University of Cape Town

Understanding urban ecology: exploring the ecological integrity of small scale greening interventions in the City of Cape Town

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Abstract

Urban green areas have shown to be regions of remarkable social and ecological importance (Pickett et al. 2008); from providing valuable ecosystem services, to being embedded in the identity of the local communities that use them (Ernstson 2010). There is a growing academic interest in urban ecology. The literature is replete with numerous floristic and faunal as well as social-ecological studies in urban ecosystems worldwide. An understanding of the role that interactions between ecological and social systems play in determining the ecological integrity of urban environments is required. More specifically, there is a need to focus on how human intervention and management activities can change key ecological processes so as to affect not just the local environment, but also landscape ecological processes, and alongside this, change how the city (through social processes) views itself as a social-ecological system. Few such studies have been done in cities in Africa.

This research explores the ecological integrity of three small-scale interventions in urban greening in a single catchment in the City of Cape Town, within the Cape Flats Sand Fynbos ecotype. The chosen intervention sites were namely: Tokai Park, Princess Vlei and Bottom Road Sanctuary. The study aimed to bridge a gap in the current research by contributing to an understanding of the ecological *value* of social management and intervention. This was done by providing biophysical measurements of key attributes to develop an increased understanding of the ecological integrity of these intervention sites. An ecological continuum exists within the City ranging from relatively degraded sites, to those that have a high conservation status. In order to assess where the chosen intervention sites fell within this continuum, the study required a known continuum in order to have a standard to which these intervention sites could be compared. Firstly, appropriate reference sites which together with the intervention sites represented an ecological continuum, were identified, in order to assess the relative ecological integrity of the three chosen intervention sites. Secondly, field data collections allowed for an indication of the vegetation composition, the soil quality and pollinator numbers at the six chosen sites. Lastly, semi-structured interviews with site management provided information on the management ideas and actions that have been implemented at the various sites. This study goes on to discuss

the biophysical measurements in light of these more descriptive social data, so as to bring some idea as to how different management interventions might be shaping ecological outcomes. The research is carried out against the background of debates in the literature around socio-ecological theory, the notion of ecosystem integrity, and the challenges of choosing indicators to measure ecological integrity in an urban context.

Data analysis highlighted that the social intervention sites investigated in this study are on some form of trajectory towards the ecological potential of more formally conserved reserve environments, reinforcing their conservation potential and placing these previously degraded sites in the same domain or 'playing field' as small urban conservation areas. The need for greater connectivity between these sites was reinforced as each had its own unique vegetation composition. All intervention sites had relatively high plant functional diversity, implying good ecological functionality. Species-specific management regarding alien invasive plant species and Red Data List species signify an additional upside to social intervention, where alien invasive species such as *Acacias* are controlled while endangered species and those extinct in the wild are planted into areas where they otherwise might never have been found growing again. Clear soil improvements were observed with particular regard to organic content, suggesting that through the planting of indigenous fynbos species, social intervention had indeed increased the integrity of these soils. While the pollinator studies did not present a clear picture, owing to possible sampling issues, the overall trend in the data suggests that social intervention benefits pollinators in the City by increasing pollinator numbers at these sites, creating refuge areas, nesting grounds and increasing connectivity for pollinators across the city. This may have beneficial implications for urban and peri-urban agriculture in Cape Town. The valuable social dimension of the more civic-led interventions is reinforced, where ecology becomes something everyone can enjoy and relate to as opposed to something that is exclusively reserved for the educated or the privileged. This study concluded that social interventions can indeed significantly increase the ecosystem functionality and integrity of urban green spaces. This dual-benefit, being important both socially and ecologically, speaks to the sustainability of urban ecosystems in this regard, making these spaces an important complement to how urban nature is currently managed in the City of Cape Town.

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List of Abbreviations

ANOVA	Analysis of variance
CFR	Cape Floristic Region
CFWF	Cape Flats Wetland Forum
CoCT	City of Cape Town
IUCN	International Union for the Conservation of Nature
MANOVA	Multivariate analysis of variance
POSA	Plants of Southern Africa database
SANBI	South African National Biodiversity Institute
TMNP	Table Mountain National Park
WESSA	Wildlife and Environmental Society of South Africa

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Chapter 1: Introduction

Nature's provision of vital ecosystem services and resources enables humankind's very survival on this earth; binding humans and nature infinitely together (Odum 1989) into what has been referred to as 'social-ecological' systems (Berkes and Folke 1998). This perspective is emphasised by Beck (1992, pg. 81) who aptly stated that, "[a]t the end of the twentieth century, nature is society and society is also nature". Urban green areas have been shown to be regions of remarkable social and ecological importance (Pickett et al. 2008). In this thesis they form a dynamic and fascinating interface between society and nature and can be defined as vegetated land within or adjoining an urban area which are, "directly used for active or passive recreation, or indirectly used by virtue of their positive influence on the urban environment" (EU-URGE 2004).

Urban green spaces should rightfully be viewed as the epitome of processes that entangle society and nature, and with urbanisation being an increasing and global trend (UN 2007), urban ecology becomes a study of how humans, with their organisations, institutions, management and collective action, participate in shaping biophysical processes and ecological relations. Furthermore, since urbanisation is linked to the degradation of natural resources and ecosystem services, both within and outside urban areas (Folke et al. 1997), understanding the role of humans as a part of urban ecosystems, can generate knowledge of how the management and restoration of ecological processes and biological diversity can best be undertaken (Ernstson et al. 2010).

1.1.1 Social-ecological systems

Urban ecological systems have been characterised as having some of the most interestingly varied ecological conditions on the planet, whilst being notably different from ecological systems in non-urban areas (Grimm et al. 2000). Urban green spaces create patchworks of dynamic and complex socio-ecological systems (Berkes and Folke

1998), formed by the amalgamation of biophysical and ecological drivers on the one hand and social and economic drivers on the other (Pickett et al. 2001).

The rate of urbanisation is steadily increasing worldwide. The UN's 2007 World Population Prospects predicted an estimated one million km^2 expansion in urban area to occur over the next 25 years, with an expected 60% of the global population to be living in cities by 2030 (UN 2007). This has resulted in the rising importance of urban green spaces to provide essential areas of interaction between society and nature (Ernstson et al 2008). Conversely, increased urbanisation has also generated a great amount of pressure to develop any urban green areas into alternative land-uses (CoCT Nature Reserves 2010).

The Millennium Ecosystem Assessment concluded that the degradation of the world's ecosystems is reflected in the worldwide decline of ecosystem services for human wellbeing (Millennium Ecosystems Assessment 2005). Although the report hardly touched on urban ecosystems, a growing number of signs have shown that urban green spaces act as providers of a large number of vital ecosystem services (Barthel 2005; Andersson et al. 2010; Niemelä et al 2011) as well as a habitat for many organisms. These services could potentially help lessen the increasing disconnection of urban populations from nature, which could undermine large-scale efforts of ecosystem protection (Miller 2005). Needless to say, there have been urgent calls for the advancement of knowledge and understanding of the role of urban green spaces in this context; in sustaining species richness, as important generators of ecosystem services (Grimm et al. 2008); as well as their role in decreasing the effects of fragmentation as a result of urban sprawl, by increasing connectivity between urban habitat patches (Noss 1993).

There is general agreement that the transformation of habitats into alternative land-uses and the additional loss of habitat due to fragmentation have adverse effects on indigenous species and biodiversity (Niemelä 1999). Habitat transformation can also affect formal urban green spaces as was shown in the uninformed 'upgrading' of an urban park in New York City which ultimately resulted in the extermination of over 25% of its indigenous species over a period of 50 years (De Candido 2004). In urban landscapes, green areas are usually small and highly interspersed by a matrix of built environment and their connectivity is an important factor affecting species occurrence (Niemelä 1999). Connectivity of these areas can be improved by creating movement corridors or greenways through the restoration of more urban green spaces. However, as suggested by Noss (1993), these connective urban green spaces should not substitute the conservation of large, intact nature reserves within an urban landscape; as these areas are necessary for the preservation of species populations which are more sensitive and as valuable source areas from which other areas may be colonised (Halme and Niemelä 1998).

1.1.2 Theoretical context

Niemelä and co-authors propose the following definition for the field of urban ecology: "Urban ecology integrates both basic (i.e. fundamental) and applied (i.e problem oriented), natural and social science research to explore and elucidate the multiple dimensions of urban ecosystems" (Niemelä et al. 2011, pg. 9). With regards to the development of urban ecology as a field of science, one could claim that as human development continues to spread, more landscapes and their biophysical processes will in turn become human-dominated, or 'urbanized', making a theory of urban ecology a much more prevalent field of research (Niemelä 1999; Grimm et al. 2000; Grimm et al. 2008; Pickett et al. 2008; Ernstson et al. 2010;). It is thanks to this growing research that a framework for urban ecology is emerging, but incorporation of this understanding of social-ecological systems into policy, governance, and planning is still lagging behind (Niemelä 1999).

A specific ecological theory which can be applied to contribute to an understanding of urban ecology is island biogeographic theory, which tries to explain the factors (chiefly the rate of immigration and extinction) that affect the species richness of natural communities in fragmented landscapes or archipelagos (MacArthur and Wilson 1963). As would be expected from the classical island biogeography theory, Klausnitzer (1993) presented the positive relationship between species richness and the area of urban habitat patches. Correspondingly, Weigmann (1982) noted that species richness of a number of groups of arthropods was positively correlated with the size of their habitat patch. While the roots of biogeography lie in ecology and geography, the extensiveness of human induced impact on natural environments makes it essential that this theory takes into account the distributional dynamics of species as a result of anthropogenic influence (Cummings et al. 2010).

This study aims quantitatively to assess the ecological changes produced by human intervention at specific small-scale greening interventions in the City of Cape Town. This is needed in order to build an understanding of how human intervention forms part of the larger urban ecosystem through the effect of ecological connectivity, and for understanding more specifically how one can augment and complement the current management of biological diversity and urban ecosystem services in the City.

In the literature, there are several studies that have empirically engaged such social-ecological relationships, of which only a few will be mentioned here to place the present study among a broader research field that stretches from cities as a whole, to local patches, from a focus on ecological changes, to studies of management practices.

In Pickett et al. (2008) and Grimm et al. (2008), a set of studies that have measured changes in ecological processes in cities are summarised. Often using randomised patches, the focus tends to be to view the whole city as an ecosystem (in this case Baltimore and Phoenix, respectively). However, such studies may fail to appreciate the details that can be understood from smaller-scale studies epitomised by this research. Other studies have selectively approached the city and chosen smaller-scale sites based on theoretical interests. From Stockholm, Barthel et al. (2005) linked historical management practices in a large city park to its high records of biodiversity; whereas Borgström et al. (2006) did a comparative study of the management practices at several managed green areas in Stockholm (Borgström et al. 2006). Ernstson et al. (2008) used quantitative social network data to bring an understanding of the protective capacity of civil society alliances and the mediating role that civil society can play in urban development. Similar studies are found from other cities, for instance Helsinki (Yli-Pelkonen and Niemelä 2006).

According to Cilliers et al. 2009, South Africa's urban green areas can be particularly regarded as unique study areas for the amalgamation of socioeconomic and biophysical aspects in ecological studies. This is due to their dualistic development which is characterized by a predominantly Third World sector, supported by a relatively strong First World infrastructure. From a South African perspective, Lubbe et al. (2010) investigated the species diversity of urban home gardens along socioeconomic gradients in the North-West Province to understand what contribution these gardens made to urban green 'infrastructure' in terms of plant diversity. However, the publication that comes closest to the study pursued here is a study from Stockholm, Sweden by Andersson, Barthel and Ahrné (2010). Here, the ecological functions of pollination and seed-dispersal were measured (by measuring the abundance and diversity of bumblebees and birds) as a function of qualitatively assessing management practices at small-scale urban farming areas (so-called 'allotment gardens'), cemeteries and city parks. The present study focuses on the 'interaction' between humans and urban green spaces, which is sometimes termed 'management' or 'intervention', in order to assess its ecological effects. This study aims to contribute to the field of urban ecology by providing a better understanding of the ecological integrity of specific urban green spaces in the Cape Flats Sand Fynbos ecotype, in the City of Cape Town. This against a backdrop of broader socio-ecological studies in the same area, behind the management practices of these urban green spaces.

1.1.3 Ecological integrity and ecological indicators.

Conceptual models of ecosystems are difficult to develop owing to the limited understanding of complex ecological systems and the danger of overlooking key system components. Limitations in current knowledge become apparent when we try to specify the extent of the system, essential system components, the linkages among components and the appropriate scale (temporal and spatial) to observe and measure the components. Because ecosystem processes are always in flux, either because of disturbances or because of internal ecological mechanisms, it should be continually refined as new knowledge is acquired (Muñoz-Erickson et al. 2007). In relation, Rapport (2003) highlights the difficulty in assessing ecosystem health owing to the inherently complex and ever-changing nature of ecological systems. Rapport (2003) argues that the concept of ecosystem health should be treated holistically to incorporate both socio-cultural and biophysical aspects. Further complexity arises when humans are recognised as a part of these systems as opposed to an outside force that simply exerts 'external pressure.'

This study focuses on the biophysical or ecological aspects of certain social interventions made in particular green spaces in the City of Cape Town in a single vegetation type. Social and cultural assessments will not form an integrated part of the study, but rather, these will operate on Noon's (2003) notion of existing social values, as evident in the interventions and look at the ecological outcomes of these interventions. In this regard, it is essential to develop measures of ecosystem functioning, otherwise known as the concept of ecological 'integrity', closely linked to that of ecosystem health. According to Leo and Levin (1997), the notion of ecological integrity must incorporate process and recognise a human standpoint; the ability of an ecosystem to continue to deliver the services that humans expect; for managed ecosystems in particular, the ability to supply ecosystem services. Leo and Levin (1997) reinforce that, "these are imposed measures, conditional on a definition of 'use' for a system". In this way, the notion of integrity differs fundamentally from the definition of 'ecological health', which is seen as more of an evolved aspect. Instead, the notion of ecological integrity can be seen as a tool to guide management.

Ecological integrity is not an absolute monolithic concept, but a multi-dimensional, scale-dependant, complex one (Leo and Levin 1997). No universal standard exists that defines its multifaceted aspects. According to the Oxford dictionary 'integrity' is, "the state of being whole and undivided, the condition of being unified or sound in construction". As such, a system subject to external perturbations will retain its integrity if it is able to maintain all its components as well as the functional relationships between its components (Leo and Levin 1997). Similarly, ecosystems are organized hierarchically and operationally into species, communities and populations of organisms that interact not only with each other and with abiotic features of the environment, but also functionally, where components produce and consume, processing energy and materials (Limburg et al. 1986). Quantifiable definitions of integrity include those of Cairns (1977): "[t]he maintenance of the community structure and function characteristic of a particular locale or deemed satisfactory to society," and of Karr and Dudley (1981): "[t]he capability of supporting and maintaining a balanced, integrated, adaptive, community of organisms having species composition, diversity, and functional organisation comparable to that of natural habitats of the region." Ultimately integrity should be seen as something that reflects the ability of the ecological system to support services of value to humans. Notably even Karr and Dudley's definition reflects this human perspective (Leo and Levin 1997).

Rather than debating over which is the most comprehensive definition of integrity, Leo and Levin (1997), in line with 'ecological resilience' as advocated by Holling (1973; 1978) suggests that it is much more useful to,

> [c]haracterize in detail the functional and structural aspects of ecosystems to provide a conceptual framework for assessing the impact of human activity on biological systems and to identify practical consequences stemming from this framework.

Ultimately, the concept of ecosystem integrity is far from a cure-all remedy for any management issues. Its definition is reflective of the capability of ecosystems, however characterised, to provide ecological services, including intrinsic and aesthetic elements, which are valued by humans. Measures of integrity must therefore recognise the importance of maintaining processes that support these critical services (Leo and Levin 1997).

Ecological indicators are a widely used tool of measuring ecological integrity (Carignan and Villard 2002). In order to identify indicators, it is necessary to identify distinguishable structural and compositional elements of the system that reflect the state of the underlying processes in an ecosystem (Muñoz-Erickson et al. 2007). Structure and composition both influence and are influenced by process and function. Indicators should be identified and need to reflect these underlying ecological processes and be measurable in a cost and time effective manner (Muñoz-Erickson et al. 2007). The idea of ecosystem health indicators and indicators in general, is not without criticism (Lackey 2001). Notwithstanding, indicators are a useful means of understanding ecosystems through consolidating a vast quantity of information whenever the key information of a system is too complex to be handled without some form of aggregation (Müller et al. 2000). Muñoz-Erickson et al. (2007, pg. 4) suggest that,

> [e]cosystem health indicators are particularly applicable for monitoring managed ecosystems such as collaboratively governed ecosystems in which the environment is highly influenced by human activity and thus conditions need to be assessed with respect to both ecological integrity and societal goals.

The use of indicators also allows a comparison to be made between different stages of a collaborative conservation process (Muñoz-Erickson et al. 2007) such as the intervention sites investigated in this study. The empirical measurement of certain indicators is used to compare sites and answer questions of ecological integrity, i.e. relating to patterns and processes in these ecosystems of value to society. Indicators have been extensively used to assess ecosystem health in both protected and managed ecosystems as shown by the extensive collection of case studies presented by Rapport et al. (2003).

According to Rapport et al. 1998, assessments of ecosystem integrity should encompass indicators that reflect properties of resilience, organisation, and vigour. Vigour is measured in terms of the metabolism or primary productivity of the existing organic base; organisation is assessed by examining the diversity and number of interactions between system components; resilience is measured in terms of a system's capacity to maintain structure and function in the presence of stress (Muñoz-Erickson 2007). Ecosystem resilience can be explained using the concepts of functional redundancy and functional insurance, which are strongly linked terms, and have been at the core of the ecosystem functioning debate. The concept of functional redundancy can be understood through the idea that the larger the number of functionally similar species in a fragment, the greater the likelihood that at least some of these species will survive changes in the environment and uphold the properties of the ecosystem (Chapin et al. 1996). Functional insurance, suggests that the greater the variation in responses among plants in a community, the lower the species richness required to buffer an ecosystem. Although most of an ecosystem's resource dynamics depend on the presence of a few dominant species, the presence of minor species within each functional group, performing similar roles in terms of resource dynamics, but which respond differently to disturbance factors (e.g. climate change, fire, pollution or pathogens) might have important repercussions for the stability of the ecosystem as a whole (Walker et al. 1999; Elmqvist et al. 2003).

Assessment of these properties in large-scale systems through specific indicators of resilience, organisation and vigour has been attempted for many marine ecosystems (Rapport 1989), freshwater ecosystems (Wichert and Rapport 1998), forested ecosystems (Yazvenko and Rapport 1997), arctic ecosystems (Rapport et al. 1997) and arid grasslands (Whitford et al. 1996). Relatively well-developed ecological indicators exist for many of these systems, however, as of yet, no similar template exists for urban fragments.

There is a large spectrum of ecological indicators that could be drawn upon to assess the ecological integrity of urban fragments; however, a necessity for this research in particular was to select a small subset of these indicators to effectively explore the particular sites under question. The reasoning behind chosen biotic and abiotic indicators is discussed in more detail in Chapter 4.

1.1.4 Empirical context: Urban ecology in the City of Cape Town

Cape Town is an extraordinary city. Situated in one of the world's biodiversity hot spots, the Cape Floristic Region (CFR), it is a diverse and sophisticated urban centre of great biodiversity and conservation significance. The CFR was declared a National World Heritage Site of "universal significance to humanity" and is the richest of the world's six floral kingdoms boasting approximately 9000 plant species, many of which are endemic to South Africa (CoCT Nature Reserves 2010). Cape Town hosts approximately one third of the CFR's species with 319 threatened and 13 already extinct plant species. According to the City of Cape Town (CoCT Nature Reserves 2010, pg. 7),

> [The CFR] does not merely surround Cape Town; it is part of the City's urban fabric, with critically endangered plants found on road verges, indigenous gardens, pavements, sports fields and public open spaces.

These residual habitats are increasingly under threat as the city grows and expands. An ideal example of a critically endangered fynbos ecotype that is part of the City's urban fabric is Cape Flats Sand Fynbos.

In 2010, more than 3.5 million people lived in Cape Town, within the Cape Floristic Region (CoCT Nature Reserves 2010). Low-density, middle-class suburban sprawl and high density informal settlements, along with invasive introduced plants (otherwise known as 'aliens') and agriculture are the major factors undermining Cape Town's biodiversity (CoCT Nature Reserves 2010). Many developing countries, including South Africa, face the challenges of achieving economic development along with increased equity and equitable access to social and economic opportunities. In Cape Town, apartheid's unjust economic legacies have enabled the rich white minority to "over-consume space and water, undermining ecosystem services, while poorer citizens are forced to place their shacks in areas that cause them to erode biodiversity and local ecosystem services" (Ernstson et al. 2010). It is a real challenge to address these issues without further degrading Cape Town's spatially restricted biological diversity and the various ecosystem services it sustains.

