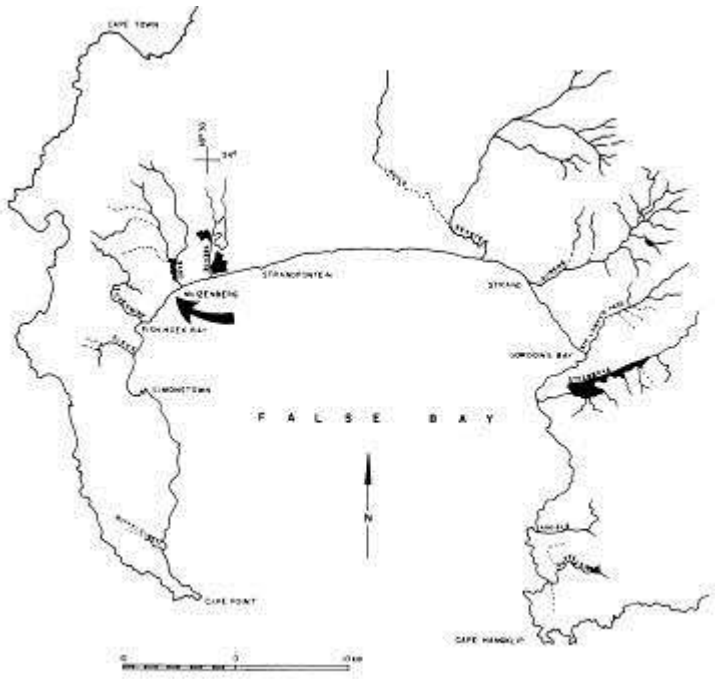

Figure 1. The False Bay coastline indicating the position of the Zandvlei estuary. From Morant & Grindley 1982.

The history of the wetland is marred by urban development impacts since the Dutch East India Company established a cattle post on the edge of the vlei in 1673 (Morant & Grindley (1982). Since then human impacts have drastically transformed the area. A railway bridge along the north side of the vlei was constructed in 1882.There was a failed attempt to drain the area completely in 1977; and dredging from 1947 – 1961 resulted in "…at least [32 ha] of wetland [being] obliterated during the dredging operations changing much of the shoreline from a gentle gradient to steep, high banks requiring artificial stabilisation." (Morant & Grindley 1982). Marina da Gama (a

residential development) was established in 1970 along the east bank of the vlei. Soil excavated during this process was dumped into the vlei to form the previously non-existent Park Island. The canals walls along the marina require perennial water in the vlei for support or they will collapse – the vlei is thus no longer seasonal as it was previously (Morant & Grindley 1982).

The tributary network flows through industrial, commercial and residential areas. The pollution entering the Zandvlei water body includes chemical waste (e.g. oils, dyes and heavy metals), organic waste, and large physical obstructions. Pollution and the threat of further urban development threaten the already heavily impacted system. While the system is by no means prestine, it is of significant importance as a functional estuary, urban biodiversity conservation initiative and as an important environmental education tool that is readily accessible to local schools. A survey (City of Cape Town 1988) has shown that 2000-3000 people visited the vlei during peak holiday periods. The abolishment of the apartheid regime has made the area more accessible and it is likely that the number of visitors to the vlei has increased.

Little has been published with regards to Zandvlei. Earlier works include Azoran (1988), Morant & Grindley (1982) and Thornton *et al*. (1995); but there is no recent research published on the area. While Azoran (unpublished) provided the local municipality with a vegetation map of the Zandvlei wetlands, it was not peer-reviewed and it did not include all of the Greater Zandvlei area. Morant & Grindley's (1982) report is quite comprehensive; however they focus largely on the waterbody itself, as do Thornton *et al.* (1995). With this project I hope to provide a concise phytosociological map of the Greater Zandvlei area. The vegetation units are mapped and described with regards to their species composition and distribution. This mapped species account should provide a baseline for further research into past impacts and future implications of urban development in the area.

