



A hierarchical phytosociology of the Greater Zandvlei Area

An ecology project towards BSc. Hons. Plant Ecology

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The Zandvlei Nature Reserve is to be expanded to form the Greater Zandvlei Estuary Nature Reserve and will incorporate 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 92km² (Thornton *et al.* 1995, tributaries listed as Appendix 1) bordered by Wynberg Hill, Cecilia Ridge, Constantiaberg, Silverpine Plateau, Muizenberg Mountain (Morant & Grindley 1982).

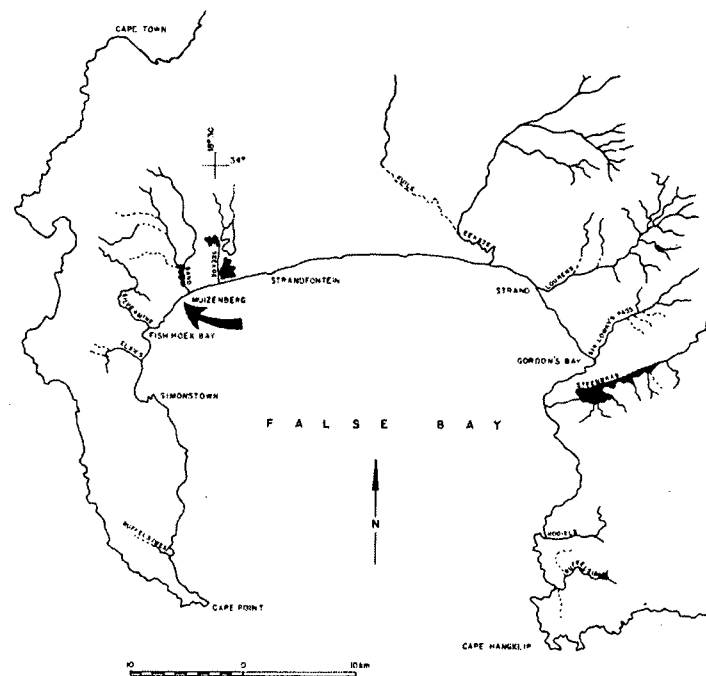


Figure 1. The False Bay coastline indicating the position of the Zandvlei estuary. From Morant & Grindley 1982.

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 canal 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 pristine, 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 were 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

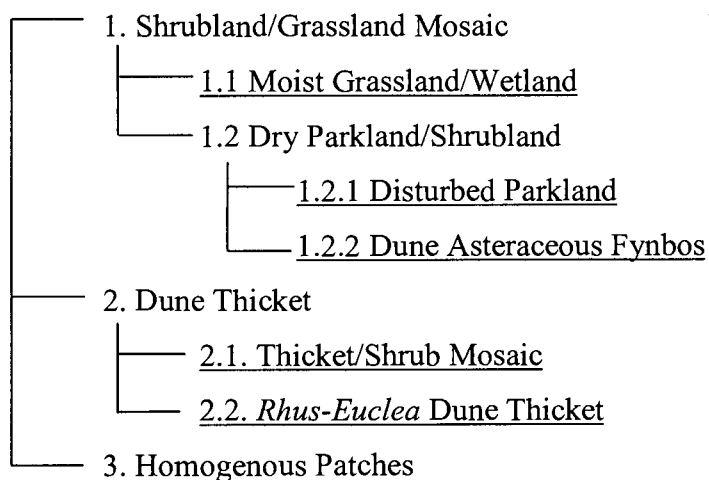
Species abundance data was analysed using the Two-way indicator species analysis (TWINSpan, Hill 1979a) to determine a hierarchical community structure of the vlei. A detrended correspondence analysis (DECORANA or DCA; Hill 1979b, Hill & Gauch 1980) ordination with down-weighting of rare species was 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 were overlaid onto the sampled areas. Areas that were 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.