There are currently 31 areas being managed as nature reserves within Cape Town's metro boundary. Private, provincial and national reserves in the region are important safe-houses for the protection of biodiversity. Nevertheless, civil servants in the City of Cape Town have argued that the area under conservation needs to be doubled in order for effective conservation to be achieved (CoCT Nature Reserves 2010). In Ernstson's (2011c, pg. 2) concept note on making urban nature public he states:

> It is becoming clear that a strategy that only focuses and devotes resources to the management of protected areas and nature reserves alone, is less and less likely to deliver on the multiple challenges that Cape Town is facing.

Conservation of additional areas, such as urban green spaces is therefore a main concern in the City of Cape Town's Biodiversity Network. City reports also put emphasis on retaining biodiversity in urban green spaces which, aside from their ecological value, could be a powerful driver of economic growth, tourism and social welfare (CoCT Biodiversity Report 2008).

The Cape's biodiversity is a valuable part of South Africa's heritage and also plays an important role in underpinning a healthy and sustainable urban environment. A fundamental step taken by the City was to prepare an Integrated Metropolitan Environmental Policy in 2001. Since then, the City has developed a Biodiversity Strategy which strives to identify key environmentally sensitive areas for intervention and aims to improve the linkages of important ecological systems across Cape Town (CoCT Biodiversity Report 2008). The management of Cape Town's natural capital involves a mix of top-down planning and community-based initiatives (Stanvliet et al. 2004; Ernstson et al. 2010). In order to prevent further degradation of ecologically sensitive sites by alien plant invasion, illegal dumping, and land invasions by informal settlements, the City collaborates with a range of stakeholders to foster increased civil society involvement in the conservation of biodiversity through community utilisation and management of urban green spaces (Ernstson et al. 2010). This strategy includes endeavours such as the now defunct, Cape Flats Nature project (CoCT Biodiversity Report 2008; Pitt and Boulle 2010).

The Cape Flats Nature project, developed in collaboration with the South African Biodiversity Institute (SANBI), focused on a small selection of sites in the City's biodiversity network. The initiative aimed at "developing an alternative, social nature conservation practice in impoverished urban areas" that places "people's needs and basic human rights at the centre of nature conservation" (Cape Flats Nature 2006, pg. 32). The project reinforced the importance of local ecosystems in communities by engaging with local organisations and schools, educating them about ecosystem services and their value to everyday life. The project nurtured the development of local leadership through the formation of local "champion forums", as well as working with the City to develop a 'people- centred' orientation for municipal nature conservation officers (Ernstson et. al 2010). It recognised the important contribution that civil society, such as voluntary informal actor groups, can make. These are often local people that are motivated to maintain their local neighbourhood environments owing to aesthetic, ethical or cultural connections to the land (CoCT Nature Reserves 2010). Cape

Flats Nature has been terminated as a project owing to financial constraints within SANBI. Its termination is an unfortunate loss owing to the solid practice of community development orientated urban nature conservation that it had catalysed in Cape Town.

Other locally driven and pioneering programmes such as the Cape Flats Wetland Forum (CFWF), which targets community conservation on the Cape Flats (Ernstson 2011a), are making encouraging developments on the ground. The Forum is a young and locally based organisation from Grassy Park, Cape Flats that carries out ecological restoration projects and steers and supports public green space projects to ensure social development. Projects such as the restoration of Bottom Road Sanctuary and Princess Vlei have catalysed collaborative ties with the City, various civic-organisations and academic institutes. Having learnt how to develop and carry out community-based restoration projects, the Forum has recently also offered its skills to the market whereby any earnings can help to cultivate the community-based projects, providing jobs for the Cape Flats communities it wants to support (ibid).

Through these civic-led interventions come a number of important social dimensions. They allow for greater associations and relationships between communities and their green spaces. Ecology becomes something everyone can enjoy and relate to as opposed to something that is exclusively reserved for the educated or the privileged. This aids in ensuring the sustainability of these urban green spaces in the City of Cape Town, by making urban nature a truly public affair, embedding ecosystems as part of the identity of residential areas and communities.

A number of greening 'interventions' within the City represent interesting interfaces between nature and society. Although one should recognise that these sites, regardless of their ecological function and level of biodiversity, act as valuable areas for cultural, aesthetic, recreational and human health, a further investigation is needed to establish how such greening interventions could be changing important ecological characteristics. In fact, no such systematic study seems to have been performed in Cape Town, and relatively few exist internationally (Andersson et al. 2010). The value of studies that link greening intervention, ecological changes and societal values are several, but one needs to be able to bring information to policy makers and practitioners as to what effects certain interventions are having on ecological characteristics. Are some interventions more effective than others in reaching certain biological aims? A further value could lie in generally increasing the societal support of such interventions, demonstrating that there are in fact also ecological changes being produced in those areas. However to be able to do such research, "a connection must be made," following Noon (2003, pg. 38), "between measuring biophysical attributes and what society values," which in turn, "requires a conceptual framework that identifies the relations between societal values and ecological integrity". As earlier mentioned, a link needs to be made between ecological integrity and the management of these urban ecosystems. It is therefore necessary to have social-ecological assessments of these areas to further understand how rehabilitation projects in Cape Town's marginalised and often neglected green spaces can empower and benefit people, fauna and flora. This study uses the concept of ecological integrity to build such a framework for analysis.

1.2 Objectives

The aim of this investigation was to understand whether small-scale social greening interventions materially improve the ecological integrity of urban green spaces. This was done by providing biophysical (biotic and abiotic) measurements of key attributes to develop an increased understanding of the ecological integrity of these intervention sites as well as qualitative information to form a contextual basis behind the management practices that each area receives. In this study, three intervention sites were selected for investigation. In order to assess the relative ecological integrity of these intervention sites, the study aimed to:

- Identify appropriate sites that function as representatives of an ecological continuum;
- Generate relevant biotic and abiotic data to achieve an ecological understanding or 'profile' for each site;
- Discuss empirical results in relation to the degree of interaction and management at each site in order to broadly assess the contributions of social intervention to the ecological integrity of the intervention sites.

Chapter 2: Methods

2.1 Methodology

An ecological continuum of Cape Flats Sand Fynbos exists within the City that ranges from badly degraded sites that may offer only very basic ecosystem services, through to pristine areas that according to City reports have a high conservation status (CoCT Nature Reserves 2010). The three urban green spaces chosen for this study will for the purpose of clarity be termed, 'intervention sites.' This term has been chosen as these three sites have all experienced some level of ecological 'intervention' by various groups and under different circumstances. The contextual basis of these various interventions will be clarified in Section 2.2.2. The question that arises is *where* the three social intervention sites fall within this ecological continuum. In other words, how do these intervention sites compare ecologically to sites which range from relatively degraded vacant lots, to those of considerable conservation potential. In order to assess the ecological integrity of the intervention sites, the study required a known continuum in order to have a standard to which these intervention sites could be compared. Subsequently, three other sites, which for the purpose of clarity will be termed 'reference' sites, were identified within the Cape Flats Sand Fynbos ecotype and investigated together with the intervention sites. The selection of these reference sites was aided by conservation experts in the field and was ultimately chosen on a subjective basis in that their ecological integrity was intuitively 'known' e.g. the vacant lot was suggested owing to it being 'degraded' (very sparsely vegetated with sandy exposed soils), whereas Kenilworth Racecourse was suggested owing to it being one of the ecologically best remaining remnants of this ecotype, with the highest known concentration of threatened species per unit area.

In order to assess the actual ecological contribution of social intervention to the intervention sites, *whereabouts* these sites are placed within this continuum was assessed using appropriate statistical analysis of biotic and abiotic indicators. These chosen measures or indicators needed to be applicable to site contexts across the ecological continuum that exists in the City of Cape Town, i.e. to incorporate sites that are relatively pristine across to those that are relatively degraded. Biotic and abiotic measures included simple static measures, as well as those that might be used to infer process as a measure of sustainability. To understand the natural processes and structure of these sites, the scales at which these patterns occur needed to be defined as they affected the local processes of population interaction and dispersal (Murrel et al. 2001). Consequently the size of each intervention site was also determined.

A pilot study was conducted in order to assess the suitability and effectiveness of the proposed methods in the field. The pilot study enabled a better understanding of the amount of time required to conduct each specific area of research. Specific details relating to appropriate measures were revisited in relation to the areas in question once all site visits occurred and the pilot study had been conducted.

In order to form a contextual background for each site, it was necessary to understand what particular practices were put into place in order to 'green' each area. Interviews with key informants were conducted so as to understand the level of intervention and current management practices within the intervention sites; as it was assumed that some correlations would exist between the ecological integrity of the sites and the level of management and intervention that they receive. While not central to the ecological focus of this research, gaining some understanding of the nature of these relationships will contribute to the broader body of on-going research around Cape Town's urban green spaces.

2.2 Site Descriptions

2.2.1 Cape Flats Sand Fynbos

An important linkage for this study, between the various intervention and reference sites, is that they are all in the Cape Flats Lowlands; an area that has the highest concentration of threatened plants per area of remaining vegetation in the world. All sites fall within the Cape Flats Sand fynbos ecotype (Mucina and Rutherford 2006).

Cape Flats Sand Fynbos used to be the most prevalent vegetation type in Cape Town. Today it is listed as critically endangered and is regarded as one of the rarest vegetation types in the world (Rebelo 2010). It has no significant grazing or agricultural potential; however, the soils underlying this fynbos type are easily drained and therefore suitable for housing. Initially it was avoided by the early settlers as its sandy characteristics made ox-wagon travel difficult. This is evident by the fact that the old main roads to Somerset West and Paarl can be seen to 'skirt' the edge of this vegetation type. Following the Second World War however, rapid urbanisation transformed most of the originally occurring Cape Flats Sand Fynbos, presently leaving 14 % of this ecotype in remnant patches, with only 5% deemed to be in a conservation worthy condition (CoCT 2010) (see plate 1).

Cape Flats Sand Fynbos consists of dense, moderately tall, ericoid shrubland containing scattered emergent tall shrubs. Proteoid and Restioid species are prevalent, with more Asteraceous and Ericaceous species occurring in drier and wetter areas, respectively. Approximately 108 threatened and near threatened Red List plant species occur on the remnants of this ecotype within Cape Town. The endemics include six species listed as extinct in the wild, some of which are being reintroduced from botanical gardens (Mucina and Rutherford 2006).

Most remaining patches are small pockets surrounded by urban settlement, including: Rondevlei Nature Reserve, Kenilworth Racecourse, Milnerton Racecourse, Plattekloof, and Rondebosch Common. Most of these patches have been identified as 'Core Flora Conservation Sites' (CoCT 2010). Only 1% is statutorily conserved as small patches at

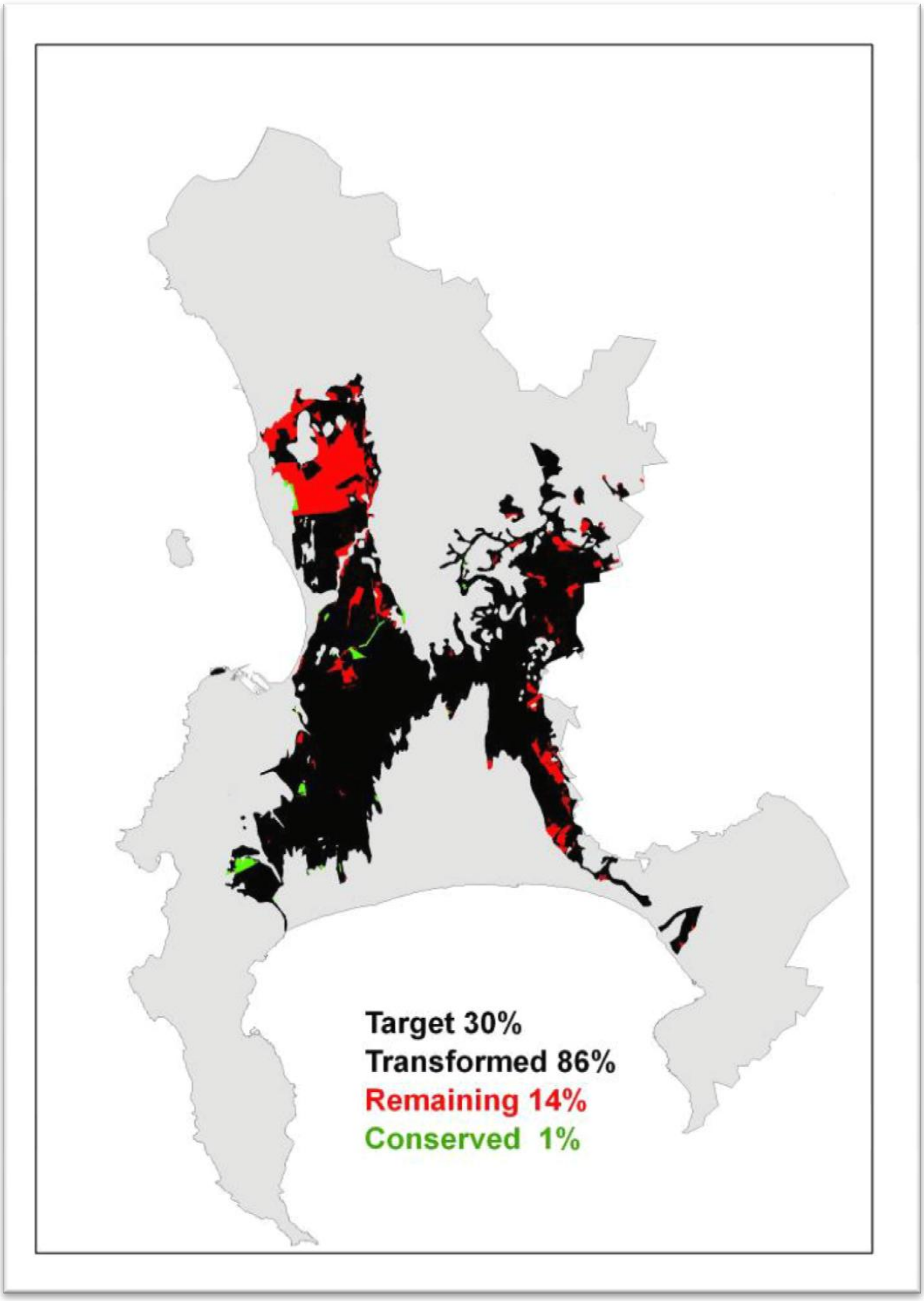


Plate 1 Image representing the remaining, conserved and transformed regions of Cape Flats Sand Fynbos in the City of Cape Town. ('Target' refers to the national conservation target of 30%. Of this ecotype, 86% has been transformed, 14% remains, including 1%, which is statutorily conserved) (CoCT 2010).

Tokai Park as well as at Rondebosch Common (although badly degraded), Bracken Nature Reserve and Blaauwberg Conservation Area. Some good remnant patches that are not formally proclaimed are found at Milnerton Race Course, Kenilworth Race Course, Sixth South African Infantry Ordinance Depot and Plattekloof (CoCT 2010).

All intervention sites and reference sites were selected based on the overarching question of this thesis, which is an examination of the ecological value of social interventions in urban greening within the Cape Flats Sand Fynbos ecotype in the City of Cape Town. The selection of these sites was subjective, based on an *a priori* understanding of the vegetation types of the area, largely formed through the work of Mucina and Rutherford (2006) and with input from botanical experts and those in the conservation field. Intervention sites and reference sites chosen for this study can be seen in Plate 2 and are listed and briefly described below.

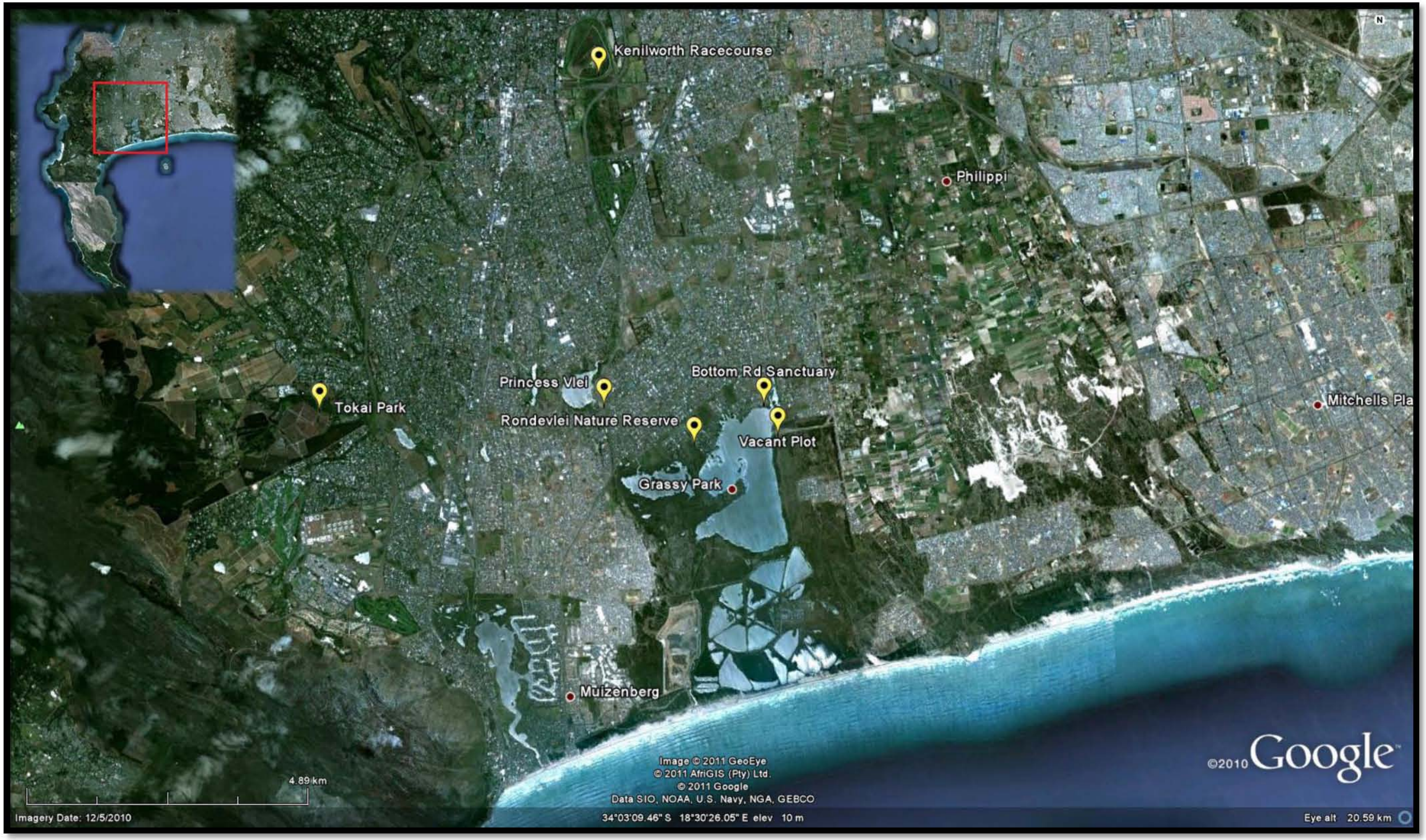


Plate 2 Location of intervention sites and reference sites within the City of Cape Town. *(Source: Google Earth 2010)*

2.2.2 Intervention Sites

Below follows a description of the intervention sites chosen for this study. The description has been made through early field visits and personal communication with people that have been involved in the management of the sites. For Bottom Road and Princess Vlei, further information has been based on published work on these sites (Ernstson 2011a, Ernstson 2011b, and Ernstson 2011c).

Intervention site 1: Bottom Road Sanctuary, Zeekoevlei, Grassy Park

Location:	**Northern shore of Zeekoevlei: (34° 3'2.91"S 18°30'59.45"E)**
Size of site:	0.08ha
Project start:	2005
Current status:	False Bay Nature Reserve: Maintenance
Intervention:	Refuse and alien removal, machine landscaping and planting of approximately 50 000 plants in total from 40 different species of Cape Flats Sand Fynbos.
Partners:	Cape Flats Wetlands Forum, Rondevlei Nature Reserve, Working for Wetlands, 'Friends' group and 12 local resident households.