Study Site:

Location

Situated on the north-west shore of the False Bay at 34°06’24”S 18°28’42”E (Figure 1); the study area is bordered by Promenade Road to the west, the M5 Main Road to the north and north-west, Prince George Drive to the east and the Atlantic Ocean (Muizenburg beach) to the south. The western border is a line parallel to the Eastern border, from the north-western tip of Westlake south to Muizenburg beach (Figure 2).

The major components of this area were the Zandvlei Nature Reserve, Norfolk Park (Westlake), Park Island and the dunes of Muizenburg beach. Smaller components include a small parkland on Bath Road (Bokmakierie Park), the undeveloped area at the end of Bath Road, the undeveloped area along the north-west of Promenade Road, and the greenbelt behind Muizenburg High School. Recreational areas sampled include the caravan park and grass lawns on the west banks south of the yacht club. Developed urban areas were not sampled.

Geology and Soil

The False Bay coastline consists of 2 major rock-types: Cape Flats quartzitic sands form the lowlands; and the older Table Mountain and Malmsbery sandstones, shales and granites that form Muizenberg Mountain to the west (Thornton *et al*. 1995). The geomorphology of the vlei bottom is described in detail by Fromme (in Morant & Grindley 1982).

Climate

The False Bay coast, Western Cape, is described as having a Mediterranean climate and as such receives winter rainfall (Cowling *et al*. 1992). The Department of Water Affairs (DWA, 1986) reported the majority of rainfall between May and September averaging 400-600mm. The climate is mild with mean summer temperatures of between 15-30°C and winter temperatures of 8-15°C; with an average diurnal variation of 8.5°C (Thornton *et al*. 1995). Hydenrych (1976) illustrates the strong prevailing south-easterly winds experienced in the region in summer months, and north-westerly winds in winter months.

Figure 2. A portion of the larger 2005 aerial photograph taken by A.O.G. Geomatics labelled CMC2005 (Cape Metropolitan Council).

Methods:

It was decided that a 10x5m plot size would be sufficient to capture the diversity seen by the Zandvlei Inventory and Monitoring Programme (ZIMP) (pers. com. Timm Hoffman). 60 stratified random plots were sampled across the Greater Zandvlei area according to the Zürich-Montpellier (or Braun-Blaun-Blanquet) School (Werger 1974) of classification. The rectangular plots were all laid out such that they were longest on the N-S axis. Werger (1974) describes a relevé as constituting the total of ecological and phytosociological observations at a certain point. The relevé data collected in this study includes a list of the species present and their relative canopy cover, total canopy cover, total organic litter, plot location, a disturbance rating and a description of the disturbance, and a soil sample. Plot location was determined using the decimal coordinates from a hand-held GPS (*Garmin GPS 72*) placed at the SE most corner of the plot. Disturbance was recorded as 5-point rating system as shown in Table 1. Note that this description of disturbance does not reflect historical disturbance, merely soil perturbation and anthropogenic impacts apparent at the time of sampling. Soil samples where analysed for soil texture, pH and carbon (organic) content.

Table 1. Plot disturbance was recorded as a rating from 1 – 5.

Disturbance Rating	Level of Disturbance	Example
1	None	No litter or mole activity
2	Low	Low amount of commercial litter or mild
3	Average	Moderate amount of litter or mole activity (or both)
4	Moderate	High levels of litter or mole activity (or both)
5	Very high	Mowed lawns

Species abundance data was analysed using the Two-way indicator species analysis (TWINSPAN, Hill 1979a) to determine a hierarchical community structure of the vlei. A detrended correspondence analysis (DECORANA or DCA; Hill 1979b, Hill & Gauch 1980) ordination with down-weighting of rare species was applied to the data to illustrate possible relationships and habitat gradients amongst the communities. A canonical correspondence analysis (CCA, McCune & Grace 2002) was plotted to show possible relationships between the communities and the abiotic variables sampled. The TWINSPAN, DCA and CCA were performed using the "PC-Ord" software package (McCune & Mefford 1999).