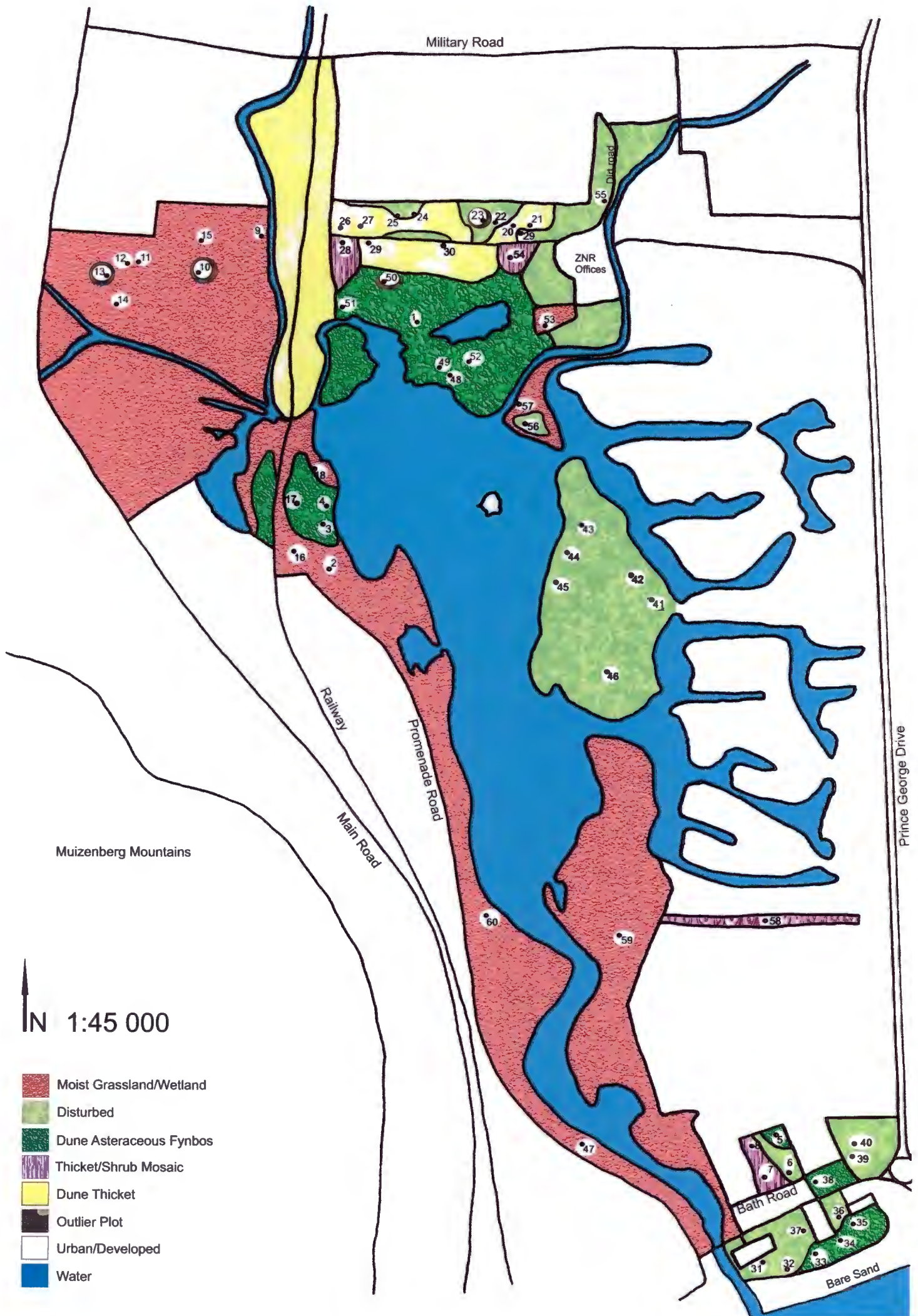


Figure 3. The phytosociology of the Greater Zandvlei Area. Communitates mapped on CMC 2005 aerial photograph by A.O.G. Geomatics (see Figure 2)

Table 2. TWINSpan results from 56 relevés. Plot numbers are listed horizontally, full species names are listed in Appendix 1. Dashed lines divide significant communities. Plots 10, 13, 23 and 50 were removed as outliers as they contained 100% cover of a single species. Percentage cover was converted using PC-Ords TWINSpan algorithm to a 1 (low) to 5 (high) rating.