Bottom Road Sanctuary borders the northern bank of Zeekoevlei and was originally an area were Cape Flats Sand Fynbos thrived. After many years of dumping, urbanisation and poor land management, the area became increasingly degraded. The project commenced in 2005 when a local resident, Kelvin Cochrane, bought land in the area. Stewarded by Cochrane, a collaborative model was created in which 12 residents decided to do away with their adjoining property walls allowing a larger combined area for ecological intervention. Furthermore, close collaboration with reserve managers at nearby Rondevlei Nature Reserve allowed for a White-paper agreement to be signed in which the City and the residents sponsored 5 meters of their shore-adjoining land, allowing the restoration project to access the ecologically important shoreline of Zeekoevlei. Since then, residents, nature conservation officials, the national Working for

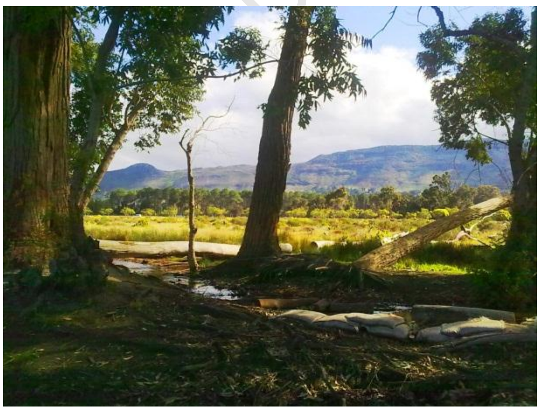
Wetlands programme and the Table Mountain Fund joined forces to create a thriving conservation sanctuary out of Bottom Road's resident 'gardens'. Through this union, tons of rubble and waste and alien vegetation was removed and replaced with numerous species of indigenous fynbos plants in their thousands, including critically endangered Serruria species and *Erica verticillata*. A storm water channel was modified to serve as an important wetland habitat for a variety of organisms. Constructed bomas, walkways and barbeque areas were also considered an important addition, so as to allow people to enjoy, interact with and appreciate this beautiful space (Ernstson 2011a; Ernstson 2011b; and Cochrane, personal communication, January 2011.)

Intervention site 2: Princess Vlei, Grassy Park

Location:	**Southeastern corner of Princess Vlei, bordering Sasmeer Rd (34°3'3.63"S 18°29'13.90"E).**
Size of site:	0.1 ha
Project start:	2008
Current status:	City of Cape Town: On-going project
Intervention:	Planting of 5000 fynbos plants including *Restios, Ericas* and *Serruria* species, Strandveld species, and some 200 trees.
Partners:	"The Dressing of the Princess" project includes: Cape Flats Wetland Forum, Department of City Parks (City of Cape Town), and the South African National Biodiversity Institute (SANBI). Extended supporters include 5 local schools on an 'adopted-a-plot' basis, local social development organisation LOGRA, the Greater Cape Town Civic Alliance, WESSA and others.

After having gained experience at Bottom Road and other fundamental projects, Kelvin Cochrane and the Cape Flats Wetland Forum aimed for a larger-scale rehabilitation project at Princess Vlei (Ernstson 2011a). This wetland and public open green space is an important but degraded wetland due to decades of neglect and mismanagement during the apartheid era until recent times. Princess Vlei has recently also been an area under consideration for a controversial large scale retail development. Not only is this site part of the Cape Flats Sand Fynbos ecotype, Princess Vlei is an area of intense meaning and cultural significance and has served as a place where local people, especially 'Coloured' communities, have for years conducted baptisms and other religious ceremonies, fished, played sport and had family gatherings. This site is also a historically relevant location with regards to the Khoi people, who used to water their herds here in pre-colonial times (Ernstson 2011a). In an attempt to rehabilitate not only the natural vegetation of the area, but also its public open space value, a memorandum of understanding (MOU) was signed between the Cape Flats Wetland Forum, City Parks, and SANBI in 2008. The project was evocatively named "The Dressing of the Princess," as a tribute to the Khoi princess, who according to legend was raped and killed by Europeans sailors in the area 500 years ago and whose tears are said to have filled the Vlei. The Cape Flats Wetland Forum, together with Working for Wetlands have been integral in the rehabilitation project. This partnership has allowed the Dressing of the Princess project to access state funds and low-paid workers to assist in the labour intensive removal of alien plants as well as the planting of thousands of fynbos plants to 'rehabilitate' the area. Local residents, schools and citizens across Cape Town with extensive involvement from the Forum's spokesperson, Kelvin Cochrane, are petitioning the development proposal and current greening interventions within the area, aside from improving the site ecologically, can also be seen as a way of staking claim to Princess Vlei as an important natural and cultural landmark for the local community (Ernstson 2011a; Cochrane, personal communication January 2011; see also Ernstson 2011b and Ernstson 2011c).

Interventions site 3: Tokai Park, Tokai



Location:	**Bordering Soetlvlei wetland (34° 3'5.97"S 18°26'6.31"E).**
Potential size of site for restoration:	120.0 ha (Study site: 0.25 ha)
Project start:	2005
Current status:	Table Mountain National Park: On-going project
Intervention:	Felling of pine trees; alien plant removals; planting of thousands of fynbos plants including *Erica verticillata* and *Serruria foeniculace;* introduction of snakes to control rodent population..
Partners:	Table Mountain National Park (TMNP), South African National Biodiversity Institute (SANBI), Kirstenbosch Gardens. Extended supporters: Friends' group, WESSA and others.

Tokai plantation, more recently named Tokai Park, is unique in Cape Town in that not only is it the largest nature reserve for Cape Flats Sand Fynbos, but it is the only fragment of this ecotype that has a connection with ecological corridors from the mountain down to the flats (personal communication Carly Cowell, TMNP 2011). Furthermore, according to Rebelo (2010) Tokai is unique in the world as one of the last remaining places on earth where many species of threatened plants may be conserved in a 'fully functioning and viable long-standing ecosystem'. Rebelo emphasises Tokai's importance:

> With as many plant species as the entire Arid Savannah of Northern Province and Botswana, and more IUCN Red List plant species than the provinces of Gauteng, Free State and North-west Province combined, the Tokai section of the Table Mountain National Park is extraordinary.

Originally planted in 1885, with the first harvesting taking place between 1920 and 1950, Tokai plantation originated as a commercial pine operation. In 1998 a compartment of the plantation was accidentally burned resulting in the emergence of indigenous seedlings allowing the realisation that rich Fynbos seed banks were still present under the pines (Rebelo 2010). In April 2005, the Tokai and Cecilia Plantations became part of the Table Mountain National Park (TMNP). Mountains to Oceans Forestry bought and paid for Tokai's timber and have leased the land from TMNP during the harvesting process, which will occur over a period of 20 years as compartments mature. As such, TMNP has taken over the management and restoration of cleared areas as the trees are felled. Along with ecological restoration, it is hoped by the Park's management that Tokai Park can achieve greater ecotourism, recreational and heritage potential.

An intervention site near the Soetvlei wetlands was recommended by TMNP as a study site for this project. This area was originally degraded and under pine forest, but in recent years has been re-vegetated with hundreds of indigenous Cape Flats Sand Fynbos plants under the careful management of Park officials. These species include the Red Data Base species, *Erica verticillata* and *Serruria foeniculacea.*

2.2.3 Reference sites

The following three selected reference sites fall within the Cape Flats Sand Fynbos ecotype and range from relatively pristine to degraded with regards to their ecological integrity.

Reference site 1: Kenilworth Racecourse Conservation Area, Kenilworth

Location:	**Precinct 4 (34°0'2.49"S 18°29'10.47"E).**
Racecourse founded:	1882, (conservation area formally managed since 2001).
Conservation area size:	41.96 ha (Study site: 0.45 ha)
Current status:	Conservation management and maintenance. The site is privately conserved but not formally proclaimed a nature reserve.
Intervention:	No formal 'intervention' as such but the site's upkeep is managed.
Partners:	Gold Circle, Western Cape Nature Conservation Board (WCNCB), City of Cape Town, WESSA, Friends' group and others.

Kenilworth racecourse was founded as a racecourse in 1882 and is currently owned and managed by a company called, 'Gold Circle'. The conservation area in the centre of the track incorporates the largest remaining area of relatively pristine Cape Flats Sand Fynbos. The present number of Red Data species is 13, of which 12 are Cape Flats' endemics with three only occurring at Kenilworth Racecourse. McDowell and Brown (1991) stated that they are unaware of any other site in South Africa that has a comparable concentration of threatened species per unit area. It can therefore be considered the most 'pristine' remnant of Cape Flats Sand Fynbos in the City of Cape Town.

This conservation site is a very good example of how business and nature conservation can find a harmonious balance within the City precinct. Although not formally declared a nature reserve, the conditions of agreement to the racecourse's rezoning approval to a Community Facilities Use Zone, secures its conservation status. Gold Circle is required to continually ensure that the conservation management plan is implemented, financially guaranteed and resource secure. The Western Cape Nature Conservation Board agreed to take on the responsibility of managing the site for Gold Circle for an interim period of three years and is currently the managing authority of the conservation area. Another condition of the development approval ensures the continual establishment of an Environmental Advisory Committee, consisting of specialists, stakeholders and the City's Environmental Department, to ensure the effective management of the Kenilworth Racecourse conservation area.

Reference site 2: Rondevlei Nature Reserve, Grassy Park

Location:	**'Erica fields', bordering Victoria Rd (34° 3'24.55"S 18°30'13.45"E)**
Reserve proclaimed:	1986
Reserve size:	290.0 ha, (Erica fields site: 0.5 ha)
Current status:	False Bay Nature Reserve: managed and maintained
Intervention:	Originally degraded school property. Indigenous species where planted including *Erica Verticillata* and *Erica turgida*.
Partners:	Cape Nature, South African National Biodiversity Institute (SANBI). Extended supporters: Friends' group, WESSA and others.

The early 1950s saw Rondevlei declared as a wild bird sanctuary. Thereafter in 1986, the site was declared a local area nature reserve. Early management focussed solely on birding issues leaving the rest of the reserve to fall under alien invasion by Acacia species. By 1990, the reserve management focus became more holistic and expanded to encompass the full spectrum of floral and faunal biodiversity present in the reserve, including alien invasive species management (Murdoch 2006). Disturbed soil conditions, following alien plant invasion, have hampered the rehabilitation of rare and endangered plant species to some extent. Among the almost 300 plant species currently recorded at Rondevlei, 19 are listed as Red Data threatened species, including *Erica* *verticillata* (which is listed as extinct in the wild, but has been propagated and reintroduced to the site), *Leucodendron levisanus* and the endemic Rondevlei Spiderhead, *Serruria aemula ssp foeniculaceae.*

A site near Victoria Rd, commonly known as the 'Erica Fields' was recommended as an appropriate reference site owing to its Cape Flats Sand Fynbos plant community. The 5 ha site was originally designated for a school and is currently on loan to the reserve from the Western Cape Education Department but is managed and conserved as part of the Reserve.

Reference site 3: Vacant plot, Zeekoevlei Rd, Grassy Park

Location:	**Eastern shore of Zeekoevlei, Zeekoevlei Rd (34° 3'19.26"S 18°31'8.68"E)**
Reserve proclaimed:	1986
Reserve size:	290.0 ha (Study site: 0.2 ha)
Current status:	False Bay Nature Reserve: managed and maintained as a low intensity leisure area.
Intervention:	No intervention. Site considered a degraded Cape Flats Sand Fynbos remnant.
Partners:	Cape Nature

The 'vacant plot' was recommended by site manager Joshua Gericke (personal communication, October2010) as a degraded remnant of Cape Flats Sand Fynbos. The Eastern shore is thought by residents to have previously been cultivated as farmland. The site has had no greening intervention, but falls under the umbrella of the False Bay Nature Reserve and is managed as a low intensity leisure area of low conservation priority.

2.3 Data Collection

2.3.1 Abiotic Measures

Soil moisture and organic content were included, amongst others, as a measure of ecological functioning. All soil sampling and analysis were conducted according to Burt (2004). The chemical properties of the soil were unable to be investigated owing to time and resource constraints, however for the purpose of this study, moisture and organic content were thought sufficient to understand the ecological value of intervention practices on the sites.

2.3.1.1 Soil moisture

Three soil samples from each site were collected from a depth of approximately 15cm using a soil auger. These samples were taken from locations that were representative of the area. Three composite samples of each of these soil samples were weighed, dried overnight at 110°C in an oven, cooled in a desiccator and re-weighed to assess percentage soil moisture. Averages were obtained for each site.

2.3.1.2 Soil organic matter

The percentage of organic matter lost on ignition can be used to define organic soils as opposed to organic matter estimates by the Walkley-Black organic carbon method, as this method has been deemed obsolete if organic carbon is less than 8%. The desiccated samples from the soil moisture analysis were heated to 400°C overnight (16h), cooled in a desiccator and weighed before and after. The mineral content is the plant ash and soil particles that remain after organic matter removal. Mineral content percentage was calculated according to the following equation:

$$\text{Mineral content (\%)} = (RW/ODW) \times 100$$

Where: RW = Residue weight after ignition, ODW = Oven-dry soil weight

Organic matter percentage was then calculated as follows:

$$\text{Organic Content (\%)} = 100 - \text{Mineral Content (\%)}$$

2.3.2 Biotic measures

2.3.2.1 Plant cover

A total of five 3x3 meter quadrats (Hanley 1978) were used to measure percentage crown cover of each species and species richness in each of the six study sites. In each quadrat, species composition and a visual estimate of percentage cover was recorded. These quadrats were spread evenly across the sites, with the centre of each quadrat randomly selected by throwing a plastic bottle over the shoulder and setting up the quadrat around where the bottle landed. The location of quadrat placements was also selected so as to minimise variability in slope and aspect as well as for accessibility. Sampling was carried out in summer 2010/2011

Herbarium specimens were taken of plants that could not be identified in the field and these were pressed and frozen for identification. Plant identification was assisted using Manning's (2009) Fynbos guidebook as well in the field by botanical student, Robert Skelton and further by experts from the University of Cape Town's Botany Department and the University's Bolus Herbarium. Taxonomic nomenclature follows SANBI's Plants of Southern Africa database (POSA 2011). For functional diversity analysis, species were assigned to one of the following life history and growth form categories: annual and perennial herbs, annual and perennial grasses, geophytes, dwarf shrubs (only including perennials of less than 25 cm in height, and all perennial herbs), woody shrubs (only including woody shrubs of more than 25 cm in height), succulents and trees (Corelissen et al. 2003).

2.3.2.2 Pollinator diversity

In this study, the pollinators given focus were namely beetles, monkey beetles, bees, flies and wasps. A pan trapping method was employed at all six sites. Sampling was carried out in summer 2010/2011. Four traps of each colour (white, blue, orange and yellow) were left out at all sites for 24 hours on 6/12/2010 and again on the 7/2/2011, except for the Rondevlei site, where sampling was only possible on the latter date. Traps were evenly scattered around the study site in places where they were not obscured by leafy vegetation or likely to tip over. All insect specimens caught were counted and a representative specimen of each was preserved and frozen in ethanol for identification. All other trapped insects that were accounted for where subsequently released.

Insect identifications were assisted by two entomological specialists, Dr Jonathan Colville of SANBI and Dr Connal Eardley of the University of Pretoria. Time constraints did not allow for all specimens to be identified to species level; however classification to a morpho-species level was possible allowing each specimen to represent a distinct species group.

2.3.3 Qualitative Data

A total of five semi-structured interviews were conducted with key informants involved in management or intervention activities in the selected intervention sites. This research was a necessary component in contributing to an understanding of site history, site management and to form a contextual background of the present ecological integrity of each intervention site. The purpose of the interviews was to identify the greening practices that have taken place thus and to understand key management practices and social institutions that can be deemed to have important implications for ecosystem dynamics, even if the linkages between these social features and ecosystem dynamics were possibly unknown to the respondents. Written questions (see Appendix B) were used as a guideline. These questions were open-ended, with the possibility to follow up key points that were brought to light. All interviews were recorded and transcribed; the length of the interviews varied between 60 and 90 minutes. Questions were steered towards understanding the actual greening activities that take place on each site (cutting, planting, weeding etc.), the frequency of intervention and the accessibility of these urban spaces to the public.

2.3.4 Data Analysis

Data analysis aimed to develop an ecological 'profile' for each site, based on the ecological indicators selected above. This profile works by making a comparison of the ecological status between intervention sites and reference sites across the ecological continuum that the sites collectively produce. Differences and/or similarities in vegetation community structure between the three intervention sites and reference sites were described using the multivariate statistical technique of correspondence analysis. The online statistical computing software, 'R,' (http://www.r-project.org/) was used for multivariate analyses of all five quadrats sampled across each study area, and within each study site. Both plant species percentage cover and percentage cover of functional type were analysed in this way. In addition, differences for plant functional type were tested statistically using the formal hypothesis test, multivariate analysis of variance (MANOVA) (Scheiner 2001). Single-factor analysis of variance (ANOVAs) and Tukey's Honest Significant Differences post-hoc analysis were used to explore significant differences in soil moisture and soil organic content as well as pollinator numbers across the six sites. Non-parametric pollinator data were analysed using a log-linear association analysis in a three-way frequency table (sites × insect type × flower colour). This was done by fitting a generalised linear model based on the Poisson family of analysis.

Qualitative information gained from the semi-structured interviews surrounding the management and intervention practices within the intervention sites were used inductively to assess the effectiveness of current interventions in possibly increasing ecological integrity.

2.3.5 Research design and limitations

In this project field surveys of vegetation, pollinator trapping and the analysis of soil samples was conducted.

A visual or ocular estimate of plant cover in plots is widely used because it is simple, quick, requires little equipment and can cover a large area (Hanley 1978). This method is more effective than methods such as the point or line intercept methods, for finding and recording rare species or species with cover values < 3%, since these methods are not as effective at capturing species with such low cover values (Hanley 1978). However, it must be noted that visually estimating cover can be very subjective, increasing observer bias (Dethier et al. 1993). Since the researcher was the only individual observing and recording cover percentages for each site and consistently used the same criteria and technique for doing so, it was assumed that this bias would be minimised.

The time-scale of this study did not allow for any temporal comparisons and although fieldwork should have ideally been conducted in spring; due to permit issues and time constraints, data collection was only possible during the summer months. This unavoidable constraint limits the potential to look at trajectories of any measurements in the field. Relief is taken in that this study is one of the first of its kind and that it might serve as a reference point against which future research might be compared.

For data on management interventions, a larger number of interviewees for each site, and even participatory observations during management work at the sites, would have been preferable. This was however, not possible due to time constraints. However, care has been taken to not overstretch the qualitative interpretation of these informants' accounts, but a focus has been retained on their factual information and how this information can be associated with certain ecological outcomes.

Chapter 3: Results

3.1 Vegetation studies

3.1.1 Vegetation Composition

A total of 93 plant species was recorded from the six study sites (see appendix A for species list). In order to understand the relationship between these species and the various sites, correspondence analysis was conducted using the percentage cover of plant species. In this way, differences or similarities in plant species composition could be investigated allowing the researcher to understand the relationships with regards to vegetation composition across the sites. To elaborate: the closer the proximity of points or groups of points, the more similar their species composition. The analysis of these plant species by quadrat yielded the following plot, as seen in Figure 1 below. Plant species names were removed from the plot for visual clarity as they crowded the points and made it difficult to observe the relationships between sites. It is evident from the distance between points in Figure 1 that there are substantial differences between the vacant plot and the other five sites. It can also be seen that there are some overlaps and homogeneity between Princess Vlei and Bottom Road Sanctuary, as well as between one of the vacant plot's quadrats and Rondevlei, but for the most part, each site appears to have its own unique vegetation composition.