One-way Analyses of variance (ANOVA's) were conducted using the "Statistica 7" software package (Statsoft 2004), to explore whether there were any significant differences in abiotic factors within and across communities. Post-hoc Fisher LSD tests for homogeneous groups were used to cluster statistically similar means and an α of 0.05 was used throughout the statistical analyses.

The CMC 2005 aerial photograph of the area was used as a baseline for the vegetation map. The map was rescaled from 1:30 000 to 1:45 000 and the communities identified from initial TWINSPAN analysis where overlaid onto the sampled areas. Areas that where not sampled have been mapped according to similarities to those areas that were sampled, through personal observation in the field.

Results:

TWINSPAN analysis (Table 2) indicates 3 primary communities, which were further subdivided. Underlined are the 5 sub-communities that are mapped (Figure 3). A full list of plot descriptions is listed as Appendix 2.

- 1. Shrubland/Grassland Mosaic
  - 1.1 Moist Grassland/Wetland
  - 1.2 Dry Parkland/Shrubland
    - 1.2.1 Disturbed Parkland
    - 1.2.2 Dune Asteraceous Fynbos
- 2. Dune Thicket
  - 2.1. Thicket/Shrub Mosaic
  - 2.2. *Rhus-Euclea* Dune Thicket
- 3. Homogenous Patches