		Moist Grassland/ Meadow	Disturbed Parkland	Asteraceous Fynbos	Dune Asteraceous	Thicket/ Shrub Mosaic	Thicket Dune	Rhus-Euclea Dune	
		11 1 1514565	3333445 12253441444	4 14553333	255	2232222			
		2514894367907	6712156692459042236	935781234581	78848	5900167			
Group 1	24	Junc krau	---355---	-----2-----					000
	93	Erod cicu	-----43-	-----1-----					000
	8	Care eckl	2--1---2---	-----1-----					000
	9	Cype long	-----2---	-----1-----					000
	20	Romu rose	-----4---	-----1-----					000
	23	Junc regi	-----4---	-----1-----					000
	30	Cyno dact	2-242--355554	---12---13--1--					000
	35	Penn cian	---5-515-54	-----1-----					000
	36	Phra aust	1--3-45-4--2	-----1-----					000
	56	Arct cale	---5-14---	---1-----1--					000
	58	Cony scab	---14-----	-----1-----					000
	59	Cotu fili	-----1---	-----1-----					000
	60	Cotu vulg	-----1---	-----1-----					000
	78	Echi plan	---1-2-----	---1-----1--					000
	101	Lavaicret	-----1---	-----1-----					000
	102	Lavi arbo	-----3---	-----1-----					000
	105	Myop tenu	-----244-	-----1-----					000
	124	Trib terr	-----1---	-----1-----					000
	11	Isol marg	54-----	-----1-----					000
	22	Junc cape	-2-----	-----1-----					000
	25	Trig bulb	35-----	-----1-----					000
	47	Sarc cape	-4-----	-----1-----					000
	55	Cent asia	1-----	-----1-----					000
	87	Medi poly	4-----1413--	---1-2-----					000
	92	Chir decu	1-----	-----1-----					000
	104	Phar line	-2-----	-----1-----					000
	112	Plan lanc	4-----1---	-----2-----					000
	115	Thes fris	3-----1---	-----1-----					000
	21	Romu tabu	-1-----	---1-----					000
	29	Cort sell	-5-5-----	-----4-----					000
	79	Raph raph	---4-----5	---1-----31-1--	-1-----				000
	89	Vici beng	---4-4-----	---1-4--1---	-21-----				000
	13	Scir nodo	-4-5-----	-----4222---	-----2-----				001
	70	Plec serp	---45-----	---1-22-----	-----5-----				001
	74	Sene litt	144---1-1-	1---1111-2-121-1-	-1-21-11-1-	11---			001
Group 2	15	Albu cana	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	33	Loli mult	-----5-4	1155545	-----111-	3-----	-----1-1-11	-----1-1-11	010
	95	Gera inca	-----2---	-----11-22---	-----111-	-----1-1-11	-----1-1-11	-----1-1-11	010
	42	Carp edul	-----2-4	-----154	4--2--1---	-----1-1-11	-----1-1-11	-----1-1-11	010
	83	Euph terr	---1-1---2	---11-1---1111-113	-1-----	1-----	-----1-1-11	-----1-1-11	010
	96	Gera moll	-----1---	-----11---	-1-----	-----1-1-11	-----1-1-11	-----1-1-11	010
	14	Albu flac	-----1---	-----1---	-1-----	-----1-1-11	-----1-1-11	-----1-1-11	010
	19	Romu hirs	-----1---	-----1---	-1-----	-----1-1-11	-----1-1-11	-----1-1-11	010
	28	Brom dian	-----3-5	-1-51-5-554344555	3-----	-----1-1-11	-----1-1-11	-----1-1-11	010
	62	Heli cris	-----3---	-----3---	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	68	Otho coro	-----3---	-----3---	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	69	Picr echi	-----1-11	-----1-11	-1-----	-----1-1-11	-----1-1-11	-----1-1-11	010
	72	Sene eleg	-----11	-----11	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	77	Vell deal	-----1-1	-----1-1	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	82	Euph heli	-----1-	-----1-	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	26	Aven sati	-----4-11	-----4-11	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	32	Lagu ovat	-----1-	-----1-	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	45	Tetr decu	-----1455	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	52	Sond hisp	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	61	Dimo pluv	-----11-1-1	-----11-1-1	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	63	Heli dasy	-----3-	-----3-	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	76	Sene terr	-----3-	-----3-	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	80	Raph sati	-----25-1-1	-----25-1-1	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	84	Acac cycl	-----55-1-1-2-1	-----55-1-1-2-1	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	88	Psor pinn	-----2	-----2	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	67	Meta muri	-----3-45	-----3-45	35-5-555552	-----1-1-11	-----1-1-11	-----1-1-11	010
	97	Gera purp	-----1-	-----1-	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	98	Pela capi	-----15-12	-----15-12	-1-1-2---	-----1-1-11	-----1-1-11	-----1-1-11	010
	57	Chry mono	-----1-55-255	-----1-55-255	-355-12-51	-----1-1-11	-----1-1-11	-----1-1-11	010
	10	Fici indi	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	51	Dasi suff	-----2	-----2	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
	75	Sene mari	-----1-	-----1-	-----1-1-11	-----1-1-11	-----1-1-11	-----1-1-11	010
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Table 2 (continued).

		Grassland/ Wetland	Moist	Disturbed Parkland	Dune Fynbos	Asteraceous Dune	Thicket/ Shrub Mosaic	Dune Thicket	Rhus-Euclea	
		1141 1514565	3333445	12253441444	4	14553333	2552	232222		
		2514894367907	6712156692459042236	935781234581		78848	5900167			
Group 3	6	Andr cape			-1-					010
	17	Glad angu			-2-					010
	27	Briz maxi			-4-5-					010
	34	Merx sp.?				1				010
	48	Rhus glac			-1-					010
	64	Heli nive			-1-22-					010
	65	Heli patu				1				010
	66	Hypo radi			-1-					010
	90	Vici hirs			-2-					010
	108	Oxal capr				1-				010
	113	Nyla spin			-2-	2				010
	120	Pass rigi				2				010
	121	Pass vulg			-51423-	4	1			010
	106	More cord			545-53-	1	4			010
	31	Ehrh vill	11-	14-4111		11115	24-	-1-		011
	1	Zant aeth	11-	1-11-		1-	1-	-1-		011
	4	Trac cili		11-11-1-1-1-			1-	1-		011
	46	Tetr frut		34433-				-4-3-		011
	54	Tori arve	-1-	1-				-2-		011
	39	Wild glom		3-		5-		2-		011
	41	Carp acin		11-	3-	111-1	3-			011
	71	Sene burc		1-2-		2-1-	1	2-		011
	3	Sene hali	44-5-	43-	5-	41-4-1-	3-	555-		011
	5	Trac diva				1-1-	2-			100
	114	Osyrc comp				4-		3-		100
	37	Sten secu		1-5-4-1-		2-	24-5-			100
	43	Phyl cana		3-			33-			100
	44	Rusc maco		4-			53-			100
	99	Pela sp.?				1	11-			100
	16	Chas aeth	1-	11-22-		1-1-1-11-	123-4-	1-21		100
	109	Oxal pes-	2-	3-11-1-	1-		2-	14		100
	94	Gera capi	4-	1-			2-	1-1		101
Group 4	85	Acac sali			1-		3-			110
	3	Aloe fero					1-			110
	7	Care clav					3-3-			110
	12	Mari thun					3-			110
	40	Cass cili					4-			110
	53	Tori sp.?					1-			110
	116	Side iner					4-			110
	122	Typh cape					3-			110
	50	Rhus luci					1-54-	5-5		110
	111	Oxal sp.2		1-			2-	1-		110
	119	Sola amer		1-1-2-			42422	23-2-4		110
Group 5	38	Isch eleo					3-			111
	100	Salv afri					4-	551-		111
	49	Rhus laev					5-	23555-5		111
	2	Aspa cape						344		111
	18	Glad cuno						1-		111
	81	Eucl race					3-	5555		111
	91	Fuma mura						2-		111
	103	Ciss cape	1-	1-				23-5-44		111
	107	Olea exas						2-		111
	110	Oxal sp.?						2-		111
	117	Lyci afri						54		111
	123	Visc cape						2-3		111
	86	Aspa hisp		1-2-				5-4-		111
	118	Lyci fero		1-				4-		111
		000000000000	000000000000000000	000000000000	11111	11111111				
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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 $7.9 \pm$