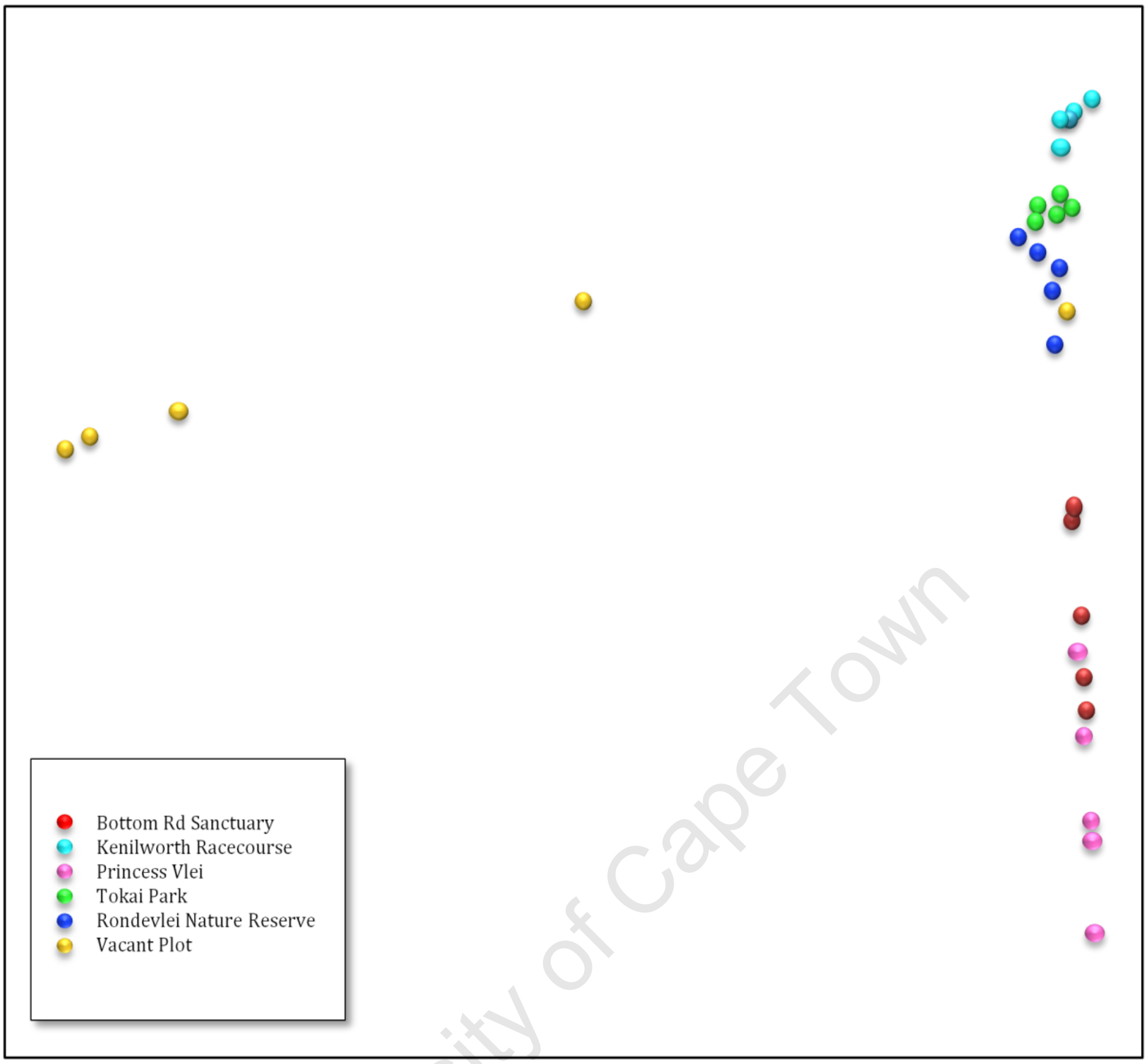


Figure 1 Two dimensional image of the correspondence analysis of the sites sampled by species composition and percentage cover, accounting for 17% of the variation in the data. Each point represents one of the five 3x3 meter quadrats sampled per site.

By removing the first (horizontal dimension) which can be attributed solely to the vacant plot's large species cover differences to the other sites, the differences among the other sites can be investigated by a plot of the 2nd, 3rd, and 4th dimensions. This can be seen in Figure 2 below which has been generated as a 3D image to visually enhance the amount of information that is represented. The clustering of specific sites in the multi-dimensional space gives confirmation that certain plant species are specifically associated with certain sites. If the coloured spheres (representing the sampled 3x3 meter quadrats) were more interspersed and mixed between sites, it could be assumed that the variety of plant species found across the six sites are more like each other and are more interconnected i.e. that the same composition of plant species grow at these sites.

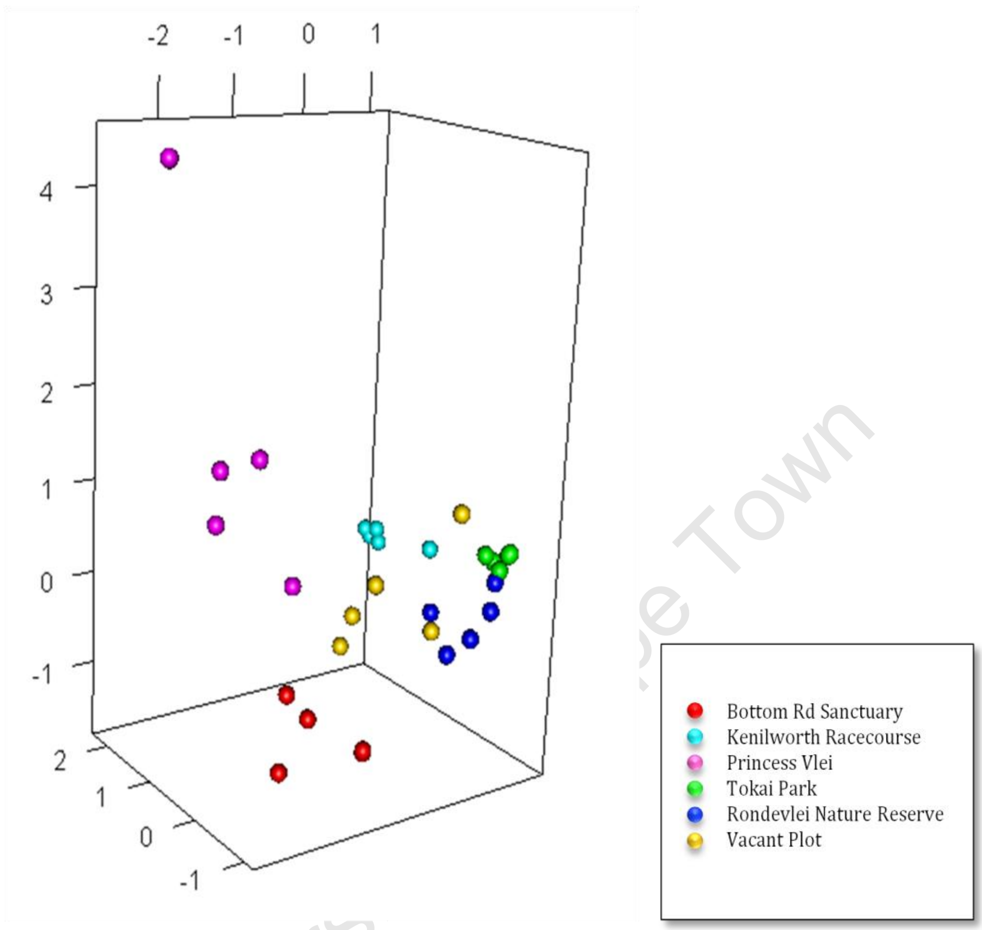


Figure 2 Three dimensional visualisation of the 2nd, 3rd and 4th dimensions of the correspondence analysis, accounting for 34% of remaining variation after removal of the 1st dimension.

Subsequent to the removal of the first dimension, along with the removal of the skewing effects of the degraded site, the clustering of the quadrats for each site in Figure 2 still clearly shows the heterogeneity in plant species composition from site to site. This image is ideally viewed on a live movable 3D interface as certain quadrats may look closer together, but when the image is moved around in space, this perception changes. Figure 2 represents the best orientation where no points are obscured by others. In both figures we see that quadrats from Tokai Park and Rondevlei Nature Reserve are particularly close together suggesting smaller differences in species composition between quadrats and more associations between certain plant species and both sites as a whole. Kenilworth Racecourse still appears to be particularly tightly clustered with no overlaps with other quadrats suggesting a unique vegetation composition. Bottom

Road Sanctuary and Princess Vlei are the only sites which occur below zero to the left of the figure further suggesting the similarities in species composition. However, differences between quadrats within Princess Vlei as well as the vacant plot are noticeable as the points for these sites are very interspersed in the plot, suggesting high species turnover between quadrats.

3.1.2 Species richness and plant functional groups

3.1.2.1 Plant functional groups

In a further step, the various species were grouped according to plant functional type. A formal hypothesis test, multivariate analysis of variance (MANOVA), based on Wilk's lambda, confirmed that the sites differ to a large extent with respect to their plant functional groups (p-value of < 0.0001). Even though the variation with regards to species percentage cover between sites was quite large, the differences between sites are so pronounced that the differences in variance would have had no large effect on the analysis (Prof. Lubbe, personal communication, March 2011). Notwithstanding, since there are differences in variance, a further step included a nonparametric permutation test. The permutation p-value calculated was also < 0.0001, confirming the results of the MANOVA: that there are highly significant differences in plant functional diversity between sites.

Figure 3 below represents the proportions of the various plant functional groups in the total plant percentage cover (± SD) for each site. Annual species are highlighted through patterned, red bars. Table 1 summarises the mean percentage cover for each site as well as the mean annual and perennial plant cover, the total number of functional types, dominant functional type and the top dominant species for each site. Taking the mean value of plant coverage at the five sampled quadrats of 3x3 meters at each sites, Tokai Park showed the highest percentage plant coverage of nearly 100%, while Princess Vlei and the vacant lot showed the lowest percentage cover of 40% and 42% respectively. On the whole, Rondevlei Nature Reserve and Kenilworth Racecourse showed the greatest variety of plant functional types (9 each). Interestingly, the more formally managed nature reserves were closely followed by Princess Vlei (7 functional types) and Bottom

Road Sanctuary (8 functional types) which were both missing annual grasses, with Princess Vlei also lacking the presence of geophytes. Tokai Park and the vacant plot both have relatively low functional diversity presumably owing to the high presence of grass cover at both of these sites. The proportion of annual species to perennial species is highest at the vacant plot where approximately 18% of plant coverage is made up of annual vegetation.

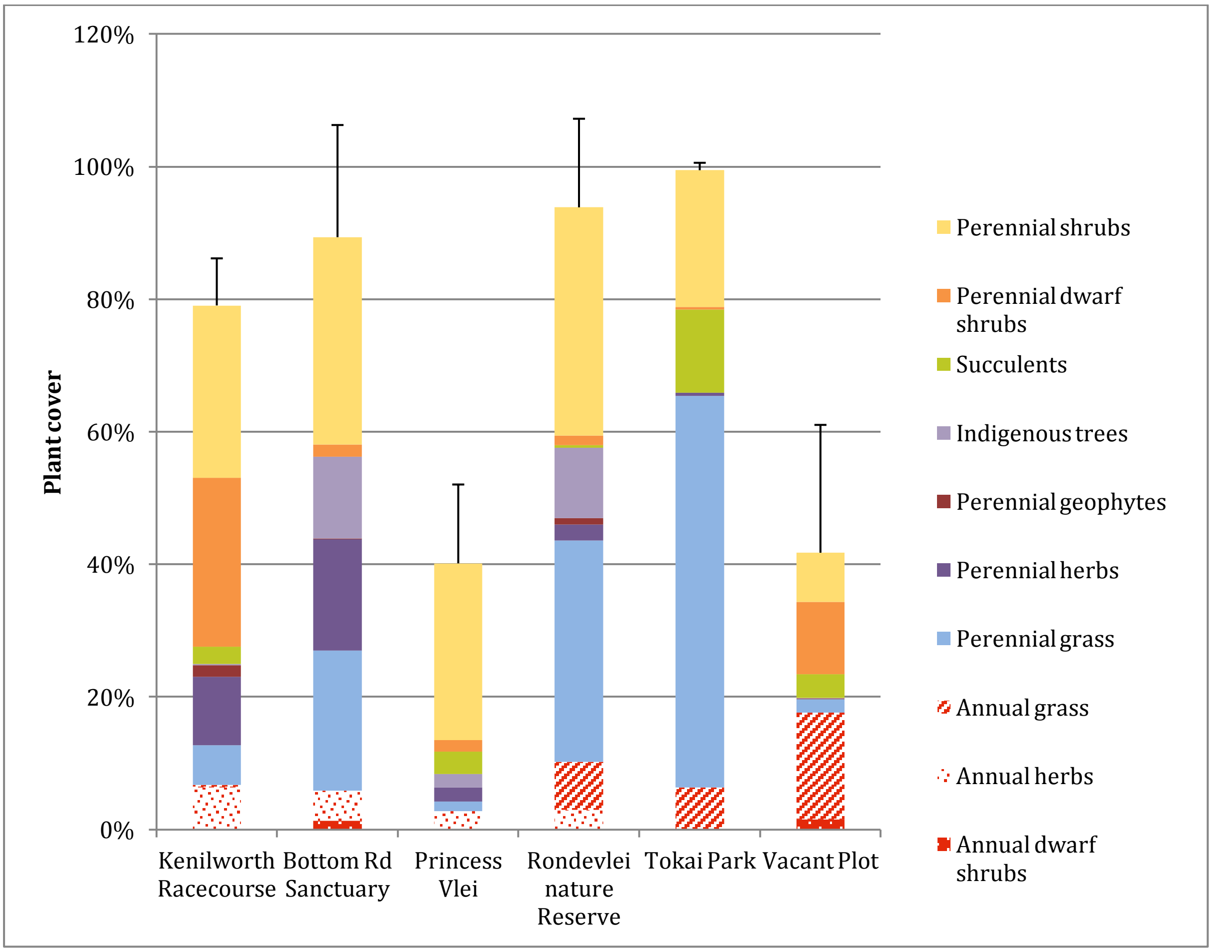


Figure 3 Bar graph representing the proportions of plant functional type within the mean (±SD) total plant coverage (%) for each site. Red patterned series highlight annual plants, while non-patterned series denote perennial plants.

3.1.2.2 Correspondence analysis

To further understand the relationship between the six sites and the ten categorised plant functional groups, a correspondence analysis was conducted and yielded the following plot (Figure 4).

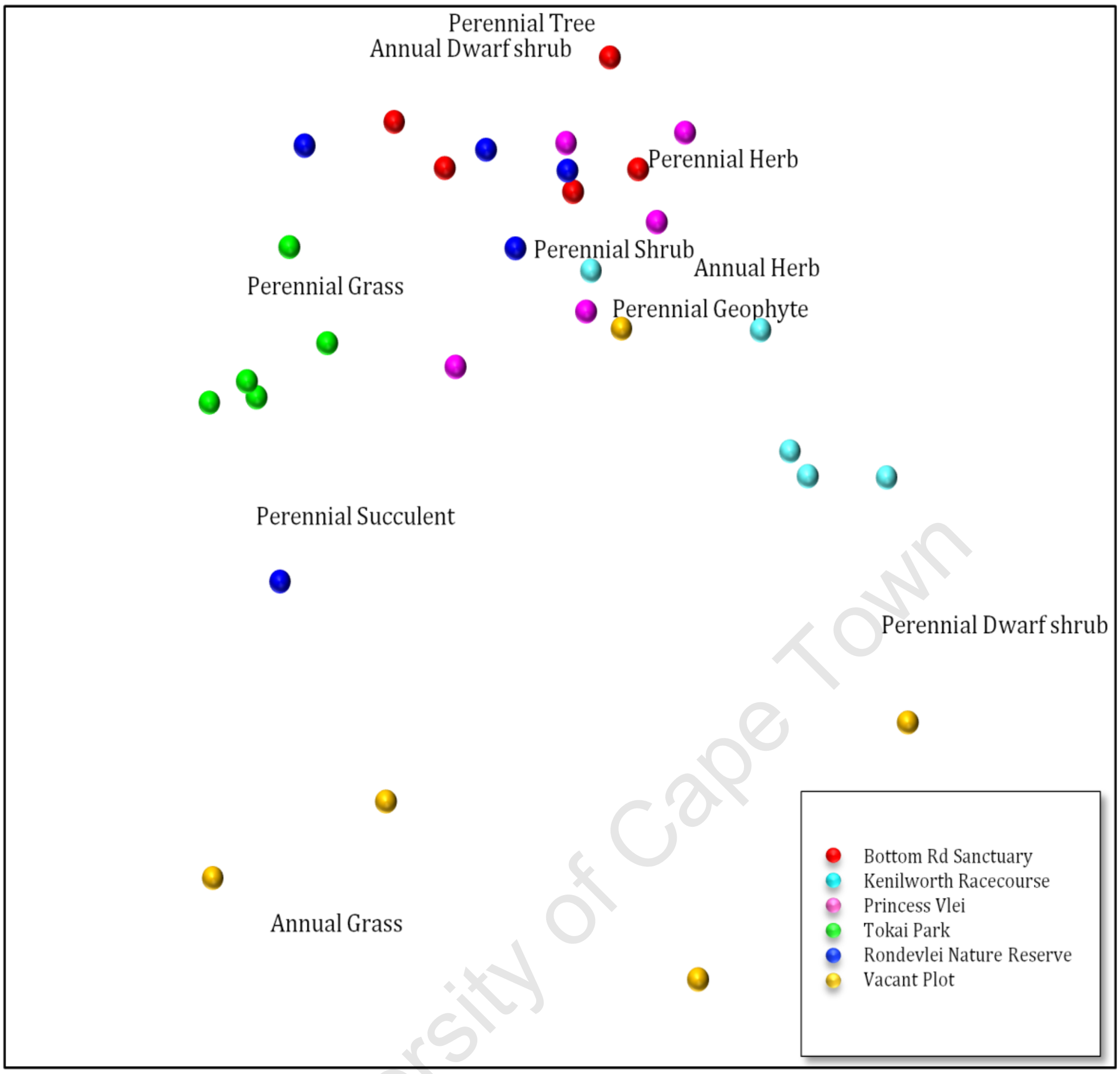


Figure 4 Correspondence analyses of the study sites sampled by plant functional types and percentage cover, accounting for 51.9 % of variation in the data.

Again, it is evident that there are marked differences between the sites. Certain plant functional types are more strongly associated with some sites than with others. Some particularly strong relationships include annual grass being predominantly associated with the vacant plot, perennial grass and succulents being strongly associated with Tokai Park and perennial dwarf shrubs being strongly associated with Kenilworth Racecourse and the vacant plot. For the most part, Bottom Road Sanctuary, Rondevlei Nature Reserve and Princess Vlei seem to overlap with regards to the plant functional types that are associated with these sites. The vacant plot is relatively spread out regarding its association with specific functional types, with the exception of annual grass and perennial dwarf shrubs, to which it is more strongly associated than others.

Table 1 The mean values (±SD) or total values of plant variables listed for each site. Results below were recorded from the five quadrats investigated at each site.

	Kenilworth Racecourse	Bottom Road Sanctuary	Princess Vlei	Rondevlei Nature Reserve	Tokai Park	Vacant Plot	N
Plant cover (%)	80±7.1	90±16.9	40±11.9	94±13.4	99±1.1	42±19.3	5
Annual plant coverage (%)	7	6	3	10	6	18	5
Perennial plant coverage (%)	73	84	37	84	93	24	5
Total number of plant functional types	9	8	7	9	6	6	5
Dominant functional type and (species number thereof)	Perennial shrubs (6), dwarf shrubs (7)	Perennial shrubs (11)	Perennial shrubs (9)	Perennial shrubs (7), perennial grass (2)	Perennial grass (2)	Annual grass (3)	5
Total species number	31	31	25	26	12	14	5
Dominant species (Mean percent coverage)	*Stoebe plumose (22%), Passerina corymbosa (11%)*	*Elegia tectorum (13.6%), Ficinia nodosa (9.8%)*	*Eriocephalus racemosus (7%), Metalasia sp. (5%), Chrysanthemoides monolifera (5%)*	*Clifortia feruginea (24%)*	*Stenotraphrum secundatum (60%)*	*Lagurus ovatus (8.1%)*	5
Red Data List species (mean % contribution to overall coverage)	*Erica margaritacea-CR (1%), Lachnaea grandiflora-VU (2.5%), Serruria glomerata-VU (1.4%)*	*Erica verticillata-EW (2%)*	*Lampranthus vernalis-NT (8.5%)*	*Erica verticillata-EW (2.3%), Leucodendron coniferum-VU (0.5%)*	*Erica verticillata-EW (2.4%), Serruria foeniculacea-CR (8%)*	*Amphithalea imbricata-R (12%)*	5
Alien invasive flora (mean %contribution to overall coverage)	*Pennisetum clandestinum(1.25%), Invasive Rumex sp. (2.2%), Briza maxima (0.5%)*	*Lagurus ovatus (1.1%), Pennisetum clandestinum (8.8%)*	*Pennisetum clandestinum (0.25%)*	*Acacia sp. (0.9%), Lagurus ovatus (0.2%, Briza maxima (7.4%), Leucadendron levisanus (0.42%)*	*Acacia sp. (1%), Briza maxima (6.5%)*	*Pennisetum clandestinum (4.7%), Lagurus ovatus (19.3%), Acacia sp. (0.24%), Briza maxima (4.8%)*	5

Notes: CR-Critically endangered; EN-Endangered; EW-Extinct in the wild; NT-Near threatened; R-Rare; VU-Vulnerable (POSA 2010).

3.1.2.3 Species richness

The relationship between species number and percentage cover is particularly interesting as a site may be relatively well vegetated but may have a low alpha diversity. In Figure 5 we see the relationship between species richness and plant cover. Overall, Bottom Road Sanctuary displayed the highest species number and percentage cover of all the six sites. Kenilworth Racecourse had the same high species number, but a slightly lower plant cover. Tokai Park has the highest plant cover overall, but was the most species poor of all the six sites. The vacant plot had the lowest species number and was one of the lowest for plant cover.

Bottom Road Sanctuary displayed the highest species number for perennial shrubs (11 species), perennial herbs along with Kenilworth Racecourse (6 species) and perennial grass along with Princess Vlei (4 species). Kenilworth Racecourse displayed the highest species number for perennial geophytes (6 species) and dwarf shrubs (7 species). A detailed list of species diversity for each functional type can be seen in Table 2 below.