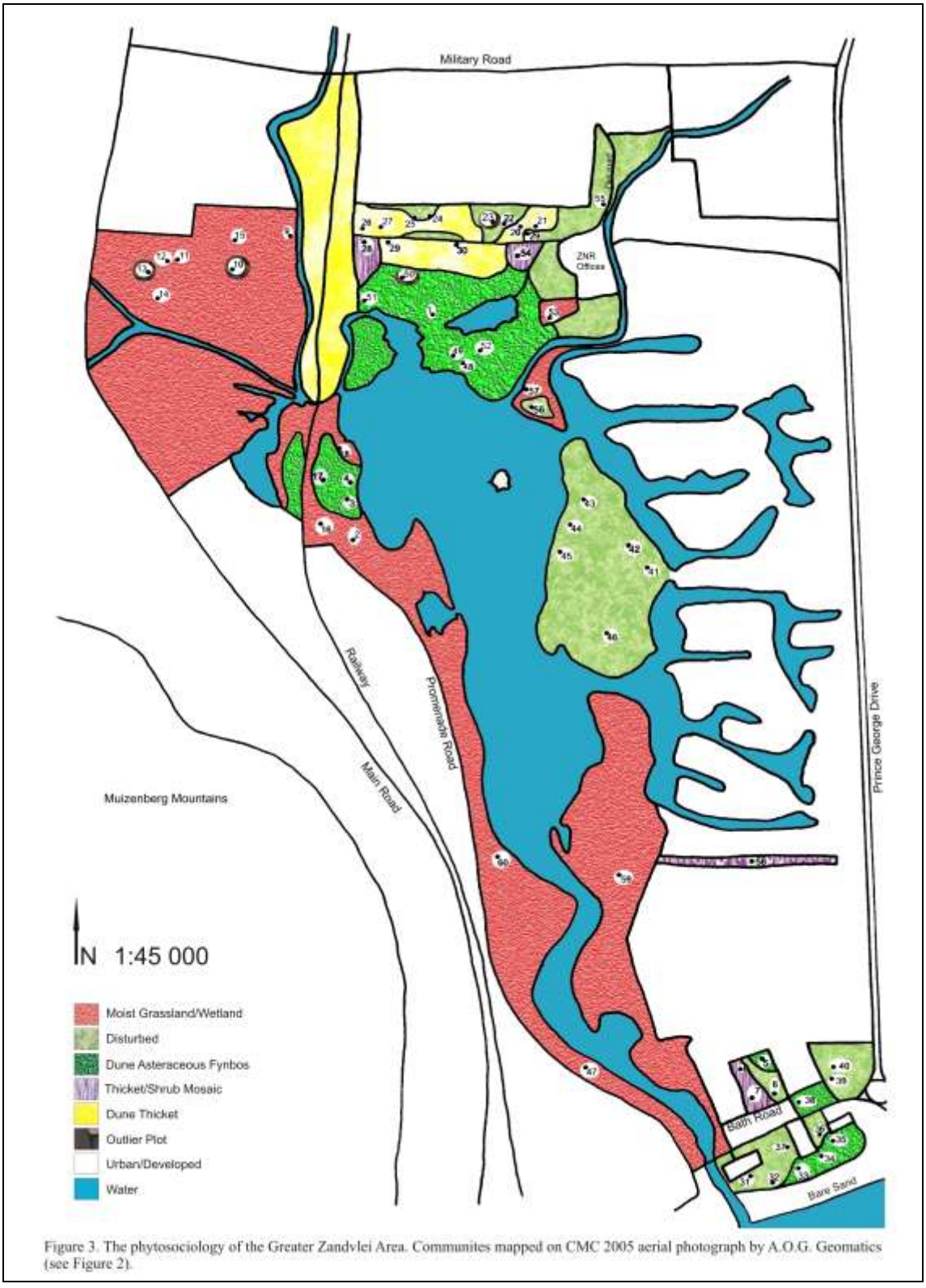

Figure 3. The phytosociology of the Greater Zandvlei Area. Communites mapped on CMC 2005 aerial photograph by A.O.G. Geomatics (see Figure 2).

1. Shrubland/Grassland Mosaic

The vast majority of the area falls within this major community. The vegetation is typical of wetlands and parklands. Much of this community has been planted and/or maintained by humans in the interest of recreational areas e.g. Park Islands grasslands and the braai (barbeque) area lawns. The species linking the 2 sub-communities include generalists such as *Senecio littorius* and *Plecostachys serpyllifolia* (those found between Group 1 & Group 2, Table 2).

1.1. Moist Grassland/Wetland

The average disturbance rating is 3.33 ± 0.51. This disturbance rating is significantly higher than the rest of the communities (Table 3b), but is not a general characteristic as it includes mowed lawns with a rating of 5 (the recreational areas) and the Westlake area, which is showed relatively low disturbance (Norfolk Park), as indicated by a high standard error. The soil in both Westlake and the mowed lawns was moist in summer and is a defining feature of this community. Soil composition included significantly less medium sand and significantly more fine sand (Table 3a). Group 1 (Table 2) was the most common suite of species, including exotic grasses such as *Cynodon dactylon* and *Pennisetum clandestinum*. *Myoporum tenuifolium* (Manatoka) was found in the caravan park, the west bank braai areas and was seen on the inaccessible islands of the vlei. Manatoka is listed as a "No Trade" alien by Henderson (2001) and as such should be removed from the banks of the vlei. *Phragmites australis* was common, however as a common reed it was found growing along the banks of the entire waterbody. The average pH for the sites sampled is 7.7 ± 0.2; which is the lowest out of the 5 sub-communities, although not significantly so (Table 3b).

1.2. Dry Parkland/Shrubland

A grassland/shrubland mosaic with dry soil in summer. This community is variable as it includes highly disturbed areas (e.g. Park Island) and semi-natural Dune Asteraceous Fynbos and should be sub-divided when making management decisions. The 2 sub-communities share some species including *Chrysanthemoides monilifera*, *Pelargonium capitatum* and *Metalasia muricata* (those found between Groups 2 and 3 in Table 3). It would seem that pH and soil carbon are dividing abiotic factors

between the two sub-communities. The mean soil pH of Disturbed Parkland is 7.9 ± 0.1, which is significantly lower than that of Dune Asteraceous Fynbos' 8.3 ± 0.1 (Table 3b). Soil carbon of Disturbed Parkland 1.2% ± 0.2% of total soil mass, which is significantly higher than that of Dune Asteraceous Fynbos' 0.4 ± 0.1 (Table 3b).