0.1, which is significantly lower than that of Dune Asteraceous Fynbos' 8.3 ± 0.1 (Table 3b). Soil carbon of Disturbed Parkland $1.2\% \pm 0.2\%$ 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 vulgaris*, 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).

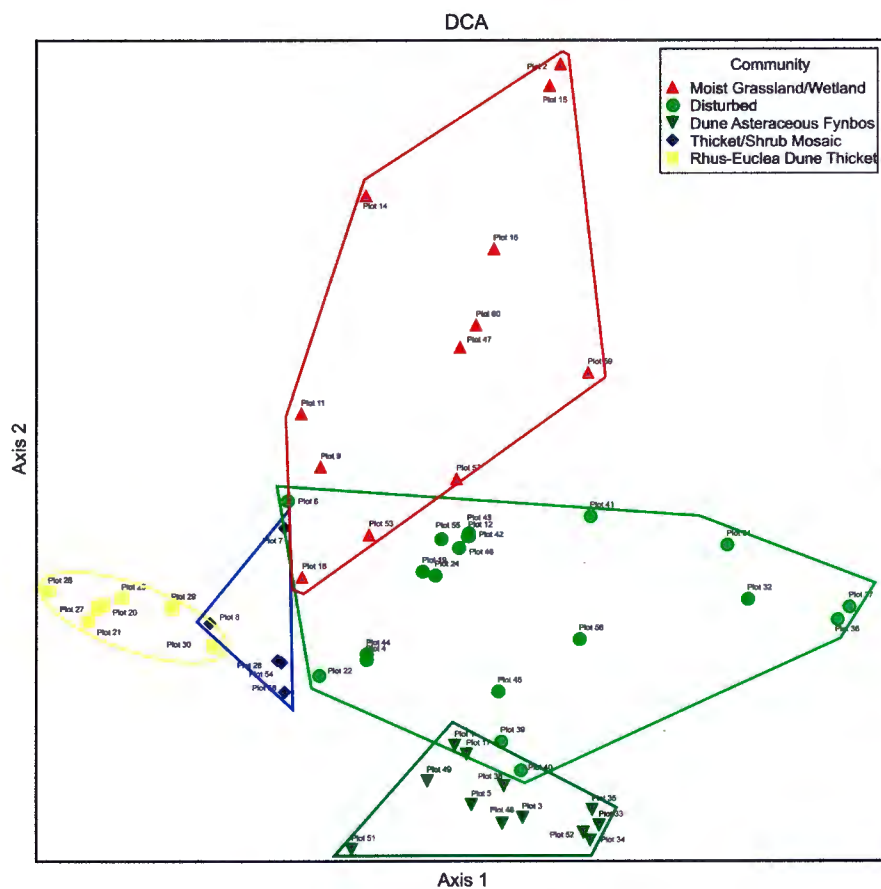


Figure 3a. Cumulative coefficient of correlation for axes 1 & 2 (chi-squared) $r^2 = 0.242$.