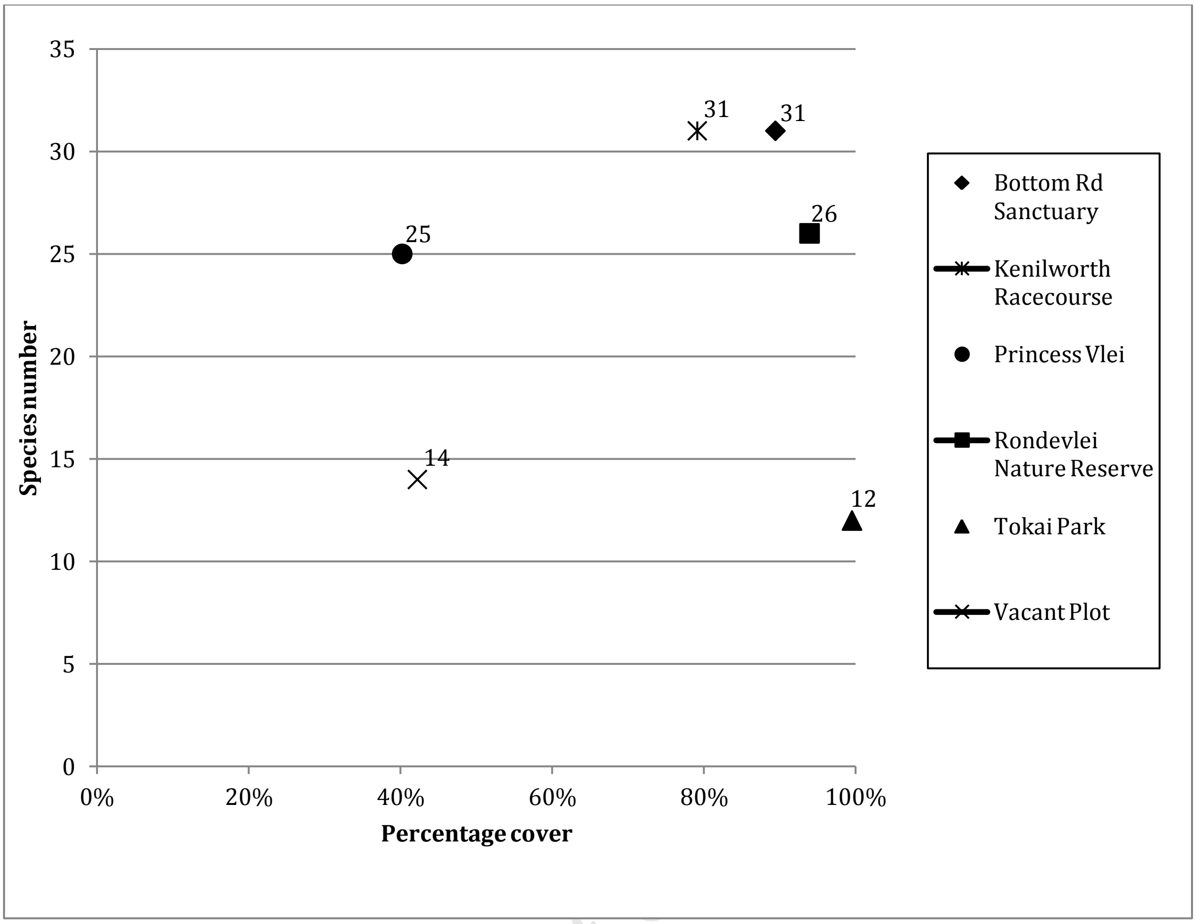


Figure 5 Scatter plot representing the relationship between total species number and mean plant cover across the six study sites (n=5). The numbers above points indicate total species number recorded per site.

Table 2 Listed plant functional types and site with highest species diversity for each.

	Site	No. of species recorded at site
Annual dwarf shrubs	Bottom Rd	1
Perennial dwarf shrubs	Kenilworth Racecourse	7
Perennial geophytes	Kenilworth Racecourse	6
Annual herbs	Princess Vlei and Kenilworth Racecourse	3
Perennial herbs	Bottom Rd and Kenilworth Racecourse	6
Perennial shrubs	Bottom Road Sanctuary	11
Succulents	All except Bottom Rd had	1
Indigenous Trees	Rondevlei	4
Annual grass	Vacant Plot	3
Perennial grass	Bottom Rd and Princess Vlei	4

3.2 Abiotic variables

All sites had soils with statistically significantly differences in organic and moisture content (see Table 3 below). Figure 6 accompanies Table 3 as a visual representation of the results.

Table 3 The mean (±SD) values of soil moisture (%) and soil organic content (%) taken from three soil samples within each study site. The significant differences ($p<0.05$) between means using Tukey's multiple range test are indicated by dissimilar superscripts in the columns for each site.

	P Value	Bottom Road Sanctuary	Kenilworth Racecourse	Princess Vlei	Rondevlei Nature Reserve	Tokai Park	Vacant Plot	N
Soil Moisture Content	4.904e-07 ***	2.55 ± 0.45^{a}	0.13 ± 0.08^{b}	0.06 ± 0.10^{b}	1.76 ± 0.52^{a}	0.21 ± 0.20^{b}	0.10 ± 0.09^{b}	3
Soil Organic content	8.57e-06 ***	0.88 ± 0.14^{ab}	0.96 ± 0.16^{ab}	1.05 ± 0.08^{b}	2.02 ± 0.41	0.83 ± 0.06^{b}	0.37 ± 0.08^{a}	3

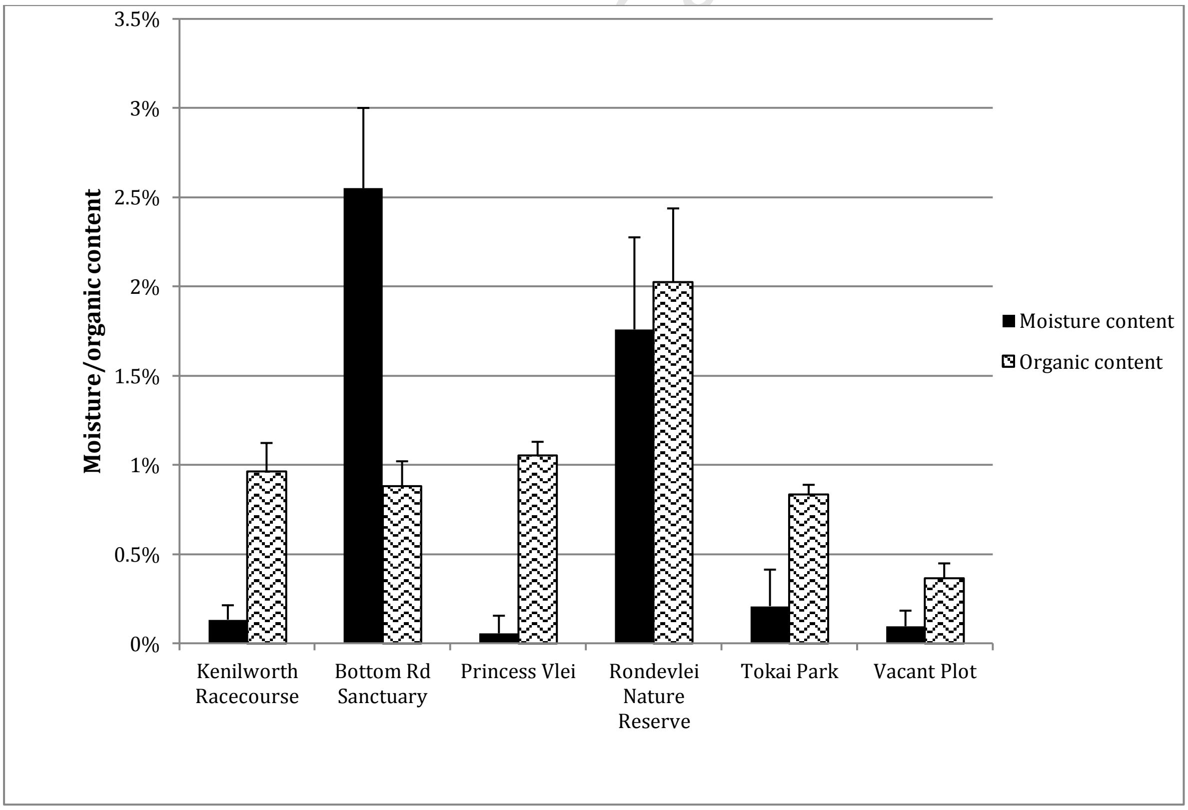


Figure 6 Bar graph representing the mean (± SD) moisture content and organic content of soil samples taken from the six study sites.

The soil of Bottom Road Sanctuary displayed the highest moisture content, followed by Rondevlei Nature Reserve, which also had the highest organic content out of the six sites (Figure 6).

In a further step, a scatter plot was generated to better understand the relationship between organic content and soil moisture between sites (Figure 7). Tokai Park, Princess Vlei and Kenilworth Racecourse clearly cluster together in the scatter plot, suggesting similar soil organic and moisture profiles for these sites. The vacant plot clearly has the poorest quality soil with regards to the variables being assessed and has the soil moisture and organic contents that are closest to zero.

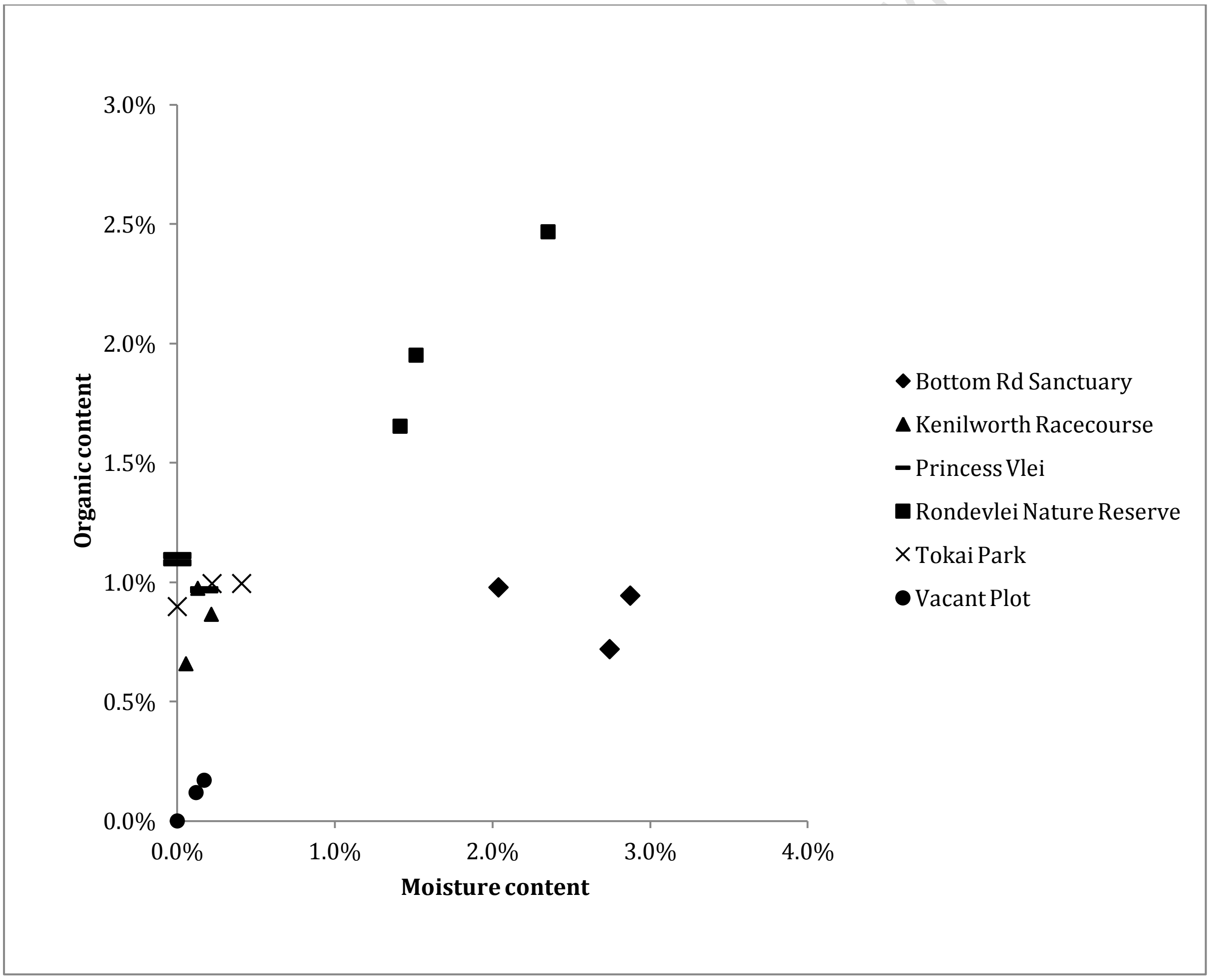


Figure 7 Scatter plot representing the relationship between soil moisture content (%) and organic content (%). Points represent single soil samples taken from each site.

Plate 3 Examples of trapped and pinned wasps and bees from various study sites

3.3 Pollinators

Overall a total of 80 insect individuals comprising of 26 different morpho-species where trapped over a period of 24 hours at the six study sites. Some examples of these pollinators are shown in Plate 3 (see Appendix A for insect taxonomy). An ANOVA revealed no statistically significant difference between the sites ($p<0.26$). However, owing to the large amount of variance in the data, it was decided that a more effective means to analyse the differences between sites would be through a log-linear association analysis in a three-way frequency table (sites × insect type × pan trap colour). This was done by fitting a generalised linear model based on the Poisson family of analysis. This formal hypothesis test showed that there were highly significant differences between study sites with regards to insect number and that site effect as well as pan trap colour played a significant role in determining how many pollinators were trapped. Table 4 compares the different models in order to explain the differences observed in the outcome variable, which is insect count. .

Table 4 Results of log-linear association analysis of insect, site and trap colour interactions with various listed models.

Model	Description	Conclusion
Insect count : site * insect type/pan trap colour	Interaction between sites and insect types with different coloured flowers for the insect types	The full model for comparison
Insect count : site + insect type/pan trap colour	Removing the interaction between sites and insect types	p-value = 0.899 No significant interaction between sites and type of insect
Insect count : site + insect type	Removing the effect of pan trap colour	p-value = 0.0009 Pan trap colour has a highly significant effect
Insect count : insect type/pan trap colour	Removing site effects	p-value < 0.0001 Highly significant differences between sites.

The majority of insect morpho-species were trapped in yellow pan traps, followed by white and then blue. It has been suggested that different coloured pan traps differentially attract pollinator species, with specialists being attracted to blue and white; and generalists being attracted to orange and yellow traps (Colville, SANBI entomologist, personal communication, November 2010). All trap colours were laid so as to attract the largest number and range of pollinators possible to the site. Kenilworth Racecourse and Princess Vlei had the highest number of insects trapped in blue and white traps. In the analysis however, all insect numbers were grouped together per site, regardless of trap colour, as time and resources disallowed all insects from being comprehensively identified, so no conclusions could be drawn with regards to actual specialist numbers at the various sites.

It must be noted, that during the pilot study conducted at Princess Vlei on 6/12/2010, a total of 57 insects of 9 morpho-species were trapped in an 8 hour period at this site alone. These insects comprised of: 5 bees, 5 beetles, 2 wasps and 45 monkey beetles. Contrastingly, the results shown in Figure 8 show no monkey beetles present at Princess Vlei. The aforementioned December Princess Vlei results could not be included in this study's main results, as no traps were laid at any of the other sites on the same day, preventing time-aligned comparisons from being made. Nonetheless, the included results still show Princess Vlei with relatively high pollinator activity (46 trapped pollinators of 5 morpho-species); coming in second after Kenilworth Racecourse (22 trapped pollinators of 6 morpho-species). Interestingly, the vacant plot appeared to have slightly higher pollinator numbers when compared to Rondevlei, Tokai and Bottom Road Garden's sites and all functional groups except beetles where trapped here.

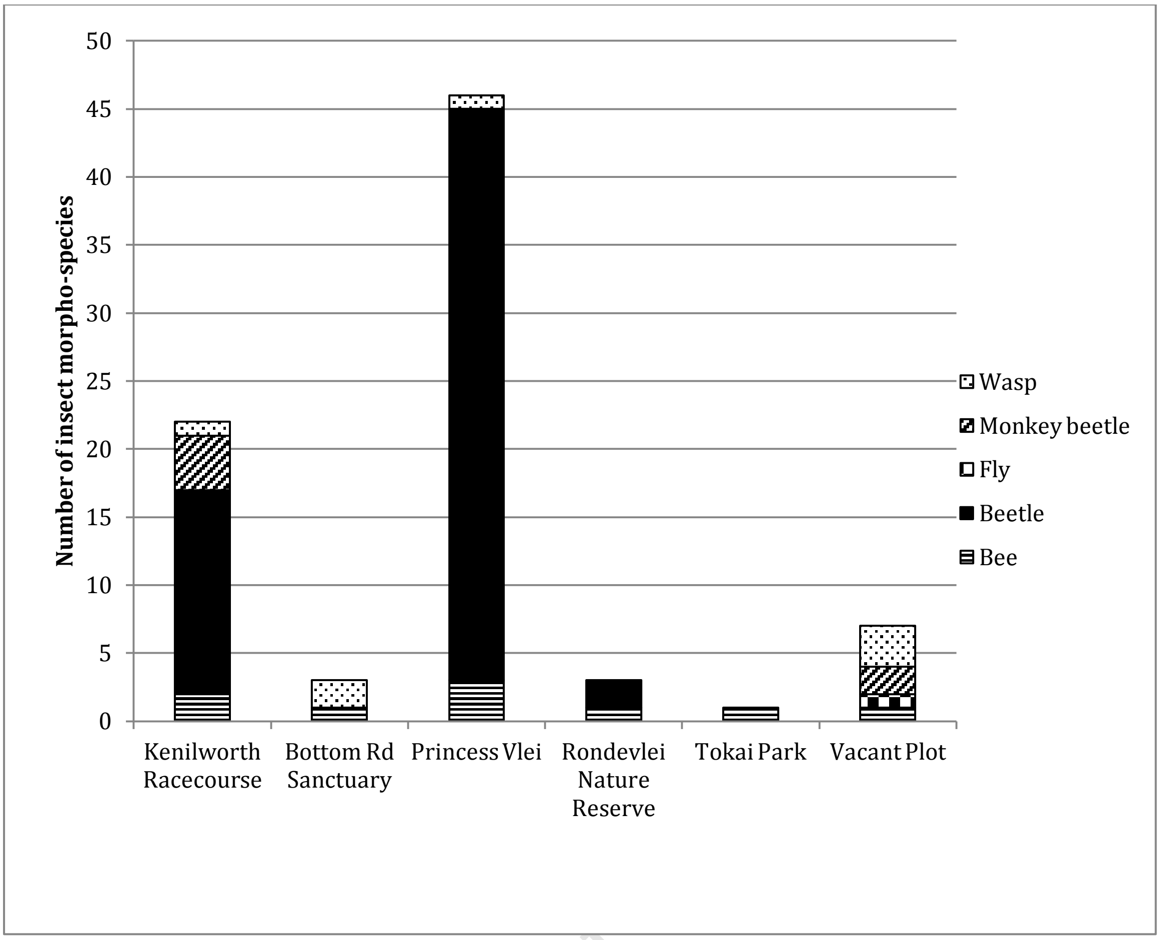


Figure 8 Bar graph representing the total number of insect pollinator morpho-species, differentiated into functional groups, collected from 24 hour pan trapping on 7/02/11

Tokai Park, Rondevlei Nature Reserve and Bottom Road Sanctuary's pollinator numbers all suggest relatively low pollinator activity for these sites. Contrary to the trapping results, ocular observations while conducting plant field studies suggested that there were in fact pollinators present at these sites. Carpenter bees (*Xylocopa sp.)* where seen flying around the abundantly flowering *Erica verticillata* plants at the Tokai site. Similarly, at the Rondevlei site, numerous bees were seen hovering on *Protea repens* flowers as well as around the *Erica verticillata* and at Bottom Road Sanctuary, there were undeniably pollinators present and flying between various flowering species, especially the *Psoralea* specimens. Notably, at the un-intervened site, a large *Sphecidae* wasp nest was noted between the branches of an *Amphithalea imbricata* shrub; however in the results, we see only three wasp specimens accounted for at this site (See Figure 9 below). Although bees and wasps were spotted, no ocular observations of beetles or monkey beetles occurred at any of the aforementioned sites.

While the trapping results as a whole show some interesting trends, in some instances they are difficult to explain and this can be attributed to sampling constraints discussed later.