1.2.1. Disturbed Parkland

Note that "Disturbed" as a community label is used to describe the historical disturbance and the vegetation sampled; rather than the 1-5 disturbance rating recorded during sampling. This community is dominated by *Bromus diandrous* and *Lolium multiflora*. *Euphorbia terracina*, *Tetragonia decumbens* and *Raphanus sativa* were also present mostly within this community. These species are all weedy plants that are often found in areas of high disturbance. The average disturbance rating for this community is 2.45 ± 0.18; which is only significantly higher than that of the *Rhus-Euclea* Dune Thicket. As such it does not reflect the known high disturbance history of the community. These areas have undergone massive changes in the past e.g. Park Island and Wildwood – both of which did not exist until the Marina was constructed (Morant & Grindley 1982).

1.2.2. Dune Asteraceous Fynbos

A dry-soiled shrubland. This community is characterised by a dominance of *Morella cordifolia* and *Passerina vulgara*, which are not present in the Disturbed Parklands. The average disturbance rating is 1.67 ± 0.31 – significantly lower than that of the Disturbed Parklands (Table 3b), although the value is raised by plots 1 & 17, which showed high mole disturbance (Appendix 2). The majority of this community is located within the ZNR. This community has significantly lower total plant cover than the other communities, barring only Moist Grassland/Wetland (Table 3b). It seems that the high soil pH, lower soil carbon content and low disturbance has created a unique niche in which 14 species were found to flourish (Group 3, Table 2). This community is often bordered by Disturbed Parklands or *Rhus-Euclea* Dune Thicket communities, but there is little overlap (Figure 3a).