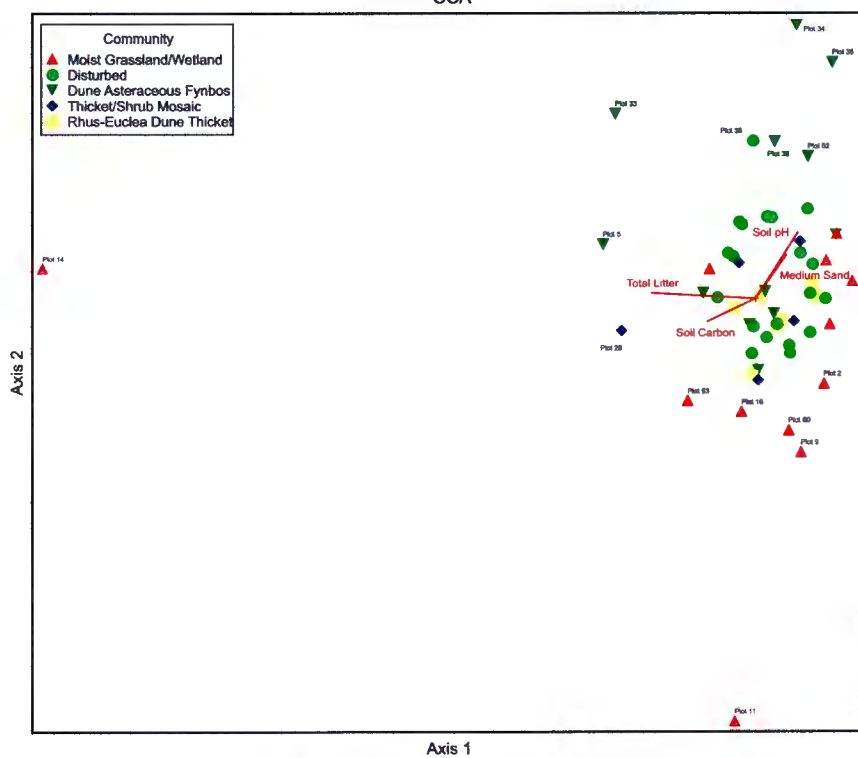


Figure 3b. Cumulative coefficient of correlation for axes 1 & 2 (chi-squared) $r^2 = 0.002$.

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 \pm 1 standard error. Dissimilar letters accompanying the means indicate significant ($p < 0.05$) differences amongst communities. The tables are separated into soil texture variables (3a) and the remaining abiotic factors (3b).

Table 3a.

Hierarchy	Community	Coarse sand	Medium sand	Fine sand	Clay	Silt
1.1	Moist Grassland/Wetland	19 \pm 2.9 ^a	28.9 \pm 2.8 ^a	50.1 \pm 4.6 ^c	1 \pm 0 ^a	1 \pm 0 ^a
1.2.1	Disturbed Parklands	24.4 \pm 2.3 ^{ab}	39 \pm 1.6 ^b	34.6 \pm 2.1 ^{ab}	1 \pm 0 ^a	1 \pm 0 ^a
1.2.2	Dune Asteraceous Fynbos	29.8 \pm 3.8 ^b	40.6 \pm 3.4 ^b	27.6 \pm 2.7 ^a	1 \pm 0 ^a	1 \pm 0 ^a
2.1	Thicket/Shrub Mosaic	18.6 \pm 3.5 ^{ab}	39.6 \pm 1.5 ^b	39.8 \pm 4.2 ^{bc}	1 \pm 0 ^a	1 \pm 0 ^a
2.2	<i>Rhus-Euclea</i> Dune Thicket	24.9 \pm 5.4 ^{ab}	39.4 \pm 3.5 ^b	33.7 \pm 2.4 ^{ab}	1 \pm 0 ^a	1 \pm 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 \pm 0.51 ^c	1.6 \pm 0.3 ^c	7.7 \pm 0.2 ^a	90.8 \pm 4.7 ^{ab}	12.5 \pm 8.2 ^a
1.2.1	Disturbed Parklands	2.45 \pm 0.18 ^b	1.2 \pm 0.2 ^{bc}	7.9 \pm 0.1 ^a	94 \pm 1.7 ^a	4.9 \pm 1.1 ^a
1.2.2	Dune Asteraceous Fynbos	1.67 \pm 0.31 ^{ab}	0.4 \pm 0.1 ^a	8.3 \pm 0.1 ^b	82.8 \pm 7.4 ^b	10.2 \pm 2.9 ^a
2.1	Thicket/Shrub Mosaic	2 \pm 0.63 ^{ab}	0.6 \pm 0.2 ^{ab}	8 \pm 0.1 ^{ab}	96 \pm 4 ^{ab}	11.2 \pm 3.6 ^a
2.2	<i>Rhus-Euclea</i> Dune Thicket	1.29 \pm 0.18 ^a	0.8 \pm 0.2 ^{abc}	7.9 \pm 0.1 ^{ab}	100 \pm 0 ^a	4.6 \pm 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 lycrancis*. 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 50m², 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 extension 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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References:

- Azoran, E.J. 1988. Distribution of plant communities in the wetlands of Zandvlei. Unpublished report, Botany Department, University of Cape Town.
- Cowling, R.M., P.M. Holmes and A.G. Rebelo. 1992. Plant diversity and endemism. In: Cowling, R.M. (ed.) *The Ecology of Fynbos: nutrients, fire and diversity*. Oxford University Press, Cape Town, South Africa.
- Henderson, L. 2001. *Alien Weeds & Invasive Plants: a complete guide to declared weeds and invaders in South Africa*. Agricultural Research Council, Pretoria.
- Hill, M.O. 1979a. *DECORANA: A Fortran Program for Detrended Correspondence Analysis and Reciprocal Averaging*. Ecology and Systematics, Cornell University, Ithaca, NY.
- Hill, M.O. 1979b. *TWINSPAN: A Fortran Program for Arranging Multivariate Data in an Ordered Two-Way Table by Classification of the Individuals and Attributes*. Ecology and Systematics, Cornell University, Ithaca, NY.
- Hill, M.O. & H. Gauch. 1980. Detrended correspondence analysis: an improved ordination technique. *Vegetatio*. **42**: 47-58.
- Hoarau, M.G. 2005. *Final report for experiential training (towards National Diploma: Nature Conservation)*. Dept. of Nature Conservation, Tswane University of Technology.
- Hydenrych, P.J. 1976. Water quality in marina and waterside housing developments. MSc. Thesis, University of Cape Town.
- McCune, B. & J. Grace. 2002. *Analysis of Ecological Communities*. MjM Software, Gleneden Beach, Oregon, U.S.A.
- McCune, B. & M. J. Mefford. 1999. *Multivariate Analysis of Ecological Data Version 4.25*. MjM Software, Gleneden Beach, Oregon, U.S.A.
- Morant, P.D. & J.R. Grindley. 1982. Report No. 14: SAND (CSW4). In Heydorn, A.E.F. & Grindley, J.R. (eds.), *Estuaries of the Cape. Part II: Synopses of Available Information on Individual Systems*. Council for Scientific and Industrial Research, Pretoria. Research Report 413.
- Thornton, J.A., H. Beekman, G. Boddington, R. Dick, W.R. Harding, M. Lief, I.R. Morrison & A.J.R. Quick. 1995. The Ecology and Management of Zandvlei (Cape Province, South Africa), and Enriched Shallow African Estuary. In: McComb, A. (ed.), *Eutrophic shallow estuaries and lagoons*. CRC Press, Boca Raton) Chapter 8, pp 109-128.
- Werger, M.J.A. 1974. On concepts and techniques applied in the Zürich-Montpellier method of vegetation survey. *Bothalia*. **11**(3): 309-323.

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

Appendix 2. Plot Descriptions (continued)

Plot	Community	GPS Coordinates		Disurbance Rating 1 (none) - 5 (high)	Disturbance Type	Total %Cover	Total %Litter	Location	Discription	
		S	E							
Moist Grassland/Wetland										
2	1.1	34.08812	18.46385	5	moles mowing	45	0	NW Promenade rd	Grassy lawn - moist in winter. Between phragmites hedgerows	
9	1.1	34.07986	18.46222	2	moles	90	0	Norfolk park	River bank	
11	1.1	34.08059	18.45988	4	moles	80	5	Norfolk park	Top of a hill. Less moist	
14	1.1	34.08087	18.45797	1		100	100	Norfolk park	Phragmites stand	
15	1.1	34.08037	18.46109	1		80	0	Norfolk park	Appears to be seasonally inundated saltpan	
16	1.1	34.08789	18.46302	5	freshly mowed	100	10	NW Promenade rd	Mowed lawn	
18	1.1	34.08568	18.46363	1		100	15	NW Promenade rd	Between road to seascouts & vlei. Flat. Moist ground.	
47	1.1	34.10184	18.47129	5	freshly mowed	100	0	West braai area	South of bowls club	
53	1.1	34.08213	18.47046	2	dumped organic refuse	100	20	ZNR	Next to palm-tree parking lot	
57	1.1	34.08346	18.46968	4	moles	95	0	Wildwood	North side of Wildwood	
59	1.1	34.09761	18.47242	5	mowing	100	0	Caravan Park	A representative plot within the caravan park	
60	1.1	34.09682	18.46909	5	mowing	100	0	West braai area	North of bowls club	
Disturbed										
4	1.2.1	34.08596	18.46362	1		100	0	NW Promenade rd	Transitional -> reed - >sand fynbos. Very thick	
6	1.2.1	34.10243	18.47724	4	moles	80	10	Bath rd E corner	Parkland. Low shrubby grass. Gentle slope	
12	1.2.1	34.08044	18.45965	2	moles	95	0	Norfolk park	Lupin patch on N side of hill - gradual slope	
19	1.2.1	34.08001	18.46919	3	moles	90	15	ZNR RR	Grass between thickets near entrance	
22	1.2.1	34.07982	18.46869	1		100	10	ZNR RR	Buffalo grass patch w <i>Carpobrotus</i> between <i>Imperatis</i> & thickets	
24	1.2.1	34.07968	18.46808	2	moles	95	0	ZNR RR	Grass patch between thickets along fenceline	
31	1.2.1	34.18472	18.47643	3	moles	90	0	Muizenburg dunes	Near parking lot - not much slope	
32	1.2.1	34.10498	18.47715	3	moles	80	2	Muizenburg dunes	Near parking lot - slight slope	
36	1.2.1	34.10415	18.47879	2	litter	100	10	Muizenburg dunes	Acacia stand between large parking lot and double story house	
37	1.2.1	34.10400	18.47724	2	litter	100	10	Muizenburg dunes	Between original parking lot and double story house	
39	1.2.1	34.10221	18.47911	3	litter	100	5	End of Bath Road	Deeper in than plot 38	
40	1.2.1	34.10192	18.47942	2	litter	100	5	End of Bath Road	In line with the road	
41	1.2.1	34.08874	18.47319	2	moles	99	0	Park Island	Grassland near the small building at the entrance	
42	1.2.1	34.08795	18.47231	2	moles	99	0	Park Island	Grassland to the N of the island	
43	1.2.1	34.08709	18.47126	2	moles	99	0	Park Island	Grassland near N bridge	
44	1.2.1	34.08769	18.47051	3	moles	80	7	Park Island	Near water, W of plot 43	
45	1.2.1	34.08937	18.47024	3	moles	90	10	Park Island	Near water, further S than plot 44	
46	1.2.1	34.08758	18.47335	2	moles	98	4	Park Island	Further S on grassland	
55	1.2.1	34.07955	18.47249	3	moles	100	0	ZNR	The road leading out of the reserve	
56	1.2.1	34.08430	18.46963	4	moles	85	10	Wildwood	The West end of Wildwood	