Figure 9 Ocular observations of pollinator activity. A) Bees in *Protea repens* capitulum, Rondevlei Nature Reserve; B) Wasp nest, vacant plot; C) Carpenter bee interacting with *Erica verticillata*, Rondevlei Nature

3.4 Qualitative Data

Semi-structured interviews with key informants brought to light some contextual information behind the various sites and their management practices. Key management practices associated with all six study sites are summarised in Table 5, with certain elements thereof further discussed below. More detailed information, brought to light in the interviews, will be further deliberated in the discussion section to follow.

3.4.1 Management plans

Bottom Road Sanctuary, the vacant plot and Rondevlei Nature Reserve all officially fall under the jurisdiction of the False Bay Nature Reserve and subsequently should all be managed under the umbrella of the *Integrated Management Plan for False Bay Nature Reserve*; however all have very different management histories and some have more active management than others. The vacant plot has not been actively planted or tended to and is currently considered a 'degraded site' (personal communication with J. Gericke

2010). According to the reserve's management plan, it is zoned as 'low intensity leisure' and is managed more to promote recreational objectives than biodiversity objectives. Unlike the vacant plot, the Rondevlei site, otherwise known as the 'Erica Fields,' has been zoned as a 'primary conservation' area and therefore receives management geared towards biodiversity conservation. Both Tokai Park's management plan and the False Bay management plan were in draft form when this research was conducted. Princess Vlei had no formal management plan as of yet. Kenilworth Racecourse was the only site with a fairly long-standing and comprehensive management plan.

3.4.2 Pests and invasive plant control

Cane rats were reported as being a serious problem at Tokai Park, where seedlings were being decimated owing to the large rodent population. To combat this problem, management decided to re-introduce predatory snake species such as Cape cobras, molesnakes and puffadders. According to Cowell from Table Mountain National Park (personal communication, February 2011), this has drastically reduced the rodent population. Moles were reported to be killed by a local resident at Princess Vlei, in order to keep their populations down.

Invasive species such as *Cliffortia feruginea* have been a major issue in sites such as Rondevlei were it has been growing rampantly across the site and out-competing other low lying plant species. Similarly, *Cliffortia* was mentioned as being a hampering issue for Tokai Park, where it was accidently planted by Working for Wetlands as a ground cover. At Tokai Park, planting teams pull it out as they work and alien clearing groups sweep the site every three months for all alien invasives, including the irksome *Acacia* species. Friends of Tokai committee members also pull any invasives or aliens species and constantly monitor the situation.

Alien grasses were noted at all six study sites. Kikuyu grass was accidently planted at Bottom Road Sanctuary along the walkways. As of yet, this has not become a serious problem with regards to hindering indigenous plant life within planted areas, although plans are in the making to remove it all together and replace it with a more suitable species. There are very minimal issues with Port Jacksons at Bottom Road Sanctuary, but these are pulled up as they are spotted.

Buffalo grass (*Stenotaphrum secundatum*) appears to be an invasive issue at Tokai Park accounting for 60% of the ground cover at the study site (see Table 1). This grass species is not considered an alien grass in South Africa and was mentioned in the semi-structured interview with Tokai Parks management as being a 'naturally occurring species' that fynbos seedlings can push through (Cowell, personal communication, February 2011). No management interventions have been put into place at Tokai to remove or control the dominance of this grass as it is thought of as a natural successional species. Other species such as Kikuyu grass were mentioned as having been mostly weeded out.

3.4.3 Disturbance regimes

It is well known amongst all the respective site managers that fynbos is a fire-maintained ecosystem, with fire being an important tool for maintaining the diversity and species composition of fynbos (Cowling 1992). Unfortunately, sites such as Bottom Road Sanctuary and Princess Vlei are not able to be subjected to managed burns owing to spatial constraints and proximity to residential areas and may need alternative options in terms of maintaining functioning fynbos ecosystems. To combat this issue, site overseer, Kelvin Cochrane suggested that when the time comes, planted species would be pulled out and replanted with new seedlings in order to maintain a somewhat 'natural,' regenerating ecosystem. Tokai Park, Rondevlei Nature Reserve and Kenilworth Racecourse all have burning regimes built into their management plans and have all but the Tokai Park study site (or 'Soetvlei'), experienced burns in the last ten years.

3.4.4 Active plant selection and planting at intervention sites

Certain species have clearly been chosen above others at certain sites owing to their endangered status, their ecological or their aesthetic value. Each management sector used different criteria when choosing what to plant and where. Tokai Park utilises a more formal approach towards planting and refers to the historically relevant 'Purcell list' for area-appropriate plant species. This list was compiled between 1917-1919 by William Purcell, who made a herbarium collection of nearly 600 species naturally occurring on Bergvliet farm, which once stretched as far as Tokai Park (Rebelo 2010). Tokai's management tries to find appropriate plants that are as close as possible to the originally recorded plant population. If these don't already occur in Tokai, populations are increased from seedlings from the nearest source- that being Kenilworth Racecourse or Rondevlei Nature Reserve.

Plant selection at Bottom Road Sanctuary and Princess Vlei was not so heavily based on strict ecological criteria or historical lists as such, but more informally, based on the personal preferences of local resident and the sites' champion, Kelvin Cochrane. Most seedlings were sourced from Rondevlei Nature Reserve and Kelvin actively chose a variety of species in order to attract certain birds and to ensure that at different times of the year there is always something seeding or flowering for the birds and pollinators. He also consciously spaced the plants at Bottom Road Sanctuary, so that there are denser spaces as well as partially open spaces to allow for bird breeding sites. The Princess Vlei intervention site was planted up less because of its ecological suitability and more because of its visibility to the public eye. Pedestrians and motorists can clearly see that something is going on and it is hoped that this will generate awareness around the Princess Vlei and the proposed shopping mall development.

Species such as *Erica verticillata* and various *Serruria* species were actively planted at Bottom Road Sanctuary, Princess Vlei, as well as Tokai Park owing to their Red Data listings.

3.4.5 Available workforce and funding

There are vast differences between sites with regards to available funding as well as the size and availability of work forces for site maintenance. All sites have 'workforces' per se, but vary with regards to the frequency and amount of time that these 'workers' can spend on site projects based on differences in available funding and resource allocations between sites. With little support from the City, intervention sites such as Bottom Road Sanctuary and Princess Vlei initially relied on the partnership with Working for Wetlands who provided low-paid workers, plants and machines to help with alien removal and planting, and lately also on City Parks for machines (Ernstson 2011b). Some initial support, but more on and ad-hoc bases, was provided by conservation managers at Rondevlei Nature Reserve and by WESSA, an NGO related to the protection of South African wildlife. However, in parallel, and lately to a increasingly greater extent, both sites have had to rely heavily on additional funding from residents, and from the newly established Cape Flats Wetland Forum, an organisation set up by Kelvin Cochrane to bring in revenues through rehabilitating other sites, which has been used to pay for maintenance at Bottom Road and Princess Vlei (Ernstson 2011b). More formally managed areas such as Kenilworth Racecourse are more stable with regards to funding and available human resources as Gold Circle's 'conditions of agreement' to the rezoning of the racecourse ensures permanent staff, active management and workers who are paid to maintain the conservation site as a whole. Rondevlei Nature Reserve has permanent staff and contract workers which are paid for by the City, however with only three permanent staff members, management of the entire 290 ha reserve is sometimes stretched. Table 1 suggests that the vacant plot has a permanent available workforce and in theory it does owing to it falling under the umbrella of the False Bay Nature Reserve; however owing to other pressing concerns at more conservation worthy areas of the Reserve, little workforce related priority is given to this site owing to its perceived degraded status (it is therefore marked with an 'A: absent' denotation for workforce). The Reserve relies heavily on Working for Wetland workers who remove alien plants every three months or so. Tokai's maintenance also relies heavily on the Working for Wetlands team, moreover on its Friends' group who's various 'task teams' perform quite extensive manual labour on site: clearing paths, removing aliens and general site maintenance.

Friends' groups play an imperative role on most sites, with the exception of Princess Vlei and Bottom Road Sanctuary, where they are not actively involved in the upkeep of the intervention sites as such. In Tokai Park, Kenilworth Racecourse and Rondevlei Nature Reserve, their importance is acknowledged and are described as being 'the eyes and the ears on the ground' (Cowell, personal communication, February 2011). These Friends' groups are made up of members from local residents and are involved in supporting conservation projects and initiatives on various levels including: physical volunteering, fundraising, providing input into planning, and several other forms of support. It is when resources are short that the dedication and resilience of these Friends' groups come into play in terms of keeping a conservation site 'alive'. Further associated research into the frequency and specific contribution of Friends' groups, may bring this to light. The civic and public involvement at Princess Vlei and Bottom Road Sanctuary is very pronounced but through other organisations, other than the often middle-class 'Friends' groups that are found primarily in areas previously classified as 'White' areas of Cape Town. As Bottom Road Sanctuary and Princess Vlei lie in what was classified as 'Coloured' area, other types of organisations have emerged, such as the Cape Flats Wetland Forum that has now built extensive relationships with various schools in the area (where children 'adopt-a-plot' and help tend to the sites in that way, while gaining an environmental education), and other civic organisations.

Table 5 Key management issues and practices (P, present; A, absent) associated with the study sites and their ecosystem effects.

Management Practices	Effect	Kenilworth Racecourse	Bottom Road Sanctuary	Princess Vlei	Tokai Park	Rondevlei Nature Reserve	Vacant Plot
Active planting of species that are endangered	Maintain/improved plant diversity	A	P	P	P	P	A†
Noticeable alien/invasive issue	Less available space and more competition for fynbos species	A	P	A†	P	P	P†
Planned disturbance regime (date of last burn)	Plant reproduction, control alien woody plants, reduce fuel load	P (2005)	A	A	P (Unburnt)	P (1997)	A†
Active pest control	Protection of certain species and seedlings	A	A	P	P	A	A†
Permanent workforce on site	Site maintenance	P	P	A	P	P	A
Actively implemented biodiversity management plan	Co-ordinated management application	P	P	A	P	P	A

Notes: For sources, see Appendix B.

† Not included in questionnaire, but identified during field observations.

Chapter 4: Discussion

4.1 Introduction

> The reason why we're intervening is to restore Cape Flats Sand Fynbos as it maybe once was. The national target for all ecosystems is 30%, that's your minimum. We don't even have 30% so what we do have, we really need to save. It isn't a question of should we or shouldn't we? It's just the question of *how*- 'how are we going to do this?' -that's important.
>
> -(Carly Cowell, Tokai Park, personal communication February 2011)

All sites investigated in this study are unique urban green spaces within the City of Cape Town. The various site managers involved in overseeing these sites are all striving for the same ultimate goal, to restore and sustain, alongside other goals, what little Cape Flats Sand Fynbos there is left remaining. What became evident through this research is that all sites are contributing ecologically in different ways, which seems to be based on the different management practices that have been put into place. An interesting dichotomy emerges with regards to the management and driving force behind the activities of the more formal science-orientated Reserves: Tokai Park, Rondevlei Nature Reserve and Kenilworth Racecourse, compared to those of the more informal and civic-led, Princess Vlei and Bottom Road Sanctuary sites. This discussion will attempt to shed light on the ecological value of social interventions by comparing the ecological and management-related differences that make these sites so unique, as well as the similarities that bind them together as important reservoirs of ecosystem services for the City of Cape Town.

4.2 Ecological starting points

Each site had its own historical context which informed its ecological starting point prior to intervention. This resulted in each site having very different ecological potentials with regards to where they currently stand and their ecological potential for the future. When focusing on the intervention sites themselves, we see obvious differences with regards to the ecological history of Tokai Park and that of Princess Vlei and Bottom Rd. The restoration project at Tokai started off with an under-pine seed bank that in the future, may allow for natural succession to occur more rapidly than at the previously degraded Princess Vlei and Bottom Road Sanctuary. These younger sites will need more intensive management in order to keep them functioning, for example: the continual re-planting of seedlings to stimulate natural regeneration in the absence of fire regimes. According to Zheng and Cheng (2000), edge effects are especially vulnerable to human and natural disturbances when fragments are small or irregularly shaped. Hence these smaller sites would be more prone to invasion by alien plants and would therefore need more frequent alien management.

4.3 The knowledge base behind intervention

Tokai Park is part of a National Park and is therefore managed accordingly, with experts in the fields of botany and Fynbos ecology to plan the scientifically established most effective way that management can contribute to the conservation of fauna and flora in the Park. Implementation of Tokai's management plan involves input from specialists and scientist as required, with volumes of input from scientists such as Holmes of the City of Cape Town and Rebelo of SANBI, who have been studying the site as part of their research for years and who are 'expert at all things Tokai' (Cowell, personal communication, February 2011) and bring a much broader expertise to this site. Restoration activities are strongly influenced by literature on recruitment dynamics, community structure, and ecosystem function (Holmes and Richardson 1999). The scientific backbone behind the restoration activities at Tokai is quite in contrast to the way in which the restoration at Princess Vlei and Bottom Road Sanctuary has come about.

Bottom Road Sanctuary and Princess Vlei can both be considered 'gardened' sites. 'Gardened' meaning that the choices around what to plant and where, were more subjective and based on the personal preferences and involvement of the champion and driving force behind both of these greening interventions: Cochrane of the Cape Flats Wetlands Forum. From the semi-structure interviews conducted with Cochrane, it became clear how passionate he was about creating meaningful linkages between people and nature through the creation of ecologically viable spaces for people to interact with. Cochrane (personal communication, February 2011), compared these interventions to Cape Town's Botanical Garden and said, "[w]e need to work on the ground and create the Kirstenbosches, amongst the people, not just in private gardens." Kelvin had self-taught knowledge about the various fynbos species before he commenced the restoration projects. He acknowledged that he had no formal botanical or ecological training and that he simply chose what to plant based on what Cape Flats Fynbos species he liked and what he knew the birds would like (Cochrane, personal communication, February 2011). This became evident when he said:

> I know the sunbirds come for the *Leonotis leonurus*, and the Rooibekkies come for the *Senecio halimifolius*…I've got no scientific way of planting, but if you look at what I've planted here, these plants look as natural as they would in the nature reserves…

The various sites were planted based on very different knowledge bases and ecological starting points (see also Ernstson 2011c). The effect of these differences is reflected in the actual biotic and abiotic data discussed below.

4.4 Interplay between vegetation composition and management practices

The correspondence analysis clearly demonstrates that the species in the vacant plot differ considerably from those of the other sites. There are also clear differences in species composition between the remaining five sites, as can be seen from the vertical grouped ordering of the different sites. This effectively illustrates a form of ecological continuum evident at the different sites. On the whole, the quadrats of each site cluster in distinct groups, with the exception of the vacant plot whose points were interspersed with clear outliers. One of these two outliers appears to have more species in common with Rondevlei Nature Reserve, than with the other quadrats in the vacant plot. Each site, with the exception of the vacant plot, appears to have its own unique vegetation composition, suggesting high species turnover between sites. High species turnover- the replacement of certain species with others at neighbouring sites- is a characteristic trait of fynbos (Manning 2009). However, in an urban environment, high species turnover may also be indicative of fragmentation and lack of connection with adjacent fragments. The analysis did however show noticeable overlaps between the plant species compositions of Bottom Road Sanctuary and Princess Vlei. Both sites have been championed and 'gardened' for the most part by Cochrane, which may have subsequently led to the presence of similar vegetation communities based on his choice of plants. Working for Wetlands was also involved in the planting of both these sites, which may have also contributed to their similarities. The interspersion of the vacant plot and Princess Vlei's points across the correspondence analysis plots, indicative of high species turnover between quadrats, may be owing to their relatively low plant cover, which would make differences in vegetation composition much more noticeable.

Ideally, with time, one would like to see all urban green spaces on a trajectory from being degraded sites that simply provide very basic and limited ecosystem services, towards being sites that actually have conservation potential. The interventions sites investigated in this research may have started off with similar conditions to that of the vacant lot, being relatively unmanaged and species poor, but have slowly moved closer and closer towards sites of greater conservation potential, epitomised in this study by Kenilworth racecourse, positioned at the end of the ecological continuum, owing to the intervention activities and management imposed on them. It is encouraging to see a trajectory towards greater conservation potential for the Tokai Park intervention site in particular, which has scale (a large surface area), connectivity to the mountain, implementable fire regimes and a natural seed-bank in its favour. Out of the three investigated intervention sites, Tokai Park is probably has the most potential to end up closest to a natural Cape Flats Sand Fynbos vestige of a similar conservation potential to that of Kenilworth racecourse, with regards to ecosystem functionality and species diversity. With time, it is hoped that this can come to fruition. However, this should not downplay the importance of Bottom Road and Princess Vlei that might better live up to societal goals of community involvement and in restoring, through ecological rehabilitation, public open space functions creating possibilities for 'socio-ecological innovations' badly needed in urban area (Ernstson et al. 2010). This will be further discussed in Section 4.7.

4.4.1 Fragmentation and connectivity

The correspondence analysis clearly shows that the species composition of the various sites was different. This may be due to a number of reasons, including intervention activities and/or management practices but may also indicate the degree of fragmentation of these urban green spaces and highlights the need for more connectivity at a landscape level. This is in accordance with general conservation island biogeographic theory which explains how larger patches and patches that are less isolated and closer to each other, have more species and more shared species than those that are smaller or less connected (Forman 1995). It is also clear from metapopulation theory that the greater the number of patches and the closer they are together, the greater the chances of colonisation (Hanski 1989).

Seed dispersal and wildlife movements are vital in determining the survival of 'metapopulations': assemblages of local populations that are connected by migration (Hanski and Gilpin 1991). These 'movements' are directly related to the connectivity of the landscape (Schippers et al. 1996). As wildlife moves between fragments, extinction and colonisation rates begin to cancel each other within fragmented urban landscapes (Bueno et al. 1995). The greater the amount of green space relative to developed area, the more chance for connectivity between green spaces and the less heavily impacted these will be by the urban population (Forman 1995). This can only be achieved through restoring more degraded urban fragments in an attempt to close the gaps between these highly disjointed green spaces. Princess Vlei and Bottom Rd Sanctuary were two intervention sites which were relatively smaller in patch size and would therefore be more vulnerable according to island biogeographic theory. More restored fragments around these areas would aid in opening up ecological corridors for seed dispersers and pollinators who may in turn increase natural succession, landscape connectivity and ecosystem services to the surrounding areas.

4.4.2 Species richness and plant functional diversity.

Biological diversity has often only been equated to species richness, with other components of diversity being generally undervalued, in particular functional diversity which has received much less attention in the literature (Tilman 2001). There is a growing consensus that the effects of diversity on the rate and extent of ecosystem processes should be ascribed to the functional composition and the number of different plant functional types, rather than just to species number alone (Diaz and Cabido 2001). For example, the loss of an entire functional type within an ecosystem (e.g. due to climate change or urbanisation) has been shown to have a larger impact on ecosystem functioning than removing the same number of species from a variety of functional types (Chapin 2000). Similarly, the addition of a species representing a new functional type can drastically affect ecosystem functioning and resource use (e.g. invasive Tussock grasses in Mediterranean Europe drastically increases fire frequency) (ibid).

On this basis, this study chose to look at both species and functional type richness with regards to the vegetation present at the various study sites as a means of better understanding the ecological functioning of each site. Not only does the variety of functional types increase the variety of available habitats for pollinators and other organisms, but functional diversity may also influence resource dynamics within an ecosystem as well as ecosystem resilience through the previously mentioned concepts of functional redundancy and functional insurance (Diaz and Cabido 2001).

Unsurprisingly, Kenilworth Racecourse, identified as the desired endpoint in an ecological continuum, had the highest total plant functional type diversity as well as total species number overall. What was interesting from the data was the fact that Bottom Road Sanctuary had only one less plant functional type than Kenilworth Racecourse and Rondevlei, and was on a par with Kenilworth Racecourse with one of the highest overall recorded species numbers. Cochrane admitted to making a concerted effort to plant numerous species and whether it was deliberate or not, he subsequently planted a substantial variety of plant functional types, thereby increasing the functional insurance of the area. His choices resulted in numerous species within each functional type, with Bottom Road Sanctuary having one of the highest species numbers recorded for perennial shrubs, perennial herbs and perennial grass across all the sites. According to Chapin (1996), the larger the number of functionally similar species in a fragment, the greater the likelihood that at least some of these species will survive environmental changes or disturbances. This functional redundancy would aid in ensuring greater chances of ecosystem survival in the face of disturbance or environmental change. Princess Vlei was almost on a par with Rondevlei Nature Reserve with regards to species richness and functional diversity. These results indicate that what Ernstson et al. (2010) denotes as "civic-led ecological rehabilitation" can indeed substantially increase the ecosystem functionality, which in turn speaks to the resilience of an ecosystem in this regards, making it comparable to that of a formally managed reserve environment (Barthel et al. 2005; Tidball and Krasny 2007).