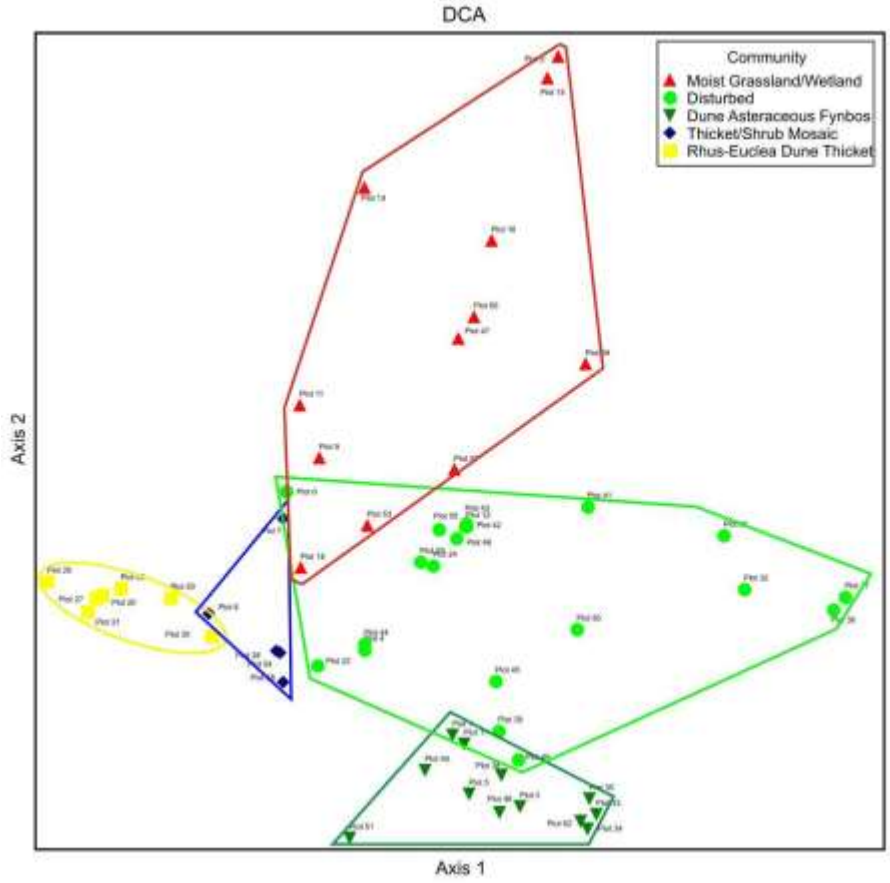

Figure 3a. Cumulative coefficient of correlation for axes 1 & 2 (chi-squared) $r^2 = 0.242$.

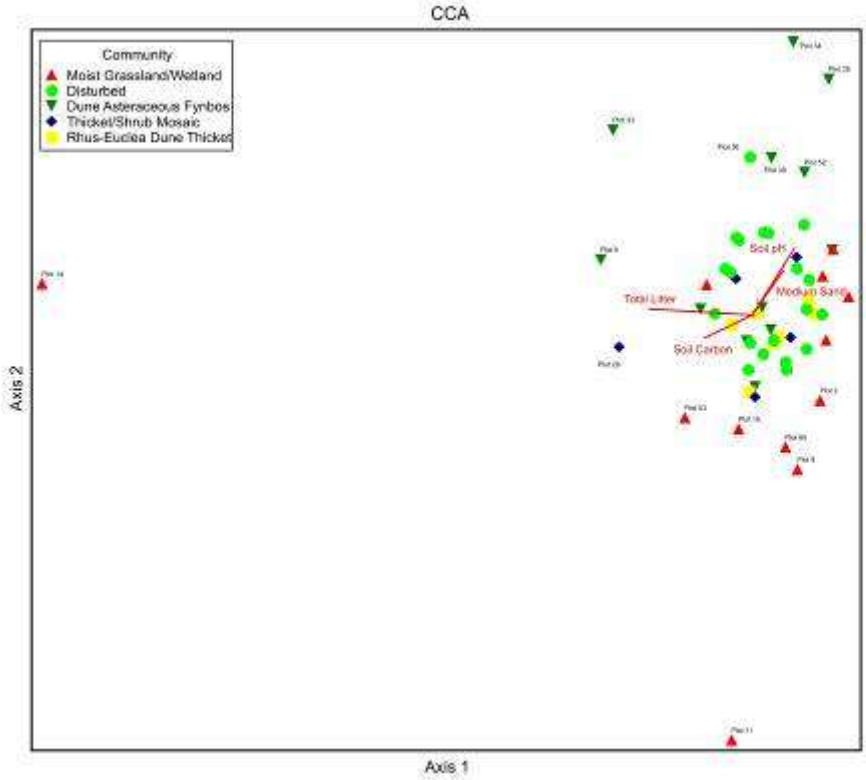

Figure 3b. Cumulative coefficient of correlation for axes 1 & 2 (chi-squared) $r^2 = 0.002$.

Figures 3a & b. A DCA and CCA ordination of 56 plots divided into 5 communities using species abundance data. Rare species were down-weighted during the DCA analysis. While all abiotic variables (Tables 3a & b) were analysed during the CCA ordination process, those indicated were found to be the most relevant.

2. Dune Thicket

There were many species shown to be intermediates between Dry Parkland/Shrubland and Dune Thicket (those found between Groups 3 & 4, Table 2). These generalists are not discussed further, as efforts to conserve either community would result in the sufficient management of these generalists. This community is split into a few thickets that are both impacted by human influence and do not have closed canopies (Thicket/Shrub Mosaic), and those that are semi-natural and have closed canopies (*Rhus-Euclea* Dune Thicket). The two sub-communities are shown (Tables 3a & b) to have no significant differences in any of the abiotic factors tested. It would appear that these two communities are in a state of succession; and that over time the Thicket/Shrub Mosaic plots (if managed correctly) might become closed-canopy thickets. This is unlikely to occur in Bath Road Park (plots 7 & 8) as the area is small and appears highly impacted by the surrounding residential development.