Appendix 2. Plot Descriptions

Plot	Community	GPS Coordinates		Disurbance Rating	Disturbance Type	Total %Cover	Total %Litter	Location	Discription
		S	E	1 (none) - 5 (high)					
Dune Asteraceous Fynbos									
1	1.2.2	34.08540	18.4705	3	moles	33	10	ZNR	Dune asteracious fynbos
3	1.2.2	34.08637	18.46366	3	moles	100	10	NW Promenade rd	Dry sand, crest of small dune
5	1.2.2	34.10173	18.47674	2	litter	100	30	Bath rd N corner	Parkland. Thick. Flat
17	1.2.2	34.08662	18.46334	4	moles	75	5	NW Promenade rd	Flat. Less moist. Near railway.
33	1.2.2	34.10461	18.47756	1		75	30	Muizenburg dunes	Dunes east of parking lot
34	1.2.2	34.10440	18.47824	1		85	5	Muizenburg dunes	SE corner of large double story house
35	1.2.2	34.10372	18.47890	1		30	5	Muizenburg dunes	SW corner of a large parking lot, sparse dune veg
38	1.2.2	34.10265	18.47803	1		100	5	End of Bath Road	NW corner
48	1.2.2	34.08214	18.46618	1		100	2	ZNR	Along path between jetty and bird hide
49	1.2.2	34.08170	18.46535	1		100	0	ZNR	Next to jetty and an open wet area
51	1.2.2	34.08163	18.46451	1		100	15	ZNR	Retio patch near fence on West of reserve
52	1.2.2	34.08158	18.46720	1		95	5	ZNR	Patch near salt marsh hide
Thicket/Shrub Mosaic									
7	2.1	34.10258	18.47665	3	moles	80	6	Bath rd S corner	Parkland. Low shrubby grass. Steep slope
8	2.1	34.10192	18.47609	4	moles litter	100	10	Bath rd W corner	Parkland. Low shrubby grass. Gentle slope
28	2.1	34.08024	18.46430	1		100	25	ZNR RR	Tall shrubs
54	2.1	34.08084	18.47056	1		100	5	ZNR	Thick patch of Senecio hami. North of vlei, South of RR
58	2.1	34.09638	18.47588	1		100	10	Behind Muizenburg H. School	Un-managed greenbelt between the school and houses
Rhus-Euclea Dune Thicket									
20	2.2	34.07984	18.46924	1		100	0	ZNR RR	Thicket near entrance
21	2.2	34.07964	18.46956	1		100	0	ZNR RR	Thicket near entrance
25	2.2	34.07932	18.46626	1		100	5	ZNR RR	Rhus patch along fenceline
26	2.2	34.07985	18.46417	1		100	10	ZNR RR	Spikey thicket in NW corner
27	2.2	34.07982	18.46443	1		100	5	ZNR RR	Rhus thicket near spikey thicket
29	2.2	34.08002	18.46596	2	moles	100	5	ZNR RR	Thicket on S of dirt road
30	2.2	34.08008	18.46785	2	moles	100	7	ZNR RR	S of dirt road - about half way along road