Both of the civic-led intervention sites lacked flowering geophyte species. This is understandable considering their historically degraded state and their subsequent lack of naturally occurring bulb flora. Natural succession of this type of bulb flora would probably be a rarity in these sites and would need to be physically introduced Although not recorded in the results, owing to their absence in the quadrats randomly chosen for investigation, flowering *Albuca* species were visibly noted at the Tokai site, reinforcing the presence of the seed and bulb bank naturally occurring there. With time and with the implementation of fire regimes, more of these naturally occurring fynbos species are likely to appear, whereas at Bottom Rd and Princess Vlei, planting interventions would continually be required. An *Albuca* species was also present at the vacant plot, suggesting that this site may have viable restoration potential owing to its naturally occurring bulb flora. Again the ecological point of departure is demonstrated as important, where typically the presence of bulb species implies relatively undisturbed soils.

4.4.3 Aliens, invasives and Red Data List species

4.4.3.1 Alien *Acacia* species

The years of previous mismanagement at Rondevlei Nature Reserve were reported in the semi-structured interview as creating a serious alien *Acacia* problem in large portions of the Reserve. The resultant disturbed soil conditions were reported to have hampered the rehabilitation of rare and endangered plant species in later years and may be the reason why there is presently such high alien grass cover dominating the site. Recent studies on the effects of invasive alien species in Sand Fynbos ecosystems show significant impacts on ecosystem processes. Yelenik et al.'s 2004 study found that woody alien *Acacia* species cause a shift in nitrogen-cycling rates (from low to high) with a subsequent increase in total soil nitrogen levels. This increase in soil nutrient levels assists the establishment and proliferation of weedy grasses and annual species, which may subsequently out-compete fynbos species which are slower growing, especially in the seedling establishment phase (Yelenik et al. 2004). Interestingly, *Acacia* species accounted for only 0.9% of overall coverage suggesting that in Rondevlei reserve, at least for the 'Erica Fields', *Acacia* removals by management has been effective in controlling their proliferation. Similarly, relatively low *Acacia* coverage was observed at all six study sites with 0% recorded at the Princess Vlei and Bottom Rd intervention sites. Not only do these findings highlight an upside to the formal conservation approach in terms of alien management, but also to the 'gardening' approach used in civic-led greening endeavours where alien species are managed more closely in urban areas, where there otherwise would be no alien removals had there not been social interest in these sites.

4.3.3.2 Invasive species

Grasses frequently act as early successors after ecosystem disturbance (Gibson 2009). At Tokai Park, Rondevlei Nature Reserve and the vacant plot, grass cover was high. The vacant lot was by far the most alien-dominated site investigated, with the annual alien grass, *Lagurus ovatus,* being the dominant vegetation cover. Fallow fields like the vacant plot that have been previously cultivated or fertilised may have elevated soil nutrient levels making them readily colonized by alien grasses and annual species (Milton 2004). The high levels of grass cover at Tokai Park, Rondevlei Nature Reserve and the vacant plot may be hindering optimal seedling recruitment. Although mostly disregarded until recently, grasses have been noted as invasive and a potential threat to Western Cape flora (Milton 2004). Invasive grasses have the potential to alter ecosystem structure and resource use with regards to fire cycles, which in turn affects nutrient-cycling, water circulation and regeneration processes (Rahlao 2009; Corbin and d'Antonio 2004). In addition, invasive grasses are widespread, successful and aggressive competitors with native species (D'Antonio and Vitousek 1992). A decrease in species richness following invasion by alien grasses has been observed for various vegetation types in the Western Cape (Vlok, 1988). A high prevalence of weedy grasses may slow down indigenous seedling recruitment, as was noted for a Renosterveld restoration pilot study on the Cape Flats (Holmes 2002), as well as internationally, in similar Mediterranean–climate ecosystems (Cione et al. 2002). Notably, the experimental removal of grass cover at a Cape Flats site significantly increased the emergence of fynbos seedlings (Wilson, 1999), suggesting that some grasses do suppress fynbos recruitment.

Princess Vlei and Bottom Road Sanctuary would be highly vulnerable to alien or invasive grass cover owing to their small size and the subsequent increased edge effects. The Kikuyu grass accidentally planted by Working for Wetlands at the Bottom Rd site may pose an invasive risk to the natural succession of planted fynbos if left unattended. Similarly, the low ground cover at Princess Vlei owing to cleared planting beds would be readily colonized by weedy species if left unattended. The results highlighted that invasive species were both a problem at the civic-led social interventions sites as well as the formally managed conservation areas. Interestingly, their potential ecological threats were viewed in different lights by the study sites' management. The extensive buffalo grass (*Stenotaphrum secundatum*) was not seen as a problem by Tokai Park's management, while the rampant *Cliffortia* and grass cover at Rondevlei Nature Reserve was side-lined owing to lack of available man-power and other more pressing Reserve issues (Allan, personal communication January 2011); time, manpower and monetary resources being the limiting factors to dealing with these invasive issues. These limiting factors will be felt even more so by the civic-led intervention sites at Bottom Rd and Princess Vlei, where available funding and manpower is a continual issue.

4.3.3.3 Red Data species

Owing to the critically endangered status of Cape Flats Sand Fynbos, it was not surprising to find Red Data List species at the more formally managed Reserve sites such as Kenilworth Racecourse, Tokai Park and Rondevlei, where these species are monitored and even planted into these sites. Surprisingly, a listed rare species, *Amphithalea imbricata* was found at the vacant plot suggesting that even this degraded site had conservation potential. What was encouraging to see was that *Erica verticillata* which would otherwise be extinct in the wild, as well as vulnerable and endangered *Serruria* species were deliberately planted at all three intervention sites. The *Erica* specimens in particular seemed to be thriving and attracting numerous pollinator species. Natural recruitment of these species was observed at all three intervention sites where seedlings were noted. These results reinforce the value of vacant or remnant land outside of the formal conservation network. These sites form part of a vital matrix of conservation potential within the City and act as connective areas and strongholds for endangered species.

4.5 Interplay between soil moisture and organic content and social intervention.

In a study by O'Farrell et al. (2008) the benefits of retaining natural Renosterveld for soil retention and hydrological services was investigated. Soil moisture and organic content were included, among others, as a measure of ecological functioning. Likewise in this study, soil moisture and soil organic matter were investigated as indicators of the value of social intervention on the ecological integrity of the intervention sites under question. Although soil moisture and soil organic matter are not the only soil data which would determine the ecological integrity of the different sites, the scope of this study did not allow for other measurements to be taken, (such as amongst others: pH, nitrogen or phosphorus levels in the soil) as time and resource constraints disallowed this. At the onset of soil investigations in the field, it was hoped that moisture and organic content of soils across the sites could be looked at comparatively, to understand if improvements in these areas had been made; away from the degraded quality of the vacant plot, towards that of the relatively pristine and undisturbed soil quality of Kenilworth racecourse.

4.5.1 Soil organic matter

Soil organic matter, which according to Bot and Benites (2005) is, 'the product of on-site biological decomposition', affects the chemical and physical properties of soil as well as its overall integrity and influences the plant, animal and micro-organism populations present. The composition of this organic matter as well as its rate of degradation affect: the soil structure and porosity; the water infiltration rate and moisture holding capacity of soils; the diversity and biological activity of soil organisms; and plant nutrient availability (Bot and Benites 2005).

4.5.2 Soil Moisture

According to Oades (1988), soil moisture is the water that is held in the spaces between soil particles and is essential to plant growth, the prevention of soil erosion and slope stability. The quantity of rainwater that is able to penetrate (infiltrate) into the soil has been shown to be related to the amount of soil cover provided by plants. Increased levels of organic matter and associated soil fauna (e.g. earthworms) lead to increased soil porosity with the immediate outcome that water is better able to infiltrate and be held in the soil (Roth, 1985). In this way, soil organic content and soil moisture are inextricably linked and dependant on each other. Soils with high organic content can hold more water than those soils low in organic matter. Conversely, the presence of soil moisture allows for the greater degradation of plant material and therefore the presence of organic matter (Bot and Benites 2005).

4.5.3 Social intervention and soil properties.

The soil results did show some interesting trends, however direct cause and effect were not always clear and this can be attributed to sampling constraints. More samples per site would have been ideal; however the short available window for sampling disallowed this. With social intervention and the subsequent planting and restoration of fynbos, one would expect to see a trend towards improved soil organic and moisture levels. Not unpredictably, the vacant plot, which had received no intervention, had comparatively low moisture levels and organic content suggesting poor soil quality (Bot and Benites 2005). This can be assumed to be due to its relatively low plant cover and the high prevalence of annual species, which subsequently leave this site bare at certain times of the year. The presence of plants on the soil surface leads to improvements in the way that soil binds or aggregates (Bot and Benites 2005). Gassen and Gassen (1996) have shown that on bare soils, runoff and therefore soil erosion is higher than when the soil is protected with plant cover. Similarly, Golluscio and Sala (1993) have shown that the loss of plant cover, in particular perennials, results in bare patches which in turn has consequences for soil moisture through increased wind evaporation and which ultimately affects soil nutrient status. Moreover, without good indigenous vegetation, soils are more susceptible to erosion resulting in lower chances of future colonisation by indigenous species (Holmes et al. 2000). In this way, social intervention may have indeed made improvements at all intervention sites in preventing soil erosion, through the planting of indigenous fynbos. While not investigated here, this warrants further studies. Princess Vlei, Tokai Park and Kenilworth Racecourse soil moisture levels, like the vacant plot, were also close to zero. Princess Vlei's low soil moisture could be attributed to the quite patchy, low plant cover at the site which would increase the amount of evaporation of moisture out of the soil, even though the site was relatively close to a water body. What is difficult to explain however, is the relatively low soil moisture levels observed at Kenilworth racecourse and Tokai Park when comparing this to the high plant cover seen at these sites. This may have been due to sampling occurring during the dry summer months, where little precipitation occurs over the Western Cape. Winter sampling, after a wet spell may have been more appropriate, in order to understand the moisture holding capacities of these soils. The relatively high moisture contents observed at Bottom Road Sanctuary and Rondevlei Nature Reserve may in part be explained owing to their high plant coverage and proximity to water (both sites are close to the banks of the water body, Zeekoevlei).

It was interesting to see how Kenilworth Racecourse, Princess Vlei, Bottom Road Sanctuary and Tokai Park grouped together with relatively similar soil organic contents, while that of Rondevlei Nature Reserve was substantially higher. The higher organic content at Rondevlei may be attributed to its previous alien invasive *Acacia* problem, which was mentioned to have 'hampered rehabilitation efforts' (Assieff Khan, personal communication, January 2011). When discussing plant cover, it must be noted that not all plant cover results in soils that are healthier to fynbos species. However, certain alien invasive plant species, such as the previously mentioned *Acacia* species as well as pine species (which previously dominated Tokai Park) change fynbos ecosystems by producing substantially more above ground biomass which in turn influences the input of organic matter and nutrients to soil (Cowling 1992). According to Cowling (1992), invading pines do not fix nitrogen and their effects on ecosystems are therefore more subtle, which may explain why organic content levels at Tokai were not particularly different from the other intervention sites. *Acacia* species, on the other hand, possess mechanisms to enhance nutrient acquisition, including N2-fixing symbionts and extensive root production (ibid). Thus due to their abundance and differing resource requirements, these species may alter the collective properties of ecosystems, including soils nutrient pool sizes, productivity and rates of nutrient turnover (Cowling 1992), creating ecosystems more favourable to their proliferation and creating soil environments that are subsequently less hospitable to indigenous fynbos species This could in turn be affecting species composition, such as the observed grass proliferation and invasive *Cliffortia* species mentioned previously. Owing to the subsequent removal of the invasive species from Rondevlei, it is hoped by management that with time, soil properties will improve to a more natural state conducive to fynbos succession.

The similarities between Tokai Park, Princess Vlei, Kenilworth Racecourse and Bottom Road Sanctuary with regards to their organic content was surprising considering the vastly differing land uses that have occurred on these sites historically. Kenilworth racecourse has been a generally well conserved area for many years, in comparison to

Tokai Park, which has recently been under pine forest, and Bottom Road Sanctuary and Princess Vlei which have been degraded, vacant plots up until recently. Clear soil improvements can be seen with regards to organic content. It can be assumed that prior to intervention, the intervention sites all had similar degraded vegetation composition with subsequent low organic content comparable to that of the vacant plot. It must be noted that there are probably several other soil factors at Kenilworth Racecourse that contribute to its relatively high ecological integrity, however, it is evident that the intervention sites have certainly experienced a shift away from the low soil quality of the vacant plot towards that of Kenilworth racecourse suggesting soil improvements. This can be assumed to be from the restoration activities that have occurred- notably the removal of alien vegetation and the planting of indigenous fynbos species naturally found in those areas. Although not blatantly evident in the results, social intervention through planting these soils with indigenous vegetation can be deductively assumed to have increased plant cover and subsequently soil integrity. The soil results from Princess Vlei, Bottom Road Sanctuary and Tokai Park suggest that these more recent intervention sites do indeed possess the soil potential, as far as organic content goes, to uphold the plant communities seen at Kenilworth Racecourse

4.6 Interplay between pollinators and study sites

In this study, the pollinators given focus were namely: monkey beetles, bees, bumblebees and wasps. Ecosystem services can be measured indirectly through surveys of functional groups such as pollinators. Andersson et al. (2010), used species diversity and abundance of bees and bumblebees as an indication of the ecosystem service of pollination and suggest that, "[t]he species abundance and composition within a functional group are indirect measures of the performance of the ecosystem service, as they determine the efficiency of the ecological functions on which the ecosystem services are based".

Pollination is a vital ecosystem service because it is crucial for the successful reproduction of the bulk of the world's key plants (Kearns et al. 1998). The majority of plant species rely on the involvement of animal vectors to transport pollen from flower to flower, and any disruption of this process may lead to reduced seed production (Bond 1994). Experts in pollination ecology have confirmed that honey bees as well as other pollinators are in long-term decline globally (Kearns et al. 1998). The deterioration of these pollinators has been recognized as one of the repercussions of habitat fragmentation as a result of human developments across a landscape (Allen-Wardell et al. 1998). The potential consequences of these pollinator losses on the conservation of biodiversity and the stability of agriculture and food crops may be in jeopardy (Matheson et al. 1996). Ultimately, the management and protection of our wild pollinators and the subsequent services they provide, is of paramount importance to our food supply system. The agricultural importance of urban green space management is emphasised by Allen-Wardell et al. (1998, pg. 1) who state that, "[p]ollination is one of the most important ecological services provided to agriculture through the responsible management and protection of wildland habitats and their populations of pollen-vectoring animals and nectar-producing plants".

Urban and peri-urban agriculture constitute an important part of Cape Town's food security (Kirkland 2008). Notably, the Phillipi Horticulture area which stretches for 3300ha within the City precinct is an excellent example of urban agriculture within the Cape Flats. Surrounded by residential suburbs and neighbouring Grassy Park (approximately 6km away according to Google Maps) , the large-scale farms in the Phillipi horticulture area cultivate more than 50 percent of the fresh produce consumed by the City of Cape Town (Theobald 2011). This area would be particularly benefitted by the ecosystem services generated by the closely situated intervention sites with regards to pollinator numbers.

4.6.1 Dominant plant cover and fragment size

Webb (1989) has identified vegetation cover as a determinant of insect species diversity in fragmented landscapes. Similarly, in a 2002 study by Donaldson et al. on the effects of habitat fragmentation on pollinators in the Renosterveld, insect pollinators were found to be more sensitive to habitat characteristics such as percentage vegetation cover and functional diversity than to fragment size. The current study sought to minimise variation in aspect and slope between sites but recorded differences in overall vegetation cover, as well as differences in dominant plant species between the sites. Such variability would almost certainly influence the microclimate, which may also be linked to abiotic factors such as soil structure (Saunders et al. 2001). Soil characteristics would be expected to influence the diversity and abundance of insects that nest or live in the soil, such as monkey beetles and ground-nesting bees (Gess & Gess 1993). In the same way, changes in vegetation cover and the ratio of shrubs to grasses would influence the availability of nesting sites for twig-nesting bees and wasps (Gess & Gess 1993). As a result, nest locations may more frequently occur at sites where soil and vegetation characteristics are favourable to pollinators, regardless of the fragment size.

In light of the above, the variation in pollinator numbers between sites was compared to the percentage cover and functional diversity of those sites. Tokai Park, the vacant plot and the Rondevlei Nature Reserve site had the lowest recorded pollinator numbers. This is possibly attributed to the dominant plant species present on these sites, namely: buffalo grass (*Stenotraphrum secundatum*), hare's tail grass (*Lagurus ovatus)* and *Cliffortia feruginea* respectively. Perennial shrubs and perennial grasses constituted the top 50% of cover for both Rondevlei Nature Reserve and Bottom Road Sanctuary. Approximately 60% of Tokai Park's cover was Buffalo grass alone and the un-intervened site's low percentage cover was largely composed of dead annual grass and dwarf shrubs. The comparatively low pollinator numbers trapped on these sites correlates with their vegetation cover which lacks habitat heterogeneity. This is in keeping with Donaldson et al.'s study (2002), which showed similar results and made clear linkages between declines in pollinators on fragments and areas of low habitat heterogeneity as a consequence of the dominance of only a few structurally similar species.

Another factor that may influence pollinator diversity and abundance at the various sites is the presence of floral bodies. The semi-structured interviews brought to light that it was a conscious decision to plant *Erica* species at both Tokai and Bottom Road Sanctuary owing to their known effects at attracting pollinators to the site. The *Erica verticillata* at Rondevlei Nature Reserve, Bottom Road Sanctuary and Tokai Park were all noted through ocular observations, to attract numerous pollinators. The species choice for planting at Princess Vlei resulted in numerous flowering Asteraceous species as well as members of the Aizoaceae family, which also seemed to attract pollinators, in particular monkey beetles. It seems that the decision of site managers to deliberately plant certain species above others has certainly increased pollinator numbers at these sites.

Notably, some plants have highly specialised and specific pollination systems and it is these plants that would be most vulnerable to pollinator extinctions (Donaldson et al. 2002). The deterioration of these pollinator mutualisms has been recognised as one of the potential repercussions of habitat fragmentation as a result of human developments across a landscape (Allen-Wardell et al. 1998). Even though evolutionary theory suggests that plants should adjust their energy resource allocations towards sexual reproduction in order to minimize the incidence of pollination deficits (Thompson 2001), these responses may not occur within the ecological time frames associated with rapid habitat fragmentation, resulting in subsequent plant extinctions (Donaldson et al. 2002).

Small fragments such as Princess Vlei and Bottom Road Sanctuary that contain important populations of planted threatened and endangered plant species require the presence of nearby large fragments such as Tokai Park, Kenilworth Racecourse and Rondevlei Nature Reserve as underlying sources of pollinators. As suggested by island biogeographic theory, pollinator presence in fragmented landscapes has been shown to be a function of the distance of a fragment to large habitat patches as large patches may provide a critical threshold of resources for pollinators (Donaldson 2002). Here the issue of connectivity comes in again. At the moment, it is not clear if the establishment of corridors between large and small fragments is essential to enable pollinators to move from source areas to smaller fragments (Allen-Wardell et al. 1998), however, the more connectivity in a landscape, the more chance of ecological functioning. Perhaps, in addition to more restored urban fragments, more well-informed, ‘wildlife-friendly’ suburban gardens may serve this purpose in forming interconnected networks of urban green space (Goddard et al. 2010).

Donaldson’s 2002 study highlighted that resources for pollinators do not decrease linearly with decreasing fragment size as relatively small fragments (<1 ha) can maintain or attract a diversity of insect pollinators. This has interesting implications when comparing the various sized study sites used in this research: An intervention site may be small and seemingly insignificant, but may hold the potential of being a hub of pollinator activity based on its vegetation cover as opposed to its size. This certainly holds true for Princess Vlei.

In concurrence with Donaldson's study, these results indicated that restored fragments in general need to be managed in a way that: increases habitat heterogeneity, reduces the density of invasives and shrubs, and promotes high-diversity flowering species to attract a larger variety and occurrence of pollinators at these sites. While there are interesting trends in the pollinator results, some of the results are hard to account for and this can be attributed to certain sampling constraints discussed below.

4.6.2 Sampling issues

The substantially large difference between Princess Vlei's trapping results from the pilot study in December 2010, when compared to those from 7 February 2011 alludes to a sampling issue and suggests that trapping conditions were substantially better during the earlier pilot study. Seasonal limitations may have come into play as an ideal sampling time would have been in early spring (Jonathan Colville, personal communication, December 2010), however the timing of this research did not allow for this.

The incongruences between ocular observations and actual trapped insects suggests that the pan traps may have been 'outcompeted' by real flowering counterparts (at least for bees and wasps) or may have been hindered in effectiveness and camouflaged by surrounding vegetation. This is particularly conceivable for the Rondevlei site, where pollinators appeared to be more attracted by the nectar and colour of nearby *Erica* plants and *Proteas* plants, than by the pan traps themselves, which became concealed between the rampant *Cliffortia feruginea*. Contrastingly, Princess Vlei's relatively low ground cover may have allowed insects to spot the colourful pan traps more easily, thereby allowing for better trapping results.

Pan trapping may not have been the most effective method that could have been employed in this study. This method works well when sites are of a more consistent vegetation cover and plant functional diversity (Allen-Wardell et al. 1998). In this study, the sites varied quite significantly in ecological integrity causing too many other variables to come into play with regards to achieving descriptive and accurate results. Perhaps a quadrat method using visual counts, similar to that employed by Andersson et al. (2007) would have worked more effectively, as sampling issues such as obscurance of traps by ground cover and out-competition by actual plants may not have affected the results between sites, as it may do with pan trapping.

4.6.3 The benefits of social intervention for pollinator numbers

In lieu of the above, the pollinator results recorded for Princess Vlei should not be played down by any means owing to the possible aforementioned sampling limitations. Regardless of whether the traps were more visible in comparison to the other more densely vegetated sites, there is an apparent draw for pollinators to the Princess Vlei intervention site: this in itself is an important find. This previously degraded area may have originally seen low pollinator numbers comparable to that of the vacant plot used in this study; the key factor creating this increase in pollinator number being attributed to social intervention and the subsequent local management of the area. The site may be in what would be termed ecologically as a pioneer phase and small in size, with relatively low plant cover, but the choices of species that have been planted there have clearly created a desirable site for pollinators to frequent. It is safe to say that the introduction of flowering Cape Flats Sand Fynbos species to the site has most certainly increased the amount of active pollinators in the area. The establishment of active pollinators in the area also speaks to the sustainability of these spaces. Not only has this ensured the succession of the plant species present in the future, created greater ecological linkage for pollinators to other areas, but has substantially enhanced the overall ecosystem services provided by this urban green space to urban and peri-urban agriculture in Cape Town. This has great implications for the perceived ecosystems services associated with this and other small, informally managed urban greening interventions.

Once again Kenilworth Racecourse showed itself to be the most ecologically desirable, where 22 pollinators of seven species were trapped comprising four functional types. The relatively high pollinator numbers and functional diversity strongly reinforces the importance of formal conservation efforts as a necessary means towards protecting and maintaining pollinator habitats and mutualisms. Likewise, the results from Princess Vlei strongly suggest that more attention should be paid towards civic-led conservation efforts and the contribution that these often underfunded, understaffed and overlooked projects can make towards enhancing the ecosystem services of the City of Cape Town's urban green spaces.

4.7 Social greening interventions: forging new connections with urban nature

With regards to the management of the chosen interventions sites, the dichotomy between the science-orientated and civic-led management that exists within Cape Town's urban green spaces becomes clear. Both are striving towards the same goal: that being the rehabilitation and protection of a very precious and endangered ecotype and the subsequent maintenance and enhancement of urban green spaces in the City of Cape Town. The semi-structured interviews highlighted the valuable social dynamic that reinforces and aids in ensuring the sustainability of these urban green spaces in the City of Cape Town, by making urban nature a truly public affair.

Civic-led social interventions such as Princess Vlei and Bottom Road Sanctuary demonstrate an important addition and complement to how urban nature is currently managed in the City of Cape Town (Ernstson 2011c). Research on the social elements of these interventions has emphasised how local and national agencies can build collaborations with interested citizens and civic associations that are involved in rehabilitating urban green areas that often fall outside of formal nature conservation areas (Ernstson 2011a). Bottom Road and Princess Vlei are public green spaces which are driven by local people who have become engaged and driven by the value of nature and are proud of its presence in their neighbourhood. This was highlighted by Cochrane (personal communication, January 2011) when he stated,

> *...b*ecause then it becomes a self-driven machine. Nature driving people driving nature. Where the word is spread and the pride is shared and spread and it spills over. Everyone wants to feel proud of something that is on their doorstep.

Non-reserve areas allow for a greater level of direct civic engagement with nature and can help to integrate urban ecosystems as part of the daily experience of citizens and subsequently aid in creating a new inclusive way, as opposed to a purely scientific way, of speaking about conservation that can be understood by the everyday citizen. What was once something that was purely left to 'White' ecological experts and conservation managers within formalised nature reserves has now become something that previously marginalised citizens of Cape Town can become involved in and claim as part of their heritage and identity (Ernstson 2011c). What appears to be developing is a new way in which urban nature can be engaged with and internalised, in post-apartheid Cape Town (Ernstson 2011c). Cochrane emphasised that all citizens have something to contribute to these interventions when he stated that,

> [o]rdinary people, in addition to the educated can bring a wonderful mix. They don't need to know what the other knows. They each bring their own dimension and together they can build a beautiful and wonderful place. There's more depth to these interventions than just pure ecology.

Cochrane suggested that civic-led greening interventions play an educative, catalytic role in getting people excited about biodiversity. These sites are an important complement to the efforts by conservation managers in the more formalised reserves and aid in embedding ecosystems as part of the identity of local communities as well as educating the public about the value of biodiversity and functioning ecosystems. The motivational factors for state agencies and policy makers to take an interest in these types of projects are numerous, but specifically include that community-driven restoration projects could serve as a cost-effective way for government to merge biodiversity goals, community upliftment and viable public open spaces (Ernstson 2011c).

It appears that both formal conservation regimes as well as civic-led greening endeavours play an important ecological role in the City of Cape Town and both management streams have something valuable to contribute. Tokai Park's driving force behind the restoration activities it has undertaken is to ensure the survival and restoration of the critically endangered Cape Flats Sand Fynbos. As such the Park makes restoration a priority when it comes to the placement of pathways, fences and signposts asking people to respect the rehabilitation process by staying clear of certain areas. The formal conservation areas ensure the survival of remnant areas of Cape Flats Sand Fynbos through management structures that are guided by years of scientific know-how, while civic-led restoration endeavours to aid in spreading ecological knowledge and the value of biodiversity to local communities at a grassroots level.

It seems overall that a new way of thinking about urban ecology is emerging. Cities can be perceived as a matrix of social-ecological 'islands' with dynamics that are still developing, resulting in a number of management challenges. However, the vast array of collaborations around urban greening seen across the City may be generating innovative ways of conserving biodiversity and ecosystems services within the City of Cape Town. Different epistemologies around restoration and ecosystem management can each bring something unique to the table. Urban ecology is a constantly evolving and developing field, making urban conservation an on-going learning experience in the City of Cape Town. This was emphasised by Asieff Khan of the False Bay Nature Reserve when he said, "[w]e constantly try to set new parameters as to what we think urban conservation actually means and I think we are continually developing those ideas and putting them into practice here".

Chapter 5: Conclusion

This study set out to establish the ecological value of social intervention in urban greening in the City of Cape Town with key focus on areas within the critically endangered Cape Flats Sand Fynbos ecotype. Firstly, appropriate sites representative of an ecological continuum were identified in order to assess the relative ecological integrity of the chosen three intervention sites: Tokai Park, Princess Vlei and Bottom Road Sanctuary. Secondly, field data collections allowed for an understanding of the vegetation composition, the soil quality and pollinator numbers at the six chosen sites. Lastly, the qualitative research on the type of management that each site received allowed for insights into the contributions of social interventions to ecological integrity. The research was carried out against the background of the debates in the literature around socio-ecological theory, the notion of ecosystem integrity, and the challenges of choosing indicators to measure this in an urban context. This conclusion presents the findings established in the course of this study, gives recommendations arising out of this work and possible future research directions.

5.1 Key findings

1) The anticipated continuum was observed from the relatively degraded vacant plot through to the desired end point in urban ecology, epitomised by Kenilworth Racecourse. Correspondence analysis highlighted the vacant plot as significantly different from the other five actively managed sites. This finding as well as the positions of the various intervention sites in the plot confirms that these sites are on some form of trajectory towards that of Kenilworth Racecourse, reinforcing their conservation potential and placing these previously degraded sites in the same domain or 'playing field' as conservation areas. Although relatively degraded, even the vacant plot has conservation value owing to the presence of an endangered plant species.

2) There is a need for greater connectivity between these sites as each had its own unique vegetation composition. This can only be achieved through restoring more degraded urban fragments in an attempt to close the 'gaps' between these otherwise disjointed spaces. Remnant sites would do well to be better connected for pollinators as their presence in the City may have important benefits for urban and peri-urban agriculture.

3) All intervention sites had relatively high plant functional diversity, implying good ecological functionality. The choice of plants planted at the 'gardened', civic-led interventions: Princess Vlei and Bottom Road Sanctuary as well as the more formally managed Tokai Park, resulted in a substantial increase in ecosystem functionality. Civic-led social interventions can indeed substantially increase the ecosystem functionality, which in turn speaks to the stability of an ecosystem in this regards, making it comparable to that of a formally managed reserve environment.

4) Species-specific management regarding alien invasive plant species and Red Data List species signify an additional upside to social intervention, especially at the more gardened sites, where alien invasive species such as *Acacias* are controlled while endangered species and those extinct in the wild are planted into areas where they otherwise would have never been found growing again.

5) Clear soil improvements were observed with regards to organic content, as all intervention sites had higher organic content than that found at the vacant plot and were comparable to that of Kenilworth racecourse, suggesting that through the planting of indigenous fynbos species, social intervention had indeed increased the integrity of these soils.

6) While the pollinator results do not present a clear picture owing to possible sampling issues, the overall trend in the data suggests that social intervention benefits pollinators in the City by increases the draw for pollinators to the sites, creating refuge areas, nesting grounds and increasing connectivity for pollinators

across the City. This may have beneficial implications for urban and peri-urban agriculture in Cape Town.

In addition to the valuable social dimensions of these interventions that have been highlighted through related research (Ernstson et al. 2008, Ernstson 2011a), this study has contributed to the field of urban ecology by showing that social interventions do indeed translate into increased ecological integrity for urban green spaces in the City of Cape Town.

5.2 Future research directions

A number of future research directions emerge from this current project. The most significant would be a monitoring study. A re-examination of the vegetation in five years' time would give a better understanding of directional change, which could be measured against this current body of work. Monitoring schemes could engage both the academic and local communities. Given predicted environmental change and increased urbanisation along with the critically endangered status of Cape Flats Sand Fynbos, there is scope for more work along these lines in order to inform urban planning decisions in response to change.

The civic-led greening interventions in the City of Cape Town have resulted in the local ecology being improved, with evidence of changes in plant community composition, cover, pollinator numbers and associated ecosystem services. The findings of this ecological research project point to the need for a change in the way that civic-led greening interventions are valued in the City and the securing of funding and resources that are comparably better provided for with regards to the management of formalized reserve areas. Civic-led restoration projects could be an economical way for government to create spaces that integrate both conservation goals and public open space functions. However, the complexity of this matter is acknowledged. This body of work has a purely ecological, and within that context, methodological focus, with significant findings to guide and contribute to any future work in this area. Maintenance of these urban green spaces for residents and for biodiversity in the face of expanding cities worldwide may require that ecological knowledge be better integrated with social science research and ultimately into urban planning to guide sustainable development. Future research should involve greater transdisciplinary efforts between the social and scientific research communities, and significantly, in conjunction with the users of these urban green spaces and the people involved in these social greening interventions. An increased participatory approach to urban planning should be investigated and may enable better conservation planning and management of Cape Town's urban green spaces.

An interesting future research direction would be to conduct socio-ecological studies towards understanding the particular relationship of 'Friends' groups to these urban green spaces, their motivation and the extent of their input in keeping these green spaces functioning. 'Friends' groups were often deeply involved in the upkeep of the sites that were investigated in this study and appeared to regularly act as the link between the general public and the managers of these sites. Research in this direction may bring to light some interesting relationships between these groups and the sustainability of Cape Town's urban green spaces.

Plate 4 Arum lily frog (*Hyperolius horstocki)* found nestled in the fynbos planted at Bottom Rd Sanctuary.

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Appendix A

Table representing percentage cover (%) of listed species from each of the five quadrats investigated per site.

Name	BR1	BR2	BR3	BR4	BR5	RV1	RV2	RV3	RV4	RV5	TP1	TP2	TP3	TP4	TP5	VP1	VP2	VP3	VP4	VP5	KR1	KR2	KR3	KR4	KR5	PV1	PV2	PV3	PV4	PV5
Athanasia crithmifolia	0	0	0	0	0	0	0	0	0	0	0	0	3	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia seedlings	0	0	0	0	0	0	1	3	0	0	0	0	2	2	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0
Aizoaceae family	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Albuca canadensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Albuca juncifolia	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0.5	0	0.5	0	0	0	0	0	0	0	0
Amphithalea imbricata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	5	0	10	0	0	0	0	0	0	0	0	0	0	0
Anthospermum prostratum	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthospermum sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Anthospermum spathulatum	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aristea bakeri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	1	0	0	0	0	0	0	0
Aspalathus sp. 1	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aspalathus sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Asparagus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Asteracious seedlings	0	0	0	0.5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Athanasia crithmifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0
Athanasia trifurcata	0	0	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atriplex sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0
Briza maxima	0	0	0	0	0	0	35	0	0	0	15	12	0	5	0	0	0	10	0	0	0	2	0	0	0	0	0	0	0	0
Carpobrotus edulus	0	0	0	0	0	0	0	0	2	0	0	5	30	25	3	0	0	0	0	18	2	5	3	3	0	0	0	0	0	0
Chrysanthemoides monilifera	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
Clifortia feruginea	0	0	0	0	0	35	20	15	50	0	0	12	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyonodon dactylon	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Cyperus laevigatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0.5	0	0	0	0	0	0
Cyperus sphaerospermus	2	0	0	1	6	1	0.5	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dead annual grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0

Elegia tectorum female	30	18	10	10	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Erica margaritacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0
Erica verticillata	0.5	0	0	8	0.5	10	0	0	0	1	0	5	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eriocephalus racemosus	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	10
Euphorbia tuberosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0
Felicia sp.	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ficinia nodosa	0	18	2	24	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gnidia simplex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Helichrysum helianthemifolium	12	0	5	5	0	2	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Helichrysum cymosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
Helichrysum indicum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	15	0	0	0	0	0	0	0
Helichrysum patulum	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hellmuthia membranacea	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0
Hypodiscus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	23	0	0	0	0	0	0	0	0	0	0	0	0
Iridaceae sp.	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0
Isolepis prolifera	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Itasina filifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0
Juncus capensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0
Juncus effusus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juncus kraussii	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lachnaea grandiflora	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	0	0	0	0	0
Lagurus ovatus	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	5	0.5	10	25	0	0	0	0	0	0	0	0	0	0	0
Lampranthus vernalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	5	2
Leonotis leonurus	0	14	2	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	8	0	0
Leucadendron sp.	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucodendron levisanus	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linum africanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Lobelia anceps	0.5	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lobostemon trichotomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0

Lolium perenne	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	3	0
Metalasia densa	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metalasia sp. PV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	5	10	0
Orphium frutescens	0	0	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oxalis glabra	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oxalis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0
Passerina corymbosa	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	15	15	15	5	5	0	0	0	0	0
Pelargonium betulinum	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelargonium capitatum	0	0	0	0	0	0	0	1	0	0	0	1	5	0	0	0	0	0.5	0	1	0	0	0	0	0	0	10	0	10	0
Pelargonium sp. 1	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelargonium sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pennisetum clandestinum	10	0	0	20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	2	3	0	0	0	0	0	0.5
Pentameris macrocalycina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
Pharnaceum lineare	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phylica sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	10	0	0	0	0	0	0
Polygalaceae sp.	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protea repens	0	0	0	0	0	0	0	0	18	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psoralea pinnata	0	0	25	0	0	1	3	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Restio paludosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Restioid sp PV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0
Rumex acetosella L. subsp. angiocarpus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	2	0	0	0	0	0	0	0
Salvia africana lutea	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	10	2
Searsia laevigata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	5	0	0	0	0	0	0	0	0
Senecio halimifolius	2	35	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Serruria foeniculacea	0	0	0	0	0	0	0	0	0	0	20	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Serruria glomerata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.5	0	0	0	0	0	0	0	0
Staberoha cernua	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	10	0	15	0	0	0	0	0	0
Staberoha distachya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0

Stenotaphrum secundatum	0	0	0	0	0	7	35	20	20	35	65	65	35	60	70	0	0	0	0	0	0	0	0	0	25	0.5	0	0	0	0
Stoebe plumosa	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	20	20	15	35	20	0	0	0	0	0
Struthiola striata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thamnochortus arenarius	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tribolium Hispidum	0.5	0	15	25	0	0	5	15	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tribulus terrestris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0.5	0.5
Wachendorfia paniculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0
Wahlenbergia capensis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Watsonia meriana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	2	3	0	0	0	0	0
Weedy asteracious annual sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	2	3	2	3	0.5
Zantedeschia aethiopica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0

Note: BR-Bottom Road Sanctuary, RV-Rondevlei Nature Reserve, TP-Tokai Park, KR-Kenilworth Racecourse, PV-Princess Vlei

Appendix B

Site manager questionnaire

Managers interviewed:

1) Kenilworth Racecourse- Maya Beukes
2) Tokai Park- Carly Cowell
3) Rondevlei and vacant plot: Tamaryn Kelley Allan and Asieff Khan
4) Bottom Rd and Princess Vlei: Kelvin Cochrane and Asieff Khan

1. Opening

- What is your position at ______.
- How long have you been working here?

2. Site context

- Who is currently responsible for managing the site?
- What is the history of the site's management? What has happened on this site in the past that you know of?
- Why did you or others choose to engage in this site and not in other sites? What made it possible to engage with this site?
- Could you describe in your opinion, the main purpose/aim of this site?
- What are your main objectives in managing the site?

3. Key management practices and protective norms

(Understanding of the full range of management practices required e.g. composting, bird feeding, enhancing bird habitat, beekeeping, enhancing pollinator habitat, active protection of natural enemies (pest control) or active choice of plant species attractive to pollinators.)

- Is there a management plan for the site?

Plants

- Where are plants sourced from?
- Who pays for or provides the plants?
- How is it decided which plants are to be pulled and which are to be planted and who decides this?
- What plants have been deliberately planted and why were certain species chosen above others for planting?
- What plants have been deliberately removed and why?
- Have you had fynbos or other plants that seem to take over and grow quicker than others, making it difficult for these others to remain?
- If yes, what have you done to control them or what do you plan to do?

Other management practices

- Are any other management practices implemented that aid pollinators/birds/soil or aid in pest prevention/alien invasion?

Disturbance regimes

- Do you actively try to simulate "natural" disturbance regimes or are you planning to do this? For instance bigger mammals disturbing the vegetation, or fire (and similar).

4. Workforce

- How often is the site tended to and by whom?
- What is the size of the workforce that deals with the site?
- Where are they from?
- How much labour is necessary to keep the site in an acceptable condition?
- Is there some kind of supervision of the everyday work that the ground staff does at the site? (That is, is there some kind of way that the management plans – written down or agreed upon verbally – are being understood by the persons doing the work on the site?

5. Management and social institutions

- Who are the key players in decision making around the site's management?
- How much say/involvement do private persons or civic organisations have in the management of this site? Through which channels does this happen?
- (Sites with 'Friends of…'/civic organisations attached) To what extent do these organisations play a role in managing the ecology of the site?

Stakeholders

- Who are the stakeholders of the site?
- Are there any established partnerships or organisations that are affiliated with the site?
- With what do they work?
- Do you interact with these organisations/partnerships?
- If you didn't have these organisations/partnerships, would your work at the site look any different?
- Would you say that they influence the everyday work you do on the site?

Users

- Who are the users of the site?
- How accessible is the site to the public and why/why not?
- Do the users of the site affect every day work that you and the staff do in any way?
- What is the level of public participation in managing the site?
- What in your opinion is the public's attitude towards the current management of the site?

Policy

- Do political decisions affect your management of the site?
- If so, which political decisions would you say affect your work?
- In what way are they good or bad? Do they promote or hinder your work?

6. Management's knowledge/rationale

- Who would you say has the most knowledge about the site when it comes to which plants are growing there, which animals live in or visit the site and a similar kind of understanding about plant and animal life in general?
- To what extent do you think this knowledge is used when it comes to managing the site?
- Does your own knowledge and thoughts about ecology affect the everyday management of the site?
- If so what kind of knowledge affects your work?
-How do you feel the labourers/staff's knowledge and thoughts about ecology affects the everyday work on the site?
-Do you think that the staff's own impact in terms of knowledge or attitudes promote or hinder management of and work on the site?
- What do you think the greatest values of the site are? Please name at least three and in which order of priority you see them.
- What are the future management plans for the site?
- What is management's ultimate vision for the site's future?

7. Challenges

- What have been the biggest hurdles in caring or managing for the site?
- How have you and others that are involved in managing the site tried to overcome some of these hurdles?
- What other resources do you feel would enable better management of the site?
- What do you think the greatest threats are to the future management of the site? E.g. financial/fire/flooding/social commitment/alien invasion?