2.1. Thicket/Shrub Mosaic

The average disturbance rating is 2 ± 0.63. This high standard error is due to a low number of plots (only 5, Appendix 2); and high disturbance along Park Road with no disturbance in the remaining 3 plots. The abiotic results for this community (Tables 3a & b) indicate that there is nothing extraordinary about these areas (as shown by insignificant differences). The community is comprised of shrubby species such as *Carex clavata* and *Solanum americanum*; however there were no defining species (Group 4, Table 2) as the species that are most dominant here are also found in *Rhus-Euclea* Dune Thicket.

2.2. *Rhus-Euclea* Dune Thicket

The soil structure, pH and carbon content in this community were not indifferent to those of the other communities, barring the Moist Grassland/Wetland areas (Table 3a). There was almost no signs of active disturbance (1.29 ± 0.18, Table 3b). A defining characteristic of this community is the complete canopy cover in all plots sampled. The plots sampled contained an overwhelming cover of either *Rhus laevigata* or *Euclea racemosa*, or both; and is thus named to represent this, although thicket-loving shrubs such as *Cissampelos capensis* as well as *Salvia africana-lutea* (an exotic that should be controlled, Henderson 2001) were also common (Group 5, Table 3).

Tables 3a & b. The abiotic variables sampled at each plot shown as means for each community ± 1 standard error. Dissimilar letters accompanying the means indicate significant ($p < 0.05$) differences amongst communities. The tables are separated into soil texture variables (3b) and the remaining abiotic factors (3b).

Table 3a.

Hierarchy	Community	Coarse sand	Medium sand	Fine sand	Clay	Silt
1.1	Moist Grassland/Wetland	19 ± 2.9^{a}	28.9 ± 2.8^{a}	50.1 ± 4.6^{c}	1 ± 0^{a}	1 ± 0^{a}
1.2.1	Disturbed Parklands	24.4 ± 2.3^{ab}	39 ± 1.6^{b}	34.6 ± 2.1^{ab}	1 ± 0^{a}	1 ± 0^{a}
1.2.2	Dune Asteraceous Fynbos	29.8 ± 3.8^{b}	40.6 ± 3.4^{b}	27.6 ± 2.7^{a}	1 ± 0^{a}	1 ± 0^{a}
2.1	Thicket/Shrub Mosaic	18.6 ± 3.5^{ab}	39.6 ± 1.5^{b}	39.8 ± 4.2^{bc}	1 ± 0^{a}	1 ± 0^{a}
2.2	*Rhus-Euclea* Dune Thicket	24.9 ± 5.4^{ab}	39.4 ± 3.5^{b}	33.7 ± 2.4^{ab}	1 ± 0^{a}	1 ± 0^{a}

Table 3b.

Hierarchy	Community	Disturbance Rating (see table 1)	Soil Carbon (%)	pH	Total % Cover	Total Litter (% cover)
1.1	Moist Grassland/Wetland	3.33 ± 0.51^{c}	1.6 ± 0.3^{c}	7.7 ± 0.2^{a}	90.8 ± 4.7^{ab}	12.5 ± 8.2^{a}
1.2.1	Disturbed Parklands	2.45 ± 0.18^{b}	1.2 ± 0.2^{bc}	7.9 ± 0.1^{a}	94 ± 1.7^{a}	4.9 ± 1.1^{a}
1.2.2	Dune Asteraceous Fynbos	1.67 ± 0.31^{ab}	0.4 ± 0.1^{a}	8.3 ± 0.1^{b}	82.8 ± 7.4^{b}	10.2 ± 2.9^{a}
2.1	Thicket/Shrub Mosaic	2 ± 0.63^{ab}	0.6 ± 0.2^{ab}	8 ± 0.1^{ab}	96 ± 4^{ab}	11.2 ± 3.6^{a}
2.2	*Rhus-Euclea* Dune Thicket	1.29 ± 0.18^{a}	0.8 ± 0.2^{abc}	7.9 ± 0.1^{ab}	100 ± 0^{a}	4.6 ± 1.4^{a}