1	<i>Zantedeschia aethiopica</i>	42	<i>Carpobrotus edulis</i>	83	<i>Euphorbia terracina</i>
2	<i>Asparagus capensis</i>	43	<i>Phyllobolus canaliculatus</i>	84	<i>Acacia cyclops</i>
3	<i>Aloe ferox</i>	44	<i>Ruschia macowanii</i>	85	<i>Acacia saligna</i>
4	<i>Trachyandra ciliata</i>	45	<i>Tetragonia decumbens</i>	86	<i>Aspalathus hispida</i>
5	<i>Trachyandra divaricata</i>	46	<i>Tetragonia fruticosa</i>	87	<i>Medicago polymorpha</i>
6	<i>Androcymbium capense</i>	47	<i>Sarcocornia capensis</i>	88	<i>Psoralea pinnata</i>
7	<i>Carex clavata</i>	48	<i>Rhus glauca</i>	89	<i>Vicia benghalensis</i>
8	<i>Carex ecklonii</i>	49	<i>Rhus laevigata</i>	90	<i>Vicia hirsuta</i>
9	<i>Cyperus longus</i>	50	<i>Rhus lucida</i>	91	<i>Fumaria muralis</i>
10	<i>Ficinia indica</i>	51	<i>Dasispermum suffuticosum</i>	92	<i>Chironia decumbens</i>
11	<i>Isolepis marginata</i>	52	<i>Sonderina hispida</i>	93	<i>Erodium cicutarium</i>
12	<i>Mariscus thunbergii</i>	53	<i>Torillia sp.</i>	94	<i>Geranium capitatum</i>
13	<i>Scirpoides nodosus</i>	54	<i>Torillia arvensis</i>	95	<i>Geranium incanum</i>
14	<i>Albuca flaccida</i>	55	<i>Centella asiatica</i>	96	<i>Geranium molle</i>
15	<i>Albuca canadensis</i>	56	<i>Arctotheca calendula</i>	97	<i>Geranium purpureum</i>
16	<i>Chasmanthe aethiopica</i>	57	<i>Chrysanthemoides monolifera</i>	98	<i>Pelargonium capitatum</i>
17	<i>Gladiolus angustus</i>	58	<i>Conyza scabrida</i>	99	<i>Pelargonium sp</i>
18	<i>Gladiolus cunonius</i>	59	<i>Cotula filifolia</i>	100	<i>Salvia africana-lutea</i>
19	<i>Romulea hirsuta</i>	60	<i>Cotula vulgaris</i>	101	<i>Lavatera cretica</i>
20	<i>Romulea rosea</i>	61	<i>Dimorphotheca pluvialis</i>	102	<i>Lavatera arborea</i>
21	<i>Romulea tabularis</i>	62	<i>Helichrysum crispum</i>	103	<i>Cissampelos capensis</i>
22	<i>Juncus capensis</i>	63	<i>Helichrysum dasyanthum</i>	104	<i>Pharnaceum lineare</i>
23	<i>Juncus regianus</i>	64	<i>Helichrysum niveum</i>	105	<i>Myoporum tenuifolium subsp. montanum</i>
24	<i>Juncus kraussii</i>	65	<i>Helichrysum patulum</i>	106	<i>Morella cordifolia</i>
25	<i>Triglochin bulbosa</i>	66	<i>Hypochaeris radicata</i>	107	<i>Olea exasperata</i>
26	<i>Avena sativa</i>	67	<i>Metalasia muricata</i>	108	<i>Oxalis caprina</i>
27	<i>Briza maxima</i>	68	<i>Othonna coronopifolia</i>	109	<i>Oxalis pes-caprae</i>
28	<i>Bromus diandrus</i>	69	<i>Picris echioides</i>	110	<i>Oxalis toralis</i>
29	<i>Cortaderia selloana</i>	70	<i>Plecostachys serpyllifolia</i>	111	<i>Oxalis sp</i>
30	<i>Cynodon dactylon</i>	71	<i>Senecio burchellii</i>	112	<i>Plantago lanceolata</i>
31	<i>Ehrharta villosa</i>	72	<i>Senecio elegans</i>	113	<i>Nylandtia spinosa</i>
32	<i>Lagurus ovatus</i>	73	<i>Senecio halimifolius</i>	114	<i>Osyris compressa</i>
33	<i>Lolium multiflorum</i>	74	<i>Senecio littoreus</i>	115	<i>Thesium frisea</i>
34	<i>Merxmüllera sp.</i>	75	<i>Senecio maritimus</i>	116	<i>Sideroxylon inerme</i>
35	<i>Pennisetum clandestinum</i>	76	<i>Senecio terracina</i>	117	<i>Lycium afrum</i>
36	<i>Phragmites australis</i>	77	<i>Vellereophyton dealbatum</i>	118	<i>Lycium ferocissimum</i>
37	<i>Stenotaphrum secundatum</i>	78	<i>Echium plantagineum</i>	119	<i>Solanum americanum</i>
38	<i>Ischyrolepsis eleocharis</i>	79	<i>Raphanus raphanistrum</i>	120	<i>Passerina rigida</i>
39	<i>Wildenowia glomerata</i>	80	<i>Raphanus sativas</i>	121	<i>Passerina vulgaris</i>
40	<i>Cassytha ciliolata</i>	81	<i>Euclea racemosa</i>	122	<i>Typha capensis</i>
41	<i>Carpobrotus acinaciformis</i>	82	<i>Euphorbia helioscopia</i>	123	<i>Viscum capense</i>
				124	<i>Tribulis terrestris</i>