3. Homogenous Patches

Initial TWINSPAN analysis revealed plots 10, 13, 23 and 50 as unique communities. They are instead grouped here as homogenous patches as they contained 80-100% cover of a single species, which is not found in surrounding plots. Plot 10 is 80% *Lupinus lycransis*. Plot 13 and 50 are 100% *Fuirena coerulescens*. Plot 23 is 95% *Imperata cylindrical*. While these patches are worth noting, there was little replication of these patches and no trends can be determined. These plots were sampled as they each covered more than $50m^2$, but are removed as outliers for further TWINSPAN analysis and DCA and CCA ordination.

Discussion & Conclusion:

The Moist Grassland/Wetland community appears to be flourishing in the area, but this is an artefact of the mowed lawn areas. The only area worth considering for the conservation of this community is that of Westlake, the northern area on Promenade Road and the periphery of Wildwood.

The Disturbed Parklands are common in areas frequented by dog walkers etc. near the coast and on Park Island. Local residents may not approve of significant restoration of the area as it would mean a removal of alien weeds such as the *Bromus diandrus* grasslands.

The Dune Asteraceous Fynbos community is often bordered by Disturbed Parkland or *Rhus-Euclea* Dune Thicket communities, but there is little overlap (Figure 3a). It seems that these species are either unable to establish in thickets and grasslands due to out-shading, or are ill-adapted to lower soil pH or higher soil carbon content, or a combination of these factors. One cannot describe any of the communities remaining in the Zandvlei area as natural or pristine, but the Dune Asteraceous Fynbos community appeared well managed and as it contains species not found elsewhere in the sampled area, it is essential to focus on conserving this habitat.

The Thicket/Shrub Mosaic is a small community, but it provides a habitat for species not found elsewhere in the reserve and is thus important to consider when trying to maximise biodiversity conservation.

Rhus-Euclea Dune Thicket appears to be a small, well managed community within the ZNR, and is somewhat inaccessible and therefore not highly impacted outside of the ZNR. This suite of species is unique within the sampled area and continued preservation of these thickets is vital. Continued alien removal is suggested.

A spread of homogenous patches would lead to a reduction in biodiversity and this should be taken into account when considering even indigenous species such as *Fuirena coerulescens* and *Imperata cylindrical*.

While the DCA ordination (Figure 3a) showed clear separations amongst many of the communities which support the TWINSPAN results, the correlation co-efficient reveals that only 24% of the data can be explained in the ordination. The CCA analysis of the abiotic data sampled reveals that the abiotic variables are very poor indicators of the community structure ($r^2 = 0.002$). It is likely that competition plays an important role in preventing communities from invading each other, but this was not explored. It is suggested that a future project may include soil depth, salinity and water table analyses to better understand the distributions of these communities.

Plans regarding the development of the R300 / N21 (southern section 1) toll road and Steenberg Road extention through the Zandvlei area are not yet finalised. These road developments could have vast implications for the conservation of the communities described in this paper, but they are beyond the scope of this project and more research is needed. This phytosociology is provided as a tool for future research in the area, and it is hoped to assist in future management decisions regarding the newly founded GZENR.

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Appendix 1: ***The tributaries that feed into the Zandvlei catchment (from Morant & Grindley 1982)***

River	Length (km)
Little Princess Vlei Stream	**1.05**
Westlake Stream	**4.70**
Westlake Stream tributaries	**1.10**
Keysers River	**7.50**
Keysers River tributaries	**2.20**
Langvlei Canal	**3.95**
Sand River Canal/Diep River	**12.60**
Total length of all rivers entering Zandvlei	**33.